IEPSP

Institute for Experimental Phonetics and Speech Pathology

LAAC

Life activities advancement center

SERBIAN GOVERNMENT
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT

PROCEEDINGS

SPEECH AND LANGUAGE 2013

4th International Conference on Fundamental and Applied Aspects of Speech and Language

Belgrade
25-26 October, 2013

Publisher:
Life Activities Advancement Center
The Institute for Experimental Phonetics and Speech Pathology

Electronic version on publication

Editors: Mirjana Sovilj, Miško Subotić

Technical editors: Slavica Maksimovic, Jevrem Bojović

Circulation: 500

ISBN: CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

81'234-053.2(082)
616.22-008.5-053.2(082)

INTERNACIONAL Conference on Fundamental and Applied Aspects of Speech and Language (4 ; Belgrade)
Speech and Language 2013 : proceedings / 4rd International Conference on Fundamental and Applied Aspects of Speech and Language, Belgrade 25-26 October, 2013 ; [editors Mirjana Sovilj, Slobodan Jovičić]. - Belgrade : Life Activities Advancement Center : Institute for Experimental Phonetics and Speech Pathology, 2013 (Belgrade : Draslar partner). - 375 str. : ilustr. ; 24 cm

Tiraž 500. - Bibliografija uz svaki rad.

ISBN 978-86-81879-45-0 (IEFPS)
1. Sovilj, Mirjana [уредник]
а) Говорни поремећаји - Деца - Зборници b) Вербална комуникација - Дефектолошки аспект - Зборници
COBISS.SR-ID 203784972

Print: Draslar Partner, Belgrade, Dalmatinska 47

The Conference **SPEECH AND LANGUAGE 2013,** 4th International Conference on Fundamental and Applied Aspects of Speech and Language and Proceedings are supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

Scientific Committee

Chair:
M. Sovilj (Serbia)

Vice-chairs:
D. Popov (Bulgaria)
M. Subotić (Serbia)

Members:
R. Bjeljac Babić (France)
V. Bojanova (Bulgaria)
G. Breakman (Israel)
V. Delić (Serbia)
F .Grandori (Italy)
S. Golubović (Serbia)
O. Gouni (Greece)
D. Horga (Croatia)
Z. Ivanovski (Macedonia)
S. Jovičić (Serbia)
Dj. Koruga (Serbia)
A. Kostić (Serbia)
E. Luschei (USA)
P. Marković (Serbia)
K. Matsuno (Japan)
Lj. Rakić (Serbia)
D. Raković (Serbia)
I. A. Sternin (Russia)
V. A. Shestakov (Russia)
B. Tošović (Austria)

Organizing Committee

Chair:
S. Đoković (Serbia)

Vice-chairs:
S. Maksimović (Serbia)
S. Punišić (*Serbia*)

Members:
T. Adamović (*Serbia*)
B. Bedričić (*Serbia*)
N. Čabarkapa (*Serbia*)
Lj. Dobrijević (Serbia)
V. Djordjević (*Serbia*)
M. Panić (*Serbia*)
M. Popović (Germany)
M. Sečujski (*Serbia*)
Z. Šarić (*Serbia*)
M. Vojnović (*Serbia*)

Secretariat:
J. Bojović (*Serbia*)
M. Vujović (*Serbia*)

Contens

WELCOME SPEECH AT THE OPENING OF THE 4TH INTERNATIONAL CONFERENCE ON FUNDAMENTAL AND APPLIED ASPECTS OF SPEECH AND LANGUAGE 8
JOVAN BAZIĆ

DIGITALIZATION OF SERBIAN WRITTEN HERITAGE: ELECTRONIC CORPUS OF SERBIAN LANGUAGE FROM 12TH TO 18TH CENTURY 10
ALEKSANDAR KOSTIĆ

THE EGG and SPERM POLARITY in UNION at HUMAN CONCEPTION 15
OLGA GOUNI, JON RG & TROYA TURNER

STRESS & ANTI-STRESS: HOLISTIC QUANTUM-INFORMATIONAL FRAMEWORK 29
DEJAN RAKOVIĆ

HOLISTIC APPROACH TO SPEECH INTERACTION IN NORM AND PATHOLOGY 40
DIMITAR POPOV, VELKA POPOVA

BASES OF (PRENATAL) COMMUNICATION 46
MIRJANA SOVILJ

FETAL AUDITORY STIMULATION AND THE CHANGE OF PULSATILITY INDEX OF THE FETAL MIDDLE CEREBRAL ARTERY 50
SNEZANA PLESINAC , SVETLANA JANKOVIC, DARKO PLECAS, OLGA ANTONOVIC, TATJANA ADAMOVIC , MIRJANA SOVILJ

VOCAL TRACT SHAPE ESTIMATION FOR CHILDREN AGES TO ONE YEAR 55
MILAN VOJNOVIĆ

MOVEMENT AND SPEECH 65
TATJANA ADAMOVIĆ, MIRJANA SOVILJ , KSENIJA RIBARIĆ-JANKES

ON APPLICATIONS OF FUZZY SYSTEMS IN AFFECTIVE COMPUTING 72
DRAGAN ŠALETIĆ

COMPARATIVE ANALYSIS OF UNDERSTANDING VERBAL ORDERS IN COCHLEAR IMPLANTED CHILDREN COMPARED TO NORMAL HEARING CHILDREN 82
SELENA TODOROVIC, SANJA DJOKOVIC

IMBALANCED LEARNING APPROACH TO THE CATEGORIZATIONOF ARTICULATION DISORDERS 89
DRAŠKO FURUNDŽIĆ, SLOBODAN JOVIČIĆ, MIŠKO SUBOTIĆ, SILVANA PUNIŠIĆ

CHARACTERISTICS OF PERCEPTIVE IDENTIFICATION OF LEVEL OF DURATION DEVIATION FOR FRIVCATIVE /Š/ IN TRAINED AND UNTRAINED LISTENERS 100
SILVANA PUNIŠIĆ , ZORKA KAŠIĆ, SLAVICA GOLUBOVIC, SLOBODAN JOVIČIĆ

CHANGES IN EEG THETA RHYTHM PEAK FREQUENCY AND AMPLITUDE IN FRONTAL MIDLINE CORTICAL REGION DURING SHORT-TERM AUDITORY MEMORY FORMATION FOR WORDS AND NON-WORDS 110
MIODRAG STOKIĆ, ZORANA RADIVOJEVIĆ, VANJA NENADOVIĆ, SLAVICA MAKSIMOVIĆ

THE SPEECH ACT OF APOLOGY IN SPOKEN VERBAL COMMUNICATION 118
DEYANA PENEVA

MOUTH ACTIONS IN SIGN LANGUAGES: THE ROLE OF MOUTHING IN HZJ 126
ANET MARCAŠ, MARINA MILKOVIĆ

MAXIMAL VOWEL SPACE 137
MILAN VOJNOVIĆ

INTUITION SPEECH 148
VESNICA KLJAJEVIĆ, DRAGANA PORTIĆ[2]

ABILITY OF PHONOLOGICAL ANALYSIS IN FIRST AND SECOND GRADE ELEMENTARY SCHOOL CHILDREN 152
NINA STANOJEVIĆ, MARINA RANĐELOVIĆ

LONGITUDINAL MONITORING VOICE QUALITY SPEECH THERAPIST 158
MARINA RANDJELOVIC, NINA STANOJEVIC

PRENATAL COMMUNICATION:HOW IT REFLECTS ON EARLY CHILD DEVELOPMENT 165
LJILJANA DOBRIJEVIC, MARIJANA RAKONJAC, MARINA VUJOVIC, IVANA BOGAVAC

SPEECH AND LANGUAGE INFORMATION PROCESSING OBSTRUCTION IN A BILINGUAL CHILD 171
ZORAN RADIČEVIĆ, LJILJANA JELIČIĆ-DOBRIJEVIĆ, MIODRAG STOKIĆ, MIŠKO SUBOTIĆ, IVANA STANKOVIĆ-MILIĆEVIĆ

THE ROLE OF BASAL GANGLIA IN SPEECH MOTOR CONTROL 177
MARINA VUJOVIĆ, LJILJANA DOBRIJEVIĆ, MARIJANA RAKONJAC, IVANMA BOGAVAC

EVALUATION OF PHONEMES QUALITY ARTICULATION USING NEURAL NETWORK ENSEMBLES 183
DRAŠKO FURUNDŽIC, SLOBODAN JOVIČIĆ, MIŠKO SUBOTIĆ, ĐORĐE GROZDIĆ,

SEMIOTIC ANALYSIS OF SPANISH ADVERTISMENT ENTITLED "AUTISMO HABLA" – "AUTISM SPEAKS" 190
IVANA MITORVIĆ DJORDJEVIC, VOJISLAV TODOROVIĆ

ASPECTS OF RELATIONSHIP BETWEEN SPECIFIC LANGUAGE IMPAIRMENT AND SPECIFIC DYSLEXIA 197
TSVETANKA TSENOVA

APPLICATION OF EEG IN RESEARCH OF AUDITORY CORTEX IN CHILDREN WITH COCHLEAR IMPLANTS 204
SANJA ĐOKOVIĆ, VANJA NENADOVIĆ, SANJA OSTOJIĆ, SLAVICA MAKSIMOVIĆ, SELENA TODOROVIĆ

INTRODUCING PUPILS INTO WRITING SKILLS 214
ZORICA CVETANOVIĆ, KRISTINA ŠULOVIĆ PETKOVIĆ

NEURAL NETWORK-BASED RECOGNITION OF WHISPERED SPEECH 223
ĐORĐE GROZDIĆ, BRANKO MARKOVIĆ, JOVAN GALIĆ, SLOBODAN JOVIČIĆ, DRAŠKO FURUNDŽIĆ

AUTOMATIC DETECTION OF STRIDENCE IN SPEECH USING THE AUDITORY MODEL 230
RUŽICA BILIBAJKIĆ, ZORAN ŠARIĆ, SILVANA PUNIŠIĆ, MIŠKO SUBOTIĆ, SLOBODAN JOVIČIĆ

THE STATE OF VERBAL ASSOCIATIONS IN PRE-SCHOOL AGED CHILDREN (NEUROPSYCHOLOGICAL ANALYSIS) 240
NELI VASILEVA

ACQUISITION OF APPROXIMANTS IN CROATIAN 248
DIANA TOMIĆ

THE INFLUENCE OF FEATURE VECTOR SELECTION ON PERFORMANCE OF AUTOMATIC RECOGNITION OF WHISPERED SPEECH 258
JOVAN GALIĆ, SLOBODAN JOVIČIĆ, ĐORĐE GROZDIĆ BRANKO MARKOVIĆ

THE POWER OF WORD IN EDUCATION AND UPBRINGING 265
LJILJANA KLAJIĆ

ABILITY OF NOMINATION IN CHILDREN WITH PHONOLOGICAL DISORDERS 269
MARIJANA PANIC, VIVIEN ĐORĐEVIĆ, SELENA TODOROVIĆ

CHANGE OF PULSATILITY INDEX OF MIDDLE CEREBRAL ARTERY AFTER PRENATAL SOUND STIMULATION IN NO RISK TERM PREGNANCIES 275
SVETLANA JANKOVIC-RAZNATOVIC, SNEZANA PLESINAC, MIRJANA SOVILJ· TATJANA ADAMOVIC, DARKO PLECAS, DJURDJICA CECEZ, LJILJANA DOBRIJEVIC, DJURO KORUGA

PALATAL LATERAL APPROXIMANT /ʎ/ AS ONE OF THE MAIN TROUBLEMAKERS IN LEARNING CROATIAN AS L2 279
ARNALDA DOBRIĆ, JORDAN BIĆANIĆ

ARTICULATION-ACOUSTIC CHARACTERISTICS OF FRICATIVES 286
MIŠKO SUBOTIĆ, SILVANA PUNIŠIĆ, NATAŠA ČABARKAPA, MILAN VOJNOVIĆ

BASIC COMPETENCIES IN GENETICS FOR SPEECH – LANGUAGE PATHOLOGIST 300
IGOR BUZGANOVIĆ , BOJANA BOBIĆ GECE

APPLICATION OF DTW METHOD FOR WHISPERED SPEECH RECOGNITION 308
BRANKO MARKOVIĆ, JOVAN GALIĆ, ĐORĐE GROZDIĆ· SLOBODAN T. JOVIČIĆ

VOWEL FORMANT FREQUENCIES ESTIMATION FOR NEWBORN CHILDREN 316
MILAN VOJNOVIĆ , IVANA BOGAVAC, LJILJANA DOBRIJEVIĆ

VACCINE INJURY AND ITS TREATMENT 326
DUBRAVKA MARKOVIC, AFTER KATE BIRCH

PROBLEMS OF CHILDREN IN SCHOOL WORK 328
IVANA PAVKOVIC

IMPACT OF PREMATURITY ON ARTICULATING STATUS OF 5 YEARS AGED CHILDREN 334
IVANA MILICEVIC STANKOVIC, SELENA TODOROVIC, VIVIEN DJORDJEVIC, MAJA MILENKOVIC

AUTOMATIC DETECTION OF SPEECH PATHOLOGY - TOWARD THE EXPERT SYSTEM 340
RUŽICA BILIBAJKIĆ, SLOBODAN JOVIČIĆ, ZORAN ŠARIĆ, SILVANA PUNIŠIĆ, MIŠKO SUBOTIĆ

LINGUISTIC CAPACITY OF CHILDREN WITH DI GEORGE SYNDROM 346
SELENA TODOROVIĆ, VIVIEN DJORDJEVIC, MARIANA PANIĆ

THE INFLUENCE OF RH INCOMPATIBILITY TO SPEECH AND LANGUAGE DEVELOPMENT 352
IGOR BUZGANOVIĆ , MIRJANA SOVILJ , NATAŠA ČABARKAPA

LEXEMES AND PHRASES IN ASSOCIATIVE FREQUENCY DICTIONARY OF PRESCHOOL CHILDREN 358
NATAŠA CABARKAPA, SAŠKA FATIC, IGOR BUZGANOVIC, ZORANA MILOSAVLJEVIC

THE INFLUENCE OF EARLY COMMUNICATION ON CHILD DEVELOPMENT AND LEARNING 368
MARIJANA RAKONJAC, LJILJANA DOBRIJEVIĆ

GRAPHOMOTOR SKILLS OF CHILDERN WHO STUTTER 372
NINA STANOJEVIC, MARINA RANDJELOVIC

WELCOME SPEECH AT THE OPENING OF THE 4TH INTERNATIONAL CONFERENCE ON FUNDAMENTAL AND APPLIED ASPECTS OF SPEECH AND LANGUAGE

JOVAN BAZIĆ
Serbian Government
Ministry of Education, Science and Technological Development

Ladies and Gentlemen,

Dear colleagues,

I'm very honored by the invitation to address you on behalf of the Ministry of Education, Science and Technological Development of Republic of Serbia at the opening of the *4 th International Conference on fundamental and applied aspects of speech and language.*

This conference is of great scientific and social importance, because it deals with issues that are not only an expression of the scientific curiosity of a small number of people who are professionally involved in speech and language issues. These issues have wider implications and reflections on the whole community because the speech and language are primary means of communication between people in society. So therefore, any attempt to improve speech and language or acquire new knowledge in this area is a great contribution to society. Therefore, the Ministry of Education, Science and Technological Development of Republic of Serbia supported this conference, as well as other forms of research activities which are undertaken in the Institute for Experimental Phonetics and Speech Pathology and Life activities advancement center in Belgrade .

Speech and language represent the unity because there is no speech nor language without speaking the language. The emergence of the speech is related to the origin of human being, and they are key factors in his evolution. Speech is not just a characteristic of the human individual, but also the experiential value of human civilization. That is why speech has a social, creative and ideological value.

Speech and language determine people in their identity. They are a basic feature of every culture. Without speech and language there is no culture and no people. Speech and language connect people, but they also differ people not only in their definition of identity, but in the cultural specificity. Great cultural and linguistic communities suppress small culture and their speech and language, especially in the contemporary processes of globalization, planetary exploitation and the rapid development of information and communication technologies. There is a growing monopoly and imposing of one language and one culture – it is the language of one-dimensional society of most advanced technology and the culture in the consumer society. In these processes a small language communities, such as ours, are increasingly neglected, both in speech and apply of their language, and in his teaching. The consequences are manifested everywhere, in everyday speech, public speech, in communication through information technology and in the expression of the mass media. People are losing the basic literacy and culture of speech. There is a pronounced trend of cultural deprivation, babbitry and primitivism. On the other hand, often can be heard advocating for a multicultural society, but they are meaningless if they can not respect multilingual character of such a society and if it is not paying more attention on national languages and their speech.

In this context, greater attention should be given to Serbian language. Much of the knowledge we can take from others or to acquire with others, but we create our knowledge of speech and language by ourselves and we have to improve and effectively transmitte it to younger generations. That's the most important role of teachers and experts dealing with the study of speech and language. But the institutions of our society need to pay more attention onj that problem: from defining curricula, textbooks, software customization of ICT characteristics of the Serbian language, the completion of projects which deals with the standardization of modern Serbian language and the development of Serbian vocabulary, improving the financial and other conditions of people engaged in the study of Serbian language.

Ministry of Education, Science and Technological Development of Republic of Serbia see a large part of its duties and responsibilities, and in that manner it is very dedicated to these issues, what should be revealed in the coming period.

Dear colleagues,

Thank You for your attention and I wish you every success in your work!

DIGITALIZATION OF SERBIAN WRITTEN HERITAGE: ELECTRONIC CORPUS OF SERBIAN LANGUAGE FROM 12TH TO 18TH CENTURY

ALEKSANDAR KOSTIĆ
Laboratory for Experimental Psychology
Faculty of Philosophy, University of Belgrade

Abstract: In the mid-fifties at the Institute of Experimental Phonetics and Speech Pathology Prof. Đorđe Kostić had initiated a project aimed at compilation of an annotated corpus that would span Serbian language from the 12th century (Serbian-Slavonic) to the contemporary Serbian language. The subsample of Serbian-Slavonic texts from the 12th to 18th consists of about 450 000 words and includes all the prominent authors of that period (St. Sava, Domentijan, Teodosije, archbishop Danilo II, Grigorije Camblak, patriarch Pajsije, Stefan Prvovenčani). Distinct segment of this subsample contains old Serbian charters and royal correspondence edited by Ljubomir Stojanović. In the mid-fifties Serbian-Slavonic texts were manually annotated at the level of inflected morphology with a system of annotation that distinguishes about 3000 grammatical forms.

The annotated Serbian medieval texts were digitalized through mutual efforts of the Institute for Experimental Phonetics and Speech Pathology and the Laboratory for Experimental Psychology, University of Belgrade. It the last five years eight volumes of frequency dictionaries of the medieval Serbian authors were published by Službeni glasnik. The printed version is accompanied with CD that contains application which allows search through the original text, concordances and collocations for each lemma and quick search of a series of frequency dictionaries.

Key words: annotated corpora, Serbian-Slavonic, diachronic corpus

The *Electronic Corpus of Serbian Langue from 12th to 18th century* is part of the diachronic *Corpus of Serbian Language (CSL)*, a project initiated and directed in the mid-fifties by Prof. Đorđe Kostić at the Institute for Experimental Phonetics and Speech Pathology in Belgrade. The CSL project was suspended in 1962 for reasons not yet unveiled and continued in 1996 as part of the project entitled *Quantitative Description of Serbian Language Structure (QDSLS).* The aim of the QDSLS project is to provide detailed quantitative specification of all aspects of Serbian language – from the level of phonology to the level of syntax. The QDSLS project is realized at the Laboratory for Experimental Psychology, University of Belgrade and the Institute for Experimental Phonetics and Speech Pathology, Belgrade.

History of the CSL project

Corpus of Serbian Language (CSL) is diachronic corpus that spans Serbian language from the 12th century to the contemporary language, consisting of about 11,000,000 words manually tagged at the level of inflected morphology. It was initiated in the mid-fifties by Prof. Đorđe Kostić as part of a broader project aimed at automatic text recognition and machine translation, also initiated and guided by Prof. Kostić. Being of the opinion that automatic text recognition and the machine translation is not possible on purely algorithmic basis, Prof. Kostić adopted probabilistic approach to this problem. Formation of grammatically annotated corpus of Serbian language was to be the language basis for the machine, but also a source from which the probabilities of all relevant aspects of language would be derived. Besides word entry probabilities, the corpus would allow approximation of probability of all grammatical forms and probability of all grammatical forms for each word.

The project was divided into two chronological phases. The first phase assumed the acoustic analysis of the phonemes of Serbian language and the specification of the probabilities of phonemes and phoneme combinations, including parallel work on the speech analyzer, phonetic typewriter and speech synthesizer. The main part of the first phase was the formation of the corpus and specification of probabilities of words and grammatical forms. The second phase, which commenced at the end of 1950s, comprised a description of the syntax of Serbian language that would be partly formalized and partly expressed in terms of probability.

As noted earlier, at the beginning of 1960s, the project was terminated.

Structure of the CSL

As noted, the Corpus of Serbian language spans Serbian language from the 12^{th} century to the contemporary language and it is chronologically divided into five samples: Serbian language from the 12^{th} to 18^{th} century, language of the 18^{th} century, complete works of Vuk St. Karadžić, language of the second part of the 19^{th} century and the contemporary Serbian language.

The sample of Serbian language from 12th to 17th century includes writings of the most prominent authors from that period as well as the old Serbian charters and letters. Serbian language of 18th and early 19th century is represented by writings of Milovan Vidaković, Gerasim Zelić, Joakim Vujić and other authors from that period. The text is given in its original form and orthography. Work of Vuk St. Karadžić represents turning point not only in development of Serbian orthography but also in terms of linguistic standards both in written and spoken language which later became generally accepted. Second half of the 19th century literature is represented by complete works of Branko Radičević, Marko Miljanov, Petar Petrović-Njegoš, Jovan Jovanović-Zmaj and Đura Jakšić. Finaly, the sample of contemporary Serbian language is divided into six parts: a. novels and essays (126 books), b. poetry (215 books), c. daily press (Politika), d. scientific prose (136 books) e. political prose and f. texts of Belgrade surrealists.

CSL – how it was made

Due to technological limitations in the late fifties, most of the work on the CSL was executed manually. The final goal was to compile a number of frequency dictionaries that would serve as a basis for automatic speech and text recognition and machine translation. Compilation of frequency dictionary consisted of 27 distinct operations. Here we outline the most important ones.

a. Within each book included in a sample, lines were enumerated on each page.

b. A4 sheet of paper was divided into 16 frames and within each frame a word from a book was transcribed. For each given word, its page and line numbers in the original book were specified as well.

c. Once the whole text was transcribed and lines and pages recorded, each word was specified for its grammatical status (see the picture).

d. Grammatical tagging was subsequently monitored by a group of linguistic experts that randomly sampled about 10% of each text. In cases where there was more than a 2% error rate, the grammatical tagging was repeated until the required criterion was reached. Sometimes the procedure had to be executed 3 or 4 times to reach the required standards of reliability.

e. Once grammatical tagging was complete, the compilation of series of frequency dictionaries could be initiated. The A4 sheet was cut into 16 frames – one frame for each word. Word frames were then sorted into alphabetical order.

f. Different grammatical forms (i.e. frames) for each word were sorted according to a specified order (e.g. for the word HOUSE, for example, all nominatives singular were put together, then all genitives singular etc.).

g. Reliability for grammatical code sorting was monitored.

h. For each word, the frequencies for each grammatical form were counted, as was the total the number of the occurrences of a word entry (e.g. HOUSE appeared 15 times in the nominative singular, 5 times in the genitive singular etc., The word HOUSE, irrespective of its grammatical form (i.e. word entry) appeared 75 times.).

i. Counting of grammatical forms and word entries was also controlled for reliability.

j. The obtained frequency counts were transcribed into a specialized form and then typed on an A4 sheet. In its final form each frequency dictionary had two distinct versions: one with word entries and grammatical forms for each word being sorted by alphabetical order and the other, with word entries sorted by rank frequency.

This project of automatic text recognition and machine translation engaged more than 500 collaborators (most of whom were technical staff working on the Corpus of Serbian Language). By the time when the project was to be suspended, more than 27,000 pages of various frequency dictionaries had been compiled. Prof. Kostić published some of the results of this research in the following books: *Probability of grammatical forms in Serbo-Croatian*, IEPSP, 1965, *Probability of phonemic co-occurrences of Serbo-Croatian phonemes*, IEPSP, 1965 and *Functions and meanings of cases in Serbo-Croatian*, IEPSP, 1965.

In 1996, through mutual efforts of the Institute of Experimental Phonetics and Speech Pathology and the Laboratory for Experimental Psychology, the materials with manually annotated text were fully digitalized. As a result, *Frequency Dictionary of Contemporary Serbian Language* (seven volumes) was published in 1999, with software that allows easy search of the Dictionary.

Serbian language from 12th to 18th century

The distinct part of the CSL is sample of Serbian language from 12th to 18th century. The sample consists of about 400,000 words and is compiled from 18 literary works by seven authors, two manuscripts by anonymous authors and vast official and private correspondence of Serbian kings and noblemen. The language and orthography are in their original form, i.e. in Serbian-Slavonic. The sample consists of two distinct types of material: a. the lives of Serbian saints (hagiographies) and b. the old Serbian charters and letters. There are also several examples of Serbian medieval church poetry.

The Corpus contains all published hagiographies, including most significant authors of that period (Teodosije, Domentijan, archbishop Danilo II, Stefan Prvovenčani, patriarch Pajsije, Grigorije Camblak and count Đorđe Branković).[1] The lives of saints constitute a distinct genre of the Serbian medieval written heritage, and present an interesting (although not always reliable) historical source as well as precious testimony of the Serbian literary language in the period between the 12th and the 18th centuries.

In the second part of the 19th century Đuro Daničić, reputed Serbian philologist and expert on old Serbian literature, edited and published manuscripts from the most important Serbian medieval writers (Domentijan, Teodosije and archbishop Danilo II). Daničić not only published those manuscripts, but through comparing the available medieval transcripts, had standardized the Serbian-Slavonic orthography. The material that constitutes the sample is in the most part based on Daničić's editions as well as the editions of Janko Šafarik, Stojan Novaković and the extensive editorial endeavor of historian Vladimir Ćorović (St. Sava and Stefan Prvovenčani).

[1] The full list of authors is given in the Appendix.

The old Serbian charters and letters encompass written documents that span five centuries of Serbian history. They include correspondence and charters of Serbian kings and noblemen, as well as contracts and other administrative documents and could be treated as valuable and reliable historical source. Unlike the lives of Serbian saints, the language in which they were written (also Serbian-Slavonic) is much closer to Serbian vernacular of that period. The old charters and letters were collected and edited at the beginning of the 20th century in their original form by Ljubomir Stojanović, one of the most prominent Serbian philologists.

Transcript and grammatical tagging of the material was carried out in the mid 1950's by Prof. Đorđe Sp. Radojičić, at the time the most prominent expert in medieval Serbian literature and the Serbian-Slavonic language, and by a group of experts in Serbian-Slavonic from the University of Novi Sad. However, for reason yet unknown, the material had not been lemmatized.

In 2003 a group of experts for Serbian-Slavonic had been formed in order to lemmatize Serbian medieval texts, to correct some mistakes in grammatical annotation and to compile frequency dictionary for each text that constitutes the sample. The group was headed by Prof. Đorđe Trifunović, the most prominent expert in Serbian medieval literature. Members of the team were dr Zorica Vitić, Radmila Kovačević and Vladan Trijić. In 2004 Frequency Dictionary of Domentijan had been compiled (three volumes), which established standards for the subsequent publications. Each publication consists of several distinct segments:

a) Original Serbian-Slavonic text;

b) Original Serbian-Slavonic text with each word being lemmatized and grammatically specified;

c) Frequency dictionary with lemmas being sorted by alphabetical order. For each lemma frequency of occurrence is given in three versions (raw frequency, frequency expressed as a proportion and $\log_2$ of the proportion). All grammatical forms for each lemma with their respective frequencies are also included.

d) Frequencies of onomastic terms (lemma and form frequencies);

e) Lemmas sorted by part of speech criteria (i.e. nouns, adjectives, verbs etc.);

f) Probabilities of grammatical forms

Thus far eight volumes of frequency dictionaries had been published by Službeni Glasnik as part of the project entitled *Quantitative Description of Serbian Language Structure*. The author of the whole series is Prof. Đorđe Kostić who initiated the project. The following volumes are available.

a) Domentijan: The Life of St. Simeon and St. Sava (three volumes, 3102 pages);

b) Teodosije. The Life of St. Sava (one volume, 1249 pages);

c) Archbishop Danilo II: The Lives of Serbian Kings and Archbishops (two volumes, 1732 pages);

d) Hagiographies – Canon – Chronicles (two volumes, 2921 pages). This publication contains writings of St. Sava, Stefan Prvovenčani, Teodosije, Grigorije Camblak, Patriarch Pajsije and Despotes Đorđe Branković.

Each publication contains CD with software application that allows easy search through the original text, list of concordances for each lemma, lemma's grammatical form and concordances for each grammatical form. In addition, the application offers list of collocations and work with frequency dictionary at the level of lemma and form frequency.

Currently, compilation of frequency dictionary of Old Serbian Charters and Letters is in progress. Once being completed, the digital Corpus of Serbian medieval written heritage will offer wide spectrum of various kinds of research that may include vocabulary, morphology, syntax, stylistic properties, diachronic studies etc. We hope this project will motivate Slavic scholars to investigate Serbian medieval culture in novel way, including statistical and mathematical approach to linguistic phenomena. The digitalized Corpus, no doubt, offers these opportunities.

APPENDIX

The list of books and items

The Old Serbian Charters and Letters. Vol. I (the 1st and the 2nd part)
Collected by Ljubomir Stojanović, Belgrade, 1929.

Teodosije: The Life of St. Sava
Edited by Đura Daničić, Belgrade 1860 (reprint, 1973)

Domentijan: The Lives of St. Simeun and St. Sava
Edited by Đura Daničić, Belgrade 1865.

Archbishop Danilo II: The Lives of Serbian Kings and Archbishops
Edited by Đura Daničić, Zagreb 1866 (reprint, London 1972)

Stefan Prvovenčani: The Life of Simeon Nemanja
Vladimir Ćorović: Svetosavski Zbornik 2, pp. 1-76

Grigorije Camblak: The Life of Stefan Uroš
Janko Šafarik: Glasnik Društva srbske slovesnosti 11, 1859, pp. 43-94

The Writings of St. Sava
Vladimir Ćorović: Belgrade – Sremski Karlovci, 1928

Patriarch Pajsije: The Life of Emperor Uroš
Ilarion Ruvarac: Glasnik Srpskog učenog Društva 5, Vol. 22, 1867, pp. 209-239

Anonimous: The Life of Joachim from Sarandapor,
Stojan Novaković: Glasnik Srpskog učenog Društva 5, Vol. 22, 1867

Excerpts from The Chronicles of Despotes Đorđe Branković,
Stojan Novaković: Glas Srpskog učenog društva 33, 1872, pp. 242 – 264

Canon for St. Sava
Đorđe Sp. Radojičić: Južnoslovenski filolog 21, Vol. 1-4, 1955-56, 137-151

THE EGG and SPERM POLARITY in UNION at HUMAN CONCEPTION

OLGA GOUNI[1], JON RG & TROYA TURNER[2]
[1]Cosmoanelixis Prebirth Psychology Center,
[1]Hellenic Union for Prenatal and Perinatal Psychology and Medicine
[1,2]Whole-Self Discovery & Development Institute, International
info@cosmoanelixis.gr

Abstract: Our human body consists of many parts each of which carries specific qualities orchestrated in a symphony of tones that makes the physical form. Each human body bears an individual resonant frequency, a kind of energy signature within the zone of frequencies that correspond to the humankind. Each one of us is unique in the meaning that each one of us can resonate at a slightly different frequency within this zone that includes less and more subtle ones and, at the same time, – as part of our Earth existence - we all resonate to the earth frequency.

Living in a world of polarities as experienced in day-night, good-evil, male-female etc, the same laws that create the two polarities in man and woman are seen to work to the egg and sperm, the two gametes that create us.

The phenomenon of the conception of each human being is a process that takes us to the depths of life, irrespective of the form that life takes to manifest, the structure of basic elements of life and such study-journey reveals us the miracle of life. Human conception unfolds in front of us as a magical process of transformation and offers keys for the understanding of human relationships along the evolutionary path.

In this paper, we will examine the egg and sperm to discover their basic biological – almost archetypal qualities - we'll compare them and spot the polarities they present. Then, we'll see how these polarities serve the co-creational ACT of human conception.

Keywords: conception, ovum, sperm, spermatozoon, gametes, zygote, frequency, (bio)resonance, relationships, information, gesture, polarity, opposition, analogy, transformation, evolution, wave theory, quantum genetics

1. THE BACKGROUND

1.1. Ancient Greek Thought

Since the times of Aristotle and the Pythagoreans, it seems that human environment has been largely organized into pairs of opposites or "tables of opposition" in which all members arranged in one column are in some sense positive while the ones arranged in the other table are inferior or negative, of the opposite polarity. Parmenides believed that males are formed on the right side of the womb, females on the left and Aristotle believed that men are hotter and dryer than women.

The Pythagorean Table contains different kinds of opposites:

- limit and unlimited,
- one and many,
- rest and motion,
- straight and curved *but also*
- odd and even,
- male and female,
- right and left

which are contraries and do not admit of intermediaries or of degrees.

In **early Greek thought**, most of the **modes of argument and forms of explanation** are arranged in two simple, logical types:

A. that of **"opposition"** in which things are classified or explained by being related to a pair of opposite principles, and

B. That of **"analogy"** in which things are likened or assimilated to something else.

1.2. The Hermetic Philosophy

In the **Hermetic Philosophy**, we read that

"Everything is in motion, everything vibrates, nothing is at rest",

facts that modern sciences have proven true.

And continues defining the **Principle of Polarity** that embodies the idea that

"***Everything is dual, everything has two poles, and everything has its opposite".***

The Ancient Greek **Thesis** and **Antithesis** are identical in nature, but different in degree.

Opposites are the same differing only in degree.

The pairs of opposites may be reconciled, extremes meet, everything is and is not at the same time there are two sides to everything etc.

In everything there are two poles, or opposite aspects. These opposites are just the two extremes of the same thing, with many varying degrees between them (The Kybalion, 1908).

1.3. The Modern Sciences

What used to be in the field of philosophy or metaphysics once, today, lies within the borders of science. Engineering, ergonomics, maths, medicine, physics, physiology - to name a few - speak about human vibration: We can measure the displacement between the maximum (peak) movement in one direction and the peak movement in the opposite direction. We can measure the frequency (F=1/t), we can unlock many of the mysteries in the past.

In the **Science of Acoustics**, frequencies can resonate when there is a common harmonic they share. When two tones of the same frequency mix together, they unite, they resonate. When one of them moves 180 degrees out of phase, then the one cancels the other and the dead beat emerges. When frequencies resonate they create a whole that can be expressed in a mathematical formula and this determines the manifested form.

All living forms are manifestations of a specific vibration in the frequency spectrum. And exactly like an orange is the totality of the specific parts (skin, juice, pips etc), our human body consists of many parts each of which carries specific qualities orchestrated in a symphony of tones that makes the physical form recognized as human.

Each human body bears an individual resonant frequency, a kind of energy signature within the zone of frequencies that correspond to the human being. Each one of us is unique in the meaning that each one of us can resonate at a slightly different frequency within this zone that includes less and more subtle ones and, at the same time, – as part of our Earth existence - we all resonate to the Earth frequency.

What is true of the whole Person, is true of the part: the **gametes**, the living sub-forms that are engaged to fulfill the task of life creation. A process, the study of which brings us to the depths of life irrespective of the form it takes, the in-depth study of the elementary structural blocks of life and the reflection of concepts such as trust, wisdom, co-operation, collectivity etc.

Research scientists in the field of Quantum genetics showed that **DNA** molecule in structure of chromosomes possess a substance-wave duality, similar to the duality of elementary particles. It means, that the DNA of chromosomes control fundamental programs of life in a dual ways: as chemical matrixes (with the help of substance DNA), and as a source of the DNA sign wave function and holographic memory (Gariaev 1994, 1997; Gariaev e.a. 2000). Gariaev (1994, 1997), others believe that the genetic device has ability to be non-local at a molecular level. It means, that in each nucleus, in every genome is kept the memory about the structure and the function of all organism.

Harold Burr in his book, *Blueprint for Immortality* contended that the electro-dynamic fields of all living things, which may be measured and mapped with standard voltmeters, mold and control each organism's development, health, and mood. He named these fields *fields of life* or L-Fields. The American scientist for the first time has found that human cells, sperm and ovum too, have the ability to generate EM energy. He has found an electrical axis of polarisation at a fertilized ovum. And, the form of the energetic field corresponded not to the ovum's form, but to the form of the future organism.

Grigori Brekhman, in his **"Wave Theory"** has shown that all cells "speak" in the meaning of sending out signals, messages, their information. He says that "The structure of ovum and spermatozoa includes molecules of water, proteins and DNA. All these components have the ability to generate and to perceive the wave information. They form specific EM wave information of the **sexual cells**.

On the surface of a female ovum there are plenty of receptor proteins. Their protein structures become the wave beacons for sperm, on the head of which the protein substance (plasma membrane) with their own wave characteristic is disposed, so that they can perceive and generate their own wave information. These "**EM taxis**" – electromagnetic taxis - provide the spermatozoa with information to spot the state and place of the ovum.

The **Zygote** becomes the **new resonant mass** generating its own EM wave, already on its own frequency. The zygote with its own frequency range is instantly placed in the "multi-voiced of chorus" of genome and other structures of organs and systems sounding in mother's organism, bringing their own information, their own "solo", which begins to subordinate to itself to the mother's biorhythms, metabolic processes, emotions and mind" (Brekhman G.).

Human conception as seen from the **Dynamic Morphology** perspective is not a simple reproduction process. When we study it, we get the keys that enable us to understand human relationships and the evolution process.

It is far from a biological act.

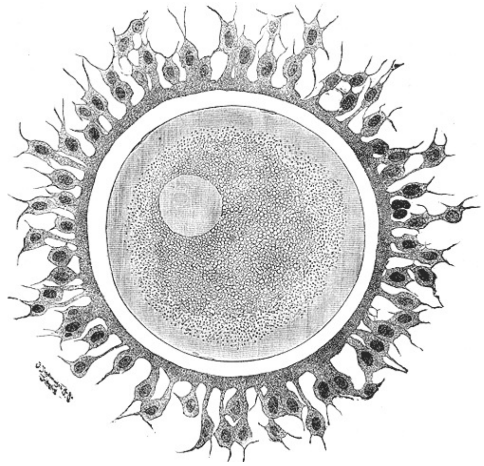
It is a transformation process.

2. THE HUMAN EGG AND SPERM

In the field of Dynamic Morphology, based on the science of phenomenology as developed by Goethe, the interest lies in the language of shapes and forms as observed in living organisms with the aim of understanding not the underlying cause but the gesture. The "**gesture**" that "**talks**" through a specific form is identified by the internal, psychological message of the underlying motion as expressed in the form.

2.1. The Dynamics of human ovum

The human ovum manifests a number of properties that exist in each cell of the human body. However, what is unique in it is that it expresses these basic, fundamental properties in such a way that it is archetypal.



2.2. 1. The Shape

The egg has a perfectly spherical shape. No other human cell presents such a mathematically precise spherical shape. Each cell has the shape that best serves its function. The spherical shape of an egg can be better understood when we realize that the egg leads a life in the ovary lying in specific 'cavities', so to speak, the egg **nests**, where one by one the eggs are on their own. Thus, there is no need to come into contact with other cells of the body and consequently, **no need to adapt in terms of shape** to serve their coexistence.

We could say that the quality seen - in the shape - is the quality of being **self-sufficient**, that **all you need to be is in an absolute expression** and therefore this quality of self-sufficiency leads to the **integrity** of being.

The spherical shape is also one which allows the minimum contact with the outside environment. It is what allows the ball to roll and not stick. The spherical shape represents the idea of **wholeness**, of being **complete**, that the egg **is a complete world of its own**. And, while **in contact** with another part of the world, however, it **does not adhere** to it.

2.2.2. The size

The egg is a human cell with the largest size. The primary oocyte has the standard size of 10 m, like all other human cells. Then, in the first phase of development, it reaches 45m and eventually it gathers a large amount of cytoplasm and reaches the diameter size of **150m-200m**, the size of a grain of sand, visible to the human eye.

The ratio of nucleus/cytoplasm is very big. This expresses the gesture "**I'm big**".

So far we have:

- I am self sufficient
- complete
- Full
- a world of my own
- Whole
- Holistic (viewed as a single system)
- integral
- I am in contact
- I do not adhere
- I'm big (huge - perhaps great as well?)

2.2.3. Open and vulnerable

The egg is in **constant interaction** with its environment. It absorbs nutrients and releases substances that affect the environment of the cell and / or attract the sperm. Just because it's **open** is very **vulnerable / sensitive** to the toxic influences that come from the environment. The internal signal and motion is: **Open to interaction** with the environment and **sensitive/ vulnerable** to signals and influences from the environment.

2.2.4 Resistance

Related to the topic of vulnerability is the fact that the egg **lives a relatively short time** - about **12 to 24** hours. For the egg, 12-24 hours is long - a lifetime, indeed, in its own environment and then dies. For the preservation of the ovum for future conception, the egg can be frozen: Oocyte cryopreservation.

2.2.5. Mobility

The egg consists mainly of cytoplasm. The mobility is **internal**.
The nucleus is stretched, the chromosomes are not folded.
The egg is **internally active** and mobile.
Externally, there is little to observe in terms of mobility.

After release, it moves passively with the help of the flow of liquid in the oviduct. Therefore, it presents a polarity: **internally active, externally passive.**

2.2.6. Number

One egg is enough for the process of conception.

- The duality of one egg is in balance with the millions of sperm needed for conception.
- The egg itself determines everything.
- It encompasses everything.

2.2.7. Location

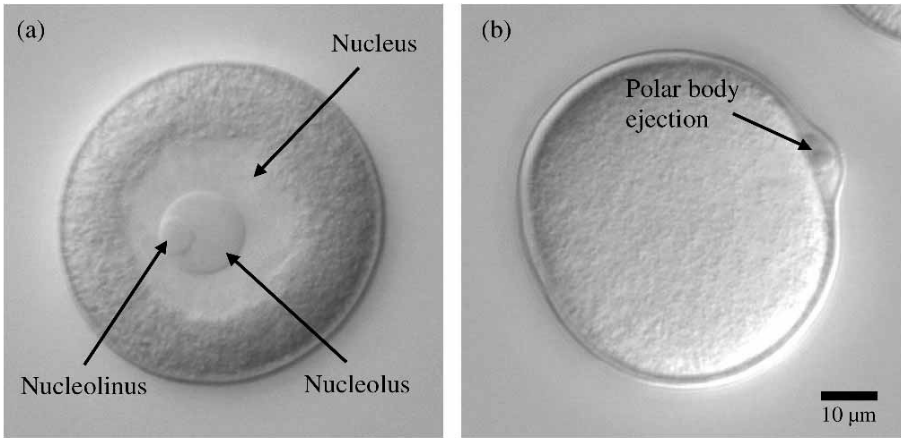
The egg develops in one of the two ovaries of the woman in the hot environment of the abdominal cavity.

- Inside
- Hot environment (endurance)

2.2.8. Development

The eggs start their existence in the unborn female child in about the fourth month of gestation as primordial oocytes. Between the third and seventh months of fetal development, the daughter cells, or **primary oocytes**, prepare to undergo meiosis. *The Principles of Anatomy & Physiology* describe meiosis as "A type of cell division restricted to sexual production involving two successive nuclear divisions that result in daughter cells with … chromosomes. At that gestational time, the process comes to a halt and remains in a state of suspended development until the girl reaches puberty. Then, the rising levels of FSH trigger the start of the ovarian cycle. Each month thereafter, some of the primary oocytes will be stimulated to undergo further development. Not all primary oocytes produced during development survive until puberty. Of the roughly 2 million *primordial follicles* at birth, each containing a primary oocyte, by the time of puberty, the number has dropped to about 400,000. The rest of the primordial follicles degenerate in the process called **atresia**.

The process of oogenesis (i.e. the process of maturation and production of oocytes), is characterized by a numerical voltage reduction. Throughout a woman's life, approximately 400 eggs will mature until by menopause, there are no primordial oocytes.



The signal here is **convergence**.

Regarding the process of meiosis, it is observed that the egg undergoes two meiotic processes in order to reduce the number of chromosomes in half. At the end of the process, we get one big cell - the oocyte - and a very small one - the polar body - which contains the other half of the chromosomal material and does not play an important role in conception. What is observed here is that there the egg functions in such a way that it conserves the relative size as big/large/huge/great.)

2.2.9. Age

Eggs are old. The process of maturation is a process that leads to the completion of life. Then, it dies.

2.2.10. A Carrier of Experience

Human eggs are created at the same time, all of them, and live together until they complete their cycle or move to the next. Thus, they record the whole experience, all information of their environment. At conception, each egg carries the perceptions and the emotional story of the mother, as recorded in it from the moment of her (mother's) own conception to the moment she conceives, including the story of her own mother and her grandmother's and so on, and the story goes on, lost in the depths of time... This history is called Epigenetics.

Everything the woman-mother feels and how she perceives herself, others, life, cosmos and the relationship with the world is information already in the egg, and will pass to this woman's child.

The more positive this information is, the better it will be for the child born.

This is how nature **maintains human life** on earth.

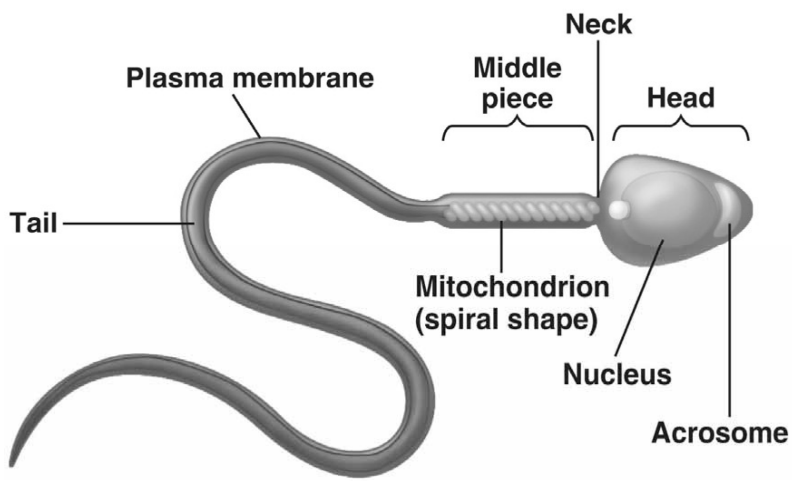
Table 1: Ovum messages

- I am self sufficient
- Complete
- Full
- A world of my own
- Whole
- Holistic (viewed as a single system)
- Integral
- I am in contact
- I do not adhere
- I'm big (perhaps up to great as well?)

- Open
- Vulnerable/sensitive
- Short Lived
- Internally active
- Externally passive
- One balances millions of sperm
- Determines everything
- Encompasses everything
- Located inside
- Endurance
- Convergence
- Maintenance
- Conservation
- Old
- Carrier of total experience
- Wisdom
- Communion

2.2. The Dynamics of Human Sperm

The human sperm exhibits a number of properties characterized by the opposite polarity. Looking at the two gametes polarities is impressive.



2.2.1.Shape

The sperm cell is almost a straight line like that of a radius

(Egg: sphere - sperm: radius). A sphere/egg is a shape consisting of many rays/sperm.

Later in conception, many sperm will exhibit convergence and focus on the egg.

Thus, it becomes even more evident/visible that the many sperm are rays of a sphere/egg.

In terms of functionality, the radial shape serves the principle of motion and auto-motion. The sperm is an organism that moves fast. Its shape is ideal to allow the sperm to respond and overcome the environmental resistance and/or friction.

2.2.2. Size

The sperm cell is a human cell that has the smallest size. It has a total length of about 60m, a head diameter of 3-4m and a tail of 1m diameter. Approximately 60,000 sperm can fit into a mature egg. When spermatogenesis is complete, we have a cell that consists of the cell membrane, *minimal cytoplasm*, and the nucleus, which form the main cellular content. The signal here is **concentration** and **getting small** (loss of volume) in contrast with the egg.

Qualities of polarity:
Sperm: Wane /I'm small - Egg: Grow/ I'm big.

2.2.3. Closed and powerful

The sperm shows no interaction with the environment. There may be all kinds of mechanical and physical manipulations and/or challenges but it can **withstand** difficult environmental conditions without difficulty.

For example, in the process of centrifugation, it can be frozen to -60 degrees below zero without any apparent harm. We could say, then, that the sperm is **closed** and **powerful/ strong/**

Polarities:
Sperm: closed & powerful/strong/withstanding-
Egg: open and vulnerable/sensitive).

2.2.4. Long life

The sperm has great vitality, living 3-5 days in the uterus under challenging conditions. The sperm can survive temperatures -60 degrees Celsius when frozen.

Its signal is "**I 'm durable**".

2.2.5. Mobility

In terms of mobility, the sperm are active and highly mobile externally. However, if we study the internal mobility of sperm, we will see that sperm are passive. More than 90% of the content of the sperm nucleus is DNA or in **crystallized** form, mainly due to the **absence of water**. **Form** and **structure** are the dominant features.

So again, we see the **polarity difference** between sperm and egg:
Externally: spermatozoon > active and mobile
Egg > passive. Internally: spermatozoon > passive - egg > active and mobile.
Also: **spermatozoon > crystallized form & structure/ less water (emotions?) – egg> lots of water (emotions?) & less form**

2.2.6. Number

Conception demands the existence of millions of sperm. A man with a sperm count of less than 20-40 million during ejaculation is considered infertile. This large number of sperm is required because most sperm will not reach the ovum. **ONE** sperm does nothing. **Millions** of sperm bring results **together**.

The polarity: Sperm: a lot - Egg: 1. (A lot=one?)

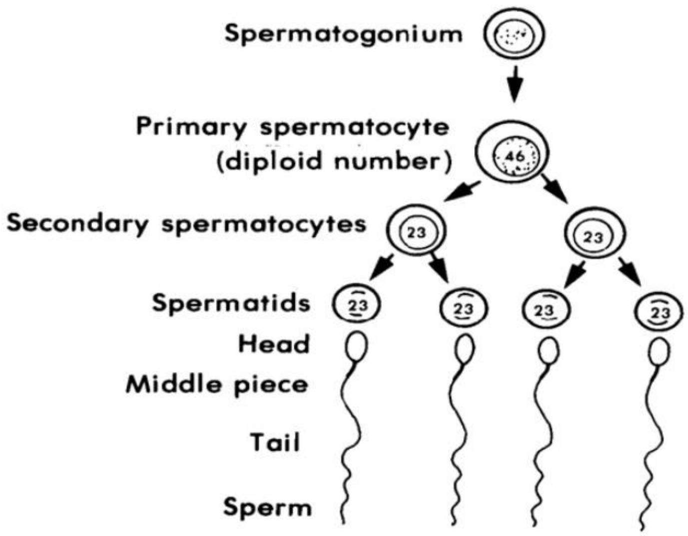
2.2.7. Location

Spermatozoa reside in the testicles - **outside** the body in a relatively **cool** environment.

The polarity: Sperm: outside - cool environment - Egg: inside - hot environment.

2.2.8. Development

The morphogenetic characteristics of spermatogenesis is **fragmentation** (become many) **division** and **reducing** the size (I'm small!). The two spermatocytes that are the result of reduction are of the same size. Sperm wants **size/volume reduction** and **concentration**. Its desired end result is to **get rid of** the cytoplasm. If there is any cytoplasm left, the sperm cannot move well and it dies. What is **necessary** for the egg (cytoplasm) is bad/ **detrimental** for sperm. From the original spermatocytes four spermatozoa appear. The signal here is: **I get small to function**.



Polarity: Sperm>fragmentation/ division/reduction & concentration –
Egg> maintain the size
Sperm> one becomes many of the same size –
Egg> one & big, the rubbish gets rid of
Sperm> (cytoplasm) is detrimental –
Egg> (cytoplasm) is necessary

What is necessary for the one is detrimental for the other.
Sperm> I get small to function –
Egg> I get big to function

2.2.9. Age

The spermatozoa are young. The first cells make their appearance in adolescence. After that moment, the process continues and never stops, hundreds of spermatocytes every second, millions every day. They live short lives - about 60 to 75 days - if ejaculation permits.

Polarity: Sperm > young/proliferation/after birth –
Egg > old/degeneration/in embryonic stages.

2.2.10. Sperm as a carrier of experience

Every sperm, from the moment of creation onwards, until conception –or death, records all the experience and information of their environment. So, when participating in conception, a sperm carries the perceptions and emotional story of the father. Everything the man / father feels during the critical time period, the way he perceives himself, others , life, cosmos and his relationship with the world is information carried in the sperm and consequently this information will pass on to his child.

The more positive this information is, the better it will be for the child born.

This is the way Nature functions to facilitate evolution of life on earth.

Polarity: Sperm > carrier of short lived experience –
Egg> carrier of age-long experience

2.2.11. Comparison

Comparing ovum and sperm (table 2), we'll see that they present opposite polarities. According to the Ancient Greek thinkers they represent Thesis & Antithesis. According to the Hermetic way of thinking the principle of Polarity is valid.

Table 2: Ovum/Sperm Polarities

OVUM	SPERM
• Spherical	• Radius
• I am self sufficient	• I can do nothing alone
• Complete	• Dependent
• Full	• Full for its function
• A world of my own	• A different world
• Whole	• Whole (as what it is)
• Holistic (Viewed as a single system)	• Holistic (Viewed as a single system)
• Integral	• Integral in its own way of function
• I am in contact	• I am in contact
• I do not adhere (minimum contact)	• I do not adhere (saturation)
• I'm big (perhaps great as well?)	• I am small
• Open	• Closed
• Vulnerable/sensitive	• Powerful/strong
• Short Lived	• Long Lived
• Internally active	• Internally passive
• Externally passive	• Externally active
• One is worth millions	• One is worth nothing
• Determines everything	• Determines nothing much
• Encompasses everything	• Is encompassed
• Located inside	• Located outside
• Endurance in heat	• Vulnerable in heat/endurance in cold
• Convergence	• Fragmentation
• Maintenance/conservation	• Evolution
• Old	• Young
• Carrier of total experience	• Carrier of short lived experience
• Wisdom	• Information
• Communion	• Communion
• Water	• Crystallized form & structure
• Grow to function	• Wane to function
• Expansion	• Concentration
• ONE	• MANY

3. THE ROLE OF OVUM & SPERM TO LIFE

Having already explored the phenomenology of the egg and sperm, we can perceive the archetypal qualities - as they are expressed through the parental egg and sperm – transferred to the child conceived.

Now, let's see the purpose behind the signals and gestures and how the egg and sperm serve life.

3.1. What is life?

According to the *Dictionary of Babiniotis*, “Life” is

- the state generally common in all forms of organic beings, differentiating them from inanimate/inorganic forms of existence or dead bodies, and which manifests in various functions such as growth through metabolism, reproduction and adaptation to environmental stimuli,
- the totality of all experiences one acquires from birth to death,
- the events one has experienced
- and also, the means one needs to meet their needs.

Furthermore, the term "Life " has several references of biological significance. The term "life" can refer to

- the constant evolution of which all living entities participate.

The term "life" can also refer to

- the period between the birth and the death of an organism.

The definition of ***what a living being is*** has evolved over time. In the ancient years, life was often synonymous with motion, so whatever presented any sort of mobility could be considered a living being. On the other hand, today, Biology defines metabolism and reproduction - based on DNA (or/and epigenetics now) - as prerequisites for the specific being to be called a living being.

We could say that, through the various processes, the aim of life is to maintain existence –through metabolism/reproduction - (survival). Along the survival road, living beings have adapted/transformed or evolved in order to continue their journey in space/time.

3.2. The life goal of gametes

The two major goals of life - preservation and evolution - are served wonderfully by the egg and sperm. More specifically:

3.2.1. Ovum

The egg has been assigned the life goal of maintaining life.

Thus, the egg carries primordial information from generation to generation and this primordial information allows the continuation of human species without showing abrupt changes (or mutations). The egg is created in the embryonic stage and carries with her all the information she needs to fulfill her destiny. Placed in the abdominal cavity, the egg is also protected.

However, this task is not the easiest of all. Keeping information from the depths of time means keeping information that is both enhancing and diminishing: information of wars, of violence, of deprivation, of threats and risks to life. Therefore, the egg, at the moment of conception, carries the universal living information - not only ancestral information over time.

The task of the Egg/Mother is not an easy one to complete well. Perhaps, this is the reason why Christianity has introduced the role of the Godmother as well, a woman of a higher psycho-spiritual level to mentor the child born in cultivating values and ideals, thus helping the biological mother to respond to all everyday needs of the child as this child grows up.

3.2.2. Sperm

If the primary life goal is to maintain life, the next goal is adaptation that leads (hopefully) to higher living forms - evolution. This task has been assigned to sperm.

The sperm carry short-lived experiences of the father, information free from the heavy weights and traumatic experiences of the past. If, of course, the father makes a creative use of his time on earth and has resolved significant aspects of his existence as they come from the past to the moment of conception it will resonate with the most enhancing aspects of the ovum. This means that their will have a truly optimal start in life.

If this is the case, and if the man has been able to live a healthy, balanced life **before** the moment of conception, his sperm - carriers of his information - will enable the activation of the most positive information, dynamically found in the egg, too, which resonate to the ones carried by it.

That's why the 2-3 months prior to conception are of great importance.

In addition to the above, seeing the father as the catalyst of evolution of life brings the man to another elevated position in the whole process. The father holds a most significant role for the child born. Women, spouses, mothers, professionals and scientists can see the father from this aspect as well and expand their research field, provide new services and embrace relationships in a new expanded way.

4. HUMAN CONCEPTION: AN ACT OF ELEVATION

During the preconception phase, (PCAC), before they unite, the egg and the sperm, both, make their own journey. As they get closer, *chemotaxis*, will start its task. The egg – alone BUT big in size- sends out info that attract sperm. A few dozen sperm will be able to come close to the egg and assemble in a radial order with their heads converging towards the center where the egg is. Through a series of chemical and biological processes, they will eventually signal

- if one of the sperm will pass and unite with the egg or not and, if so ,
- Which sperm will that be?
- Where will this take place?
- When?

Through a process of signal exchange, both cells get prepared for the moment of conception. When all done and finished, the ONE appears.

5. CONCLUSSION

Going back to the Ancient Greek Thinkers, what before conception seemed to be classified in the "Table of Opposition" now, after conception, it is classified in the "analogy" group, **"** in which things are likened or assimilated to something else. Things (that is egg and sperm) are assimilated to something else, the zygote/the human being.

The pairs of opposites have reconciled, the extremes have met, everything is and is not at the same time, the egg is there and is not, the sperm is there and is not.

The two poles (egg and sperm) are just the two extremes of the same thing (zygote/child/human being).

Both cells belong to each other. They meet each other in a new space of existence.

Human conception is not just an act of reproduction. Human conception is an act of transformation. Female and Male have transformed into ANDROGYNY.

Let's hope that such an act takes place in a context of appreciation, gratitude and trust!

REFERENCES

Bie, G. van der (2001). *Embryology*. Louis Bolk Instituut, Driebergen.

Bie G. van der, (2002), *Anatomy: Human Morphology from a Phenomenological Point of View*. Driebergen, Nederlands: Louis Bolk Institute.

Blechschmidt E. (1977). *The Beginnings of Human Life*. Sprmger-Verlag, New York.

Brekhman G. (2000). The conception of the multiple level co-ordinated action between the mother and her unborn child: the methodological approach and the methods of research, *ISPPM Congress,*Cagliari, Sardinia, IT. June 22-24, 2000.

Brekhman G. (2001). The conception of the wave multiple-level interaction between the mother and her unborn child*, Int. J. of Prenatal and Perinatal Psychology and Medicine* 13 (1/2)(2001)83-92.

Brekhman K. K. Smirnov, 2001, Water as energoinformative connection channel between an unborn child, its mother and environment*, Int. J. of Prenatal and Perinatal Psychology and Medicine* 13(1/2) (2001) 93-98.

Broglie De L. (1923). *Waves and quanta.* Compt. Ren.177 (1923) 507-512..

Burr H. S. (1972). *Blueprint for Immortality, The Electric Patterns of Life,* N. Spearman, London

Einstein A. (1917). *On the quantum mechanics of radiation,* Physikalische Zeitschrift 18 (1917) 121–128.

Fuller R. Buckminster (1975) *Synergetics: Explorations in the Geometry of Thinking* Macmillan Publishing, Co. Inc. NYC.

Gariaev, P.P. (1994). *The Wave Genome*, Obschaja polsa, Moscow.

GariaevP. P. (1997). *Wave Genetic Code*, Isdatcenter, Moscow.

GariaevP. P. (2009). *Linguistic-Wave Genome: Theory and Practice*, Institute of Wave Genetics, Kyiv,.

Gouni O. (2008). *Soul Days*, The Hellenic Union for Prenatal & Perinatal Psychology and Medicine, Athens.

Gouni O. (2010). *Welcome*, The Hellenic Union for Prenatal & Perinatal Psychology and Medicine, Athens.

Gouni O. (2009). *Conception: A Long Journey, One Moment, A Whole Lifetime*, Prenatal Psychology Congress, Budapest.

Gouni O. (2010). A small Cause, a Big Difference: The issue of (un) predictability in the process of transitions, *ISPPM congress on Times of Transition: Sense for Belonging and Individuality*, October 29th - 30th, 2010 at Alanus Highschool, Alfter near Bonn.

Gouni O. (2011). The Roots that Sprout Wings, *The International Annual Conference of ISPPM, "Roots of Life – Prenatal Psychology in the Scientific, Therapeutic, Obstetric and Counselling Context",* Haus am Dom, Frankfurt am Main, 21-23 October 2011.

Hermes Trismegistus *(*1908)., *The Kybalion,* The Yogi Publication Society.

Hertz (1962). Right and Left in Greek Philosophy. *Journal New Hellenic Sludies* 82, 196256-66).

Hertz (1964). The Hot and the Cold, the Dry and the Wet in Greek Philosophy*, Journal of Hellenic Studies* 84, 1964:92-106).

House Simon (2000), Generating Healthy People: Stages in reproduction particularly vulnerable to xenobiotic hazards& nutritional deficits , *Nutrition & Health Journal A B Academic Publishers*.

House Simon - Roy Ridgway, (2006) *The Unborn Child, Beginning a Whole Life & Overcoming Problems of Early Origin*, Karnac, London

König K. (1986). *Embryology and World Evolution*. TWT Publications, UK.

Libby John, (1981). The importance of nutrition around the time of conception in the prevention of handicap Epidemics of congenital malformations, Applied Nutrition:1, E.C. Bateman editor, *Proceedings of the British Dietetic Association Study Conference*, Exeter 1-7 April 1981, London

Lloyd G.E.R. (1966). *Pnlarily and Analogy: Two Types of Arguinentation in Early Greek Thought,* Cambridge: Cambridge University Press

Lupton Deborah (2012) *Configuring Maternal, Preborn and Infant Embodiment*. Sydney Health & Society Group Working Paper No. 2. Sydney: Sydney Health & Society Group.

McTaggart, L. (2002). *The Field: The Quest for the Secret Force of the Universe*. Harper-Collins, New York

Moore K.L. (1989). *Before we are born*. Saunders, Philadelphia.

Peerbolte M. Leitaert, (1975). Psychic Energy In Prenatal Dynamics: Introduction p.XXXII Servire B.V. Wassanaar NL.

Sheldrake, R. (1995). *The Presence of the Past: Morphic Resonance & the Habits of Nature*. Inner Traditions International Ltd. Rochester, VT

Turner Jon RG & Troya (1992). Discovering the Emotional DNA: The Emotional Continuity for the Unborn Child Through Prebirth Memory Therapy, *10th SPPM International Congress*, Cracow, Poland 15-17 May 92.

Turner Jon RG & Troya (1998). Conception, A Vital Link to Relationships in Prenatal Psychology, *International Journal of Prenatal & Perinatal Psychology & Medicine*

Trent R. (2006). *Molecular Medicine*, Pashalides publications, Athens

Tortora, G.J. & Anagnostakos, N.P. (1990). *Principles of Anatomy & Physiology,* 6th Ed. Harper Collins Publishers New York, NY

Van der Wal J. (2002). *Human conception: how to overcome reproduction*, paper

Van der Wal J. (2003). Dynamic morphology and embryology, in Bie G van der & M.

Huber, *Foundations of Anthroposophical medicine*, Floris Books, Edinburgh, UK.

Verhulst, J., 2003 (1999). *Development Dynamics in Humans and Other Primates: Discovering Evolutionary Principles through Comparative Morphology*, Adonis Press, Ghent, New York.

Wynn A.H.A., M.A. Crawford, Wendy Doyle And S.W. Wynn paper titled *Nutrition of Women In Anticipation Of Pregnancy*, Institute of Brain Chemistry and Human Nutrition, Hackney Hospital, Homerton High Street, London, A39 6BE

Wynn Arthur (1993), *The Effects of Food Shortage on Human Reproduction,* Address to the Annual General Meeting of the McCarrison Society, London, 12th December 1992,Published by: Journal of Nutrition and Health, Volume 9, pages 43 - 52.

Wynn M, Wynn A. (1995), A fertility diet for planning pregnancy. *Nutrition and Health*; 10: 219-238.

STRESS & ANTI-STRESS: HOLISTIC QUANTUM-INFORMATIONAL FRAMEWORK

DEJAN RAKOVIĆ
University of Belgrade, Faculty of Electrical Engineering, Serbia
rakovicd@etf.rs

Abstract. In the report of United Nations at the beginning of 1990s stress was marked as a disease of 20th century, as its role in the development of numerous psychosomatic disorders was undoubtedly confirmed. On these lines, contemporary investigations of psychosomatic diseases imply the necessity of application of holistic methods, oriented to healing the person as a whole and not disease as a symptom of disorder of the whole, suggesting their macroscopic quantum origin. In the focus of these quantum-holistic methods are body's acupuncture system and consciousness – which (within the Feynman propagator version of quantum mechanics) have quantum-informational structure of quantum-holographic Hopfield-like associative neural network – with very significant quantum-holographic psychosomatic implications. In the context of quantum-informational holistic acupuncture-based and consciousness-based approaches and techniques, their goal would be a resonant stimulation of the electromagnetic psychosomatically disordered quantum state (acupuncture palpatory painful or psychologically traumatic, as one of hundreds possible disordered states) thus enabling that its initial memory attractor is bioresonantly excited (similarly to annealing procedure in artificial neural networks) becoming more shallower and wider on the account of deepening of the (energy-dominating) attractor of healthy quantum state (acupuncture palpatory painless or psychologically non-traumatic) – which is then altogether quantum-holographically projected on the lower quantum-holographic cellular level, thus changing the expression of genes. However, when this process is hindered by transpersonal entangled blockages in the energy-state space of EM field of the acupuncture system / consciousness (and numerous laboratory tests are revealing the evidence of entangled minds i.e. extrasensory experiences in a quantum reality) – then memory attractors of quantum-holographic network of field-related collective consciousness should be removed as well (via prayer or circular (psycho / energy) therapies from all relevant meta-positions included in the problem, thus performing spiritual integration of personality which initiate the process of permanent healing as suggested by experiences of volunteers in post-hypnotic regressions). So, all these holistic acupuncture-based and consciousness-based approaches and techniques can be treated as quantum-informational therapies, by imposing new healing boundary conditions in the energy-state space of the acupuncture system / consciousness. The above mentioned quantum-holographic psychosomatic framework provides better understanding of the nature of psychosomatic diseases as well as limitations of the healing methods, which might help in developing strategies for psychosomatic integrative medicine in the 21st century.

Keywords*:* stress, anti-stress, psychosomatics, quantum-holographic informatics, integrative biophysics, integrative medicine, quantum-informational medicine, acupuncture system, individual consciousness, collective consciousness.

1. INTRODUCTION

Stress is inevitable consequence of life. To some extent, which is individual, stress contributes to a better adaptation to daily life and work: stress itself is the life salt (Selye, 1974). However, when this boundary is crossed, prolonged stress becomes harmful and causes numerous psychosomatic diseases. This is the reason why stress has come into the focus of science and medicine since the beginning of 1960s, when Hans Seley, director of the Institute for Experimental Medicine and Surgery of the University of Montreal, introduced the notion of *general adaptation syndrome* as a group of mutually connected *non-specific stress-reactions* of the organism (Selye, 1974; Lindemann, 1982; Blagajac, 1992; Group of authors, 1999; Raković, Škokljev, Djordjević; 2009; http://www.dejanrakovicfund.org).

The different causes of stress (hate, anger, fear, frustration, noise, nicotine etc.) were named by Seley as *stressors*, to which an organism reacts always equally: injecting sugars, fats, and adrenaline (stress-realized hormone) into the blood, followed by growth of blood pressure, narrowing of blood vessels and increasing secretion of gastric acid – as a preparatory physiological reaction of the organism for the second phase of stress, of intense muscular strain for "fight or flight". As in contemporary life and work conditions the *"fight or flight"* as a normal reaction to stressful situations is missing, thus mobilized energetic and physiological potentials are returning against the organism, and with continuing (chronic) action can cause numerous *psychosomatic disorders*.

Although the problem of stress is now especially important in the Balkans, because of the increased interpersonal, interethnic, and interreligious conflicts the whole Balkan region has been facing during 1990s, with the culmination in NATO bombing of Yugoslavia, it is not less important in industrially most developed countries. At the end of 1980s the famous American magazine *Time* chose for its headline "Stress: Epidemic of Eighties", and Paul Rosch, president of the *American Institute of Stress*, pointed out that numerous studies showed that the problem was even amplified, and that 75-90% visits to physicians are related to stress. Also, the *World Health Organization* has recently described the job stress as a *world epidemic*, and in report of *United Nations* at the beginning of 1990s it was marked as a *disease of 20th century*; at the same time, it was estimated that 60-80% job accidents were caused by stress. Finally, recent investigations undoubtedly confirmed important role of the stress in development of different psychosomatic disorders: cardiovascular, gastrointestinal, dermatological, rheumatic, immunologic, neurological, and psychiatric.

Further on the quantum-informational framework of psychosomatics will be presented, which enables better understanding of the *nature of psychosomatic disorders* from the fundamental viewpoint, as well as the *limits and methods of their prevention and healing*, including *optimization of the existing transpersonal programs within the family environment.*

2. QUANTUM-INFORMATIONAL FRAMEWORK OF PSYCHOSOMATICS

Contemporary medicine has put its emphasis on the *alopatic-dosed non-economic highly pharmaceutic-oriented* medicine technologies. On the contrary, in the past years more attention is payed to bioadequate *homeopatic-dosed economic* bioresonant *quantum-informational medicine* technologies, related to usage of such values of the field energy, appearing in normal functioning of human organism (Voll, 1975; Y. Zhang, 1987; Sit'ko and Mkrtchian, 1994; Devyatkov and Betskii, 1994; Group of authors, 1999; Bellavite and Signorini, 2002; Stambolović, 2003; Todorović, 2005; Samohin and Gotovski, 2007; Potehina, Tkachenko, Kozhemyakin, 2008; Raković, 2008, 2009, 2011; Djordjević, 2008; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Gotovskiy, Perov, Chernecova, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org; http://www.imconsortium.org/prod/groups/ahc/@pub/@ahc/@cahcim/documents/asset/ahc_asset_391689.pdf; http://www.issseem.org; http://www.energy-medicine.info). On these lines, contemporary investigations of *psychosomatic diseases* imply the necessity of application of *holistic methods*, oriented to *healing the person as a whole* and not disease as a symptom of disorder of the whole, suggesting their *macroscopic quantum origin* (Voll, 1975; Y. Zhang, 1987; Sit'ko and Mkrtchian, 1994; Devyatkov and Betskii, 1994; Group of authors, 1999; Samohin and Gotovski, 2007; Potehina, Tkachenko, Kozhemyakin, 2008; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Gotovskiy, Perov, Chernecova, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org).

In the focus of these quantum-holistic methods are body's *acupuncture system and consciousness* – which (within the Feynman propagator version of quantum mechanics) have *quantum-informational structure of quantum-holographic* Hopfield-like associative neural network (Peruš, 1996) – with very significant quantum-holographic psychosomatic implications (Group of authors, 1999; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org). In this context, it should be noted that Resonant Recognition Model (RRM) of biomolecular recognition implies that on the biomolecular level information processing is going on in the *inverse space* of Fourier spectra of the primary sequences of biomolecules (Cosic, 1994, 1997; Keković et al, 2010), similarly to (quantum) holographic ideas that cognitive information processing is going on in the *inverse space* of Fourier spectra of the perceptive stimuli (Pribram, 1971, 1991), thus supporting idea on *quantum-holographic fractal coupling* of various hierarchical levels in biological species (Y. Zhang, 1987).

In the context of *acupuncture-based and consciousness-based approaches and techniques of quantum-informational medicine* (Voll, 1975; Fishman and Grinims, 1979; Y. Zhang, 1987; Sit'ko and Mkrtchian, 1994; Devyatkov and Betskii, 1994; Group of authors, 1999; Bellavite and Signorini, 2002; Stambolović, 2003; Todorović, 2005; Samohin and Gotovski, 2007; Potehina, Tkachenko, Kozhemyakin, 2008; Raković, 2008, 2009, 2011; Djordjević, 2008; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Gotovskiy, Perov, Chernecova, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org;http://www.imconsortium.org/prod/groups/ahc/@pub/@ahc/@cahcim/documents/asset/ahc_asset_391689.pdf; http://www.issseem.org; http://www.energy-medicine. info; Paramhansa Yogananda, 1946; Lindemann, 1973; Orme-Johnson and Farrow 1977; Swami Satyananda Saraswati, 1982; Mantak Chia, 1983; Hay, 1984; Brennan, 1987; Chopra, 1989; Johari, 1989; Markides, 1990; Tart, 1992; Dossey, 1993; Vujičin, 1995, Callahan and Callahan, 1996; Milenković, 1997; Jerotić, 1998; Vlahos, 1998; Harris et al, 1999; Cohen, 1999; Hellinger and ten Hevel, 1999; Mihajlović Slavinski, 2000; Petrović, 2000; Pearl, 2001; Stibal, 2006; Master Choa Kok Sui, 2006; Murphy, 2007; Swami Sada Shiva Tirtha, 2007; Kinslow, 2008; Bartlett, 2009; Øverbye, 2009; Grof and Grof, 2010; Milenković, 2010; Panajotović, 2011; Simonovska, 2011; Tomšić Akengen, 2011; Hadži-Nikolić, 2011; Bedričić et al, 2011; Grabovoi, Smirnova, Jelezky, 2012), their goal would be a bioresonant excitation of the electromagnetic (EM) microwave (MW) / ultralowfrequency (ULF)-modulated or radiofrequency (RF) / lowfrequency (LF)-modulated psychosomatically disordered state (acupuncture palpatory-painful or psychologically traumatic, as one of hundreds possible disordered states) thus enabling that its initial memory attractor is bioresonantly excited (similar to annealing procedure in artificial neural networks (Hecht-Nielsen, 1990)) becoming more shallower and wider on the account of deepening of the (energy-dominating) attractor of healthy (acupuncture palpatory painless or psychologically traumatic-free) state – which is then altogether *quantum-holographically projected* on the lower quantum-holographic *cellular level*, thus changing the *expression of genes* (Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; http://www.dejanrakovicfund.org). Thus, all these acupuncture-based and consciousness-based holistic approaches and techniques might be considered as *quantum-informational therapies*, via *imposing new boundary conditions in the energy-state space of the acupuncture system / consciousness.*

However, when this process is hindered by *transpersonally entangled blockages* in the EM field-related energy-state space of the acupuncture system / consciousness (on numerous laboratory tests revealing the evidence of entangled minds i.e. *extrasensory experiences* in a quantum reality, see (Jahn and Dunne, 2011; Radin, 2006)) – then memory attractors of quantum-holographic network of field-related *collective consciousness* should be removed as well (via *prayer* or *circular (psycho / energy) therapies* from all relevant meta-positions included in the problem (Markides, 1990; Tart, 1992; Dossey, 1993; Vujičin, 1995, Callahan and Callahan, 1996; Milenković, 1997, Jerotić, 1998; Vlahos, 1998; Harris et al, 1999; Hellinger and ten Hevel, 1999; Mihajlović Slavinski, 2000; Petrović, 2000; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Øverbye, 2009; Grof and Grof, 2010; Raković, Arandjelović, Mićović, 2011; Tomšić Akengen, 2011; Hadži-Nikolić, 2011; Bedričić et al, 2011; http://dejanrakovicfund.org), thus providing *spiritual integration of personality* which *initiates the process of permanent healing* as suggested by experiences of clients in *post-hypnotic regressions* (Newton, 1994). These transpersonal holistic procedures, alongside with working on all levels of *EM bioresonant (MW / ULF-modulated or RF / LF-modulated) therapies* (Voll, 1975; Fishman and Grinims, 1979; Y. Zhang, 1987; Sit'ko and Mkrtchian, 1994; Devyatkov and Betskii, 1994; Group of authors, 1999; Bellavite and Signorini, 2002; Stambolović, 2003; Todorović, 2005; Samohin and Gotovski, 2007; Potehina, Tkachenko, Kozhemyakin, 2008; Raković, 2008, 2009, 2011; Djordjević, 2008; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Gotovskiy, Perov, Chernecova, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org; http://www.imconsortium.org/prod/groups/ahc/@pub/@ahc/@cahcim/documents/asset/ahc_asset_391689.pdf; http://www.issseem.org; http://www.energy-medicine.info) and *non-circular (psycho / energy) therapies* (Paramhansa Yogananda, 1946; Lindemann, 1973; Orme-Johnson and Farrow 1977; Swami Satyananda Saraswati, 1982; Mantak Chia, 1983; Hay, 1984; Brennan, 1987; Chopra, 1989; Johari, 1989; Markides, 1990; Tart, 1992; Dossey, 1993; Vujičin, 1995, Callahan and Callahan, 1996; Milenković, 1997; Jerotić, 1998; Vlahos, 1998; Harris et al, 1999; Cohen, 1999; Hellinger and ten Hevel, 1999; Mihajlović Slavinski, 2000; Petrović, 2000; Pearl, 2001; Stibal, 2006; Master Choa Kok Sui, 2006; Murphy, 2007; Swami Sada Shiva Tirtha, 2007; Kinslow, 2008; Bartlett, 2009; Øverbye, 2009; Grof and Grof, 2010; Milenković, 2010; Panajotović, 2011; Simonovska, 2011; Tomšić Akengen, 2011; Hadži-Nikolić, 2011; Bedričić et al, 2011; Grabovoi, Smirnova, Jelezky, 2012), might be the holistic clue for imposing healing boundary conditions in the energy-state space of the acupuncture system / consciousness of the patients, cf. Fig. 1.

3. ON MACROSCOPIC QUANTUM NATURE OF ACUPUNCTURE SYSTEM AND CONSCIOUSNESS

It should be pointed out that on all quantum-holographic hierarchical levels of biological macroscopic open quantum systems S_k (local cell's biomolecular protein / target, local acupuncture system / consciousness, or nonlocal out-of-body consciousness / collective consciousness), there exist *two* (interacting) macroscopic quantum subsystems (Raković, 2008, 2009; Raković, Škokljev, Djordjević; 2009): first with *modifying many-electron hypersurface* $E_e(\phi_e^{(k)})$ and second with *modifying EM multi-phonon hypersurface* $E_v(\phi_v^{(k)})$, as in Fig. 1.

It should be added that an energy hypersuface of multi-phonon quantum state might also include low-energy long-range coherent MW Frohlich excitations (created as a result of interaction of electronic and phonon subsystems (Fröhlich, 1968; Keković et al, 2005)), of particular significance in microwave resonance therapy (MRT) of a dynamic modification of the EM multi-phonon (and related many-electron) acupuncture macroscopic quantum subsystem (Sit'ko and Mkrtchian, 1994; Devyatkov and Betskii, 1994; Group of authors, 1999; Potehina, Tkachenko, Kozhemyakin, 2008; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org).

The mentioned quantum-holographic picture implies that quantum-holographic hierarchical parts carry information on wholeness, enabling subtle *quantum-holographic fractal coupling* between various hierarchical biophysical levels – including numerous acupuncture projection zones and corresponding organs and cells, with underlying *macroscopic quantum-informational control mechanisms of embryogenesis / ontogenesis and* *morphogenesis* and their backward influence on the *expression of genes*, starting from the first fertilized cell division which initializes differentiation of the acupuncture system of non-threshold electrical GJ-synapses ("gap-junctions") (Y. Zhang, 1987; Group of authors, 1999; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Jovanović-Ignjatić, 2010; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org).

This underlying quantum-coherent nonlocality might be of fundamental importance in understanding macroscopic (quantum) holistic very nature of *psychosomatic health and diseases* as well – implying also a *fuzzy borderline* between quantum coherent (nonstationary) and semi-classical decoherent (stationary) manifestations of the macroscopic quantum-informational *acupuncture system* and *consciousness* (as well as any macroscopic condensed-state physical (sub)system), and their *close relationship* with significant psychosomatic-cognitive implications (Raković et al, 2006; Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; Raković, Arandjelović, Mićović, 2011; http://www.dejanrakovicfund.org).

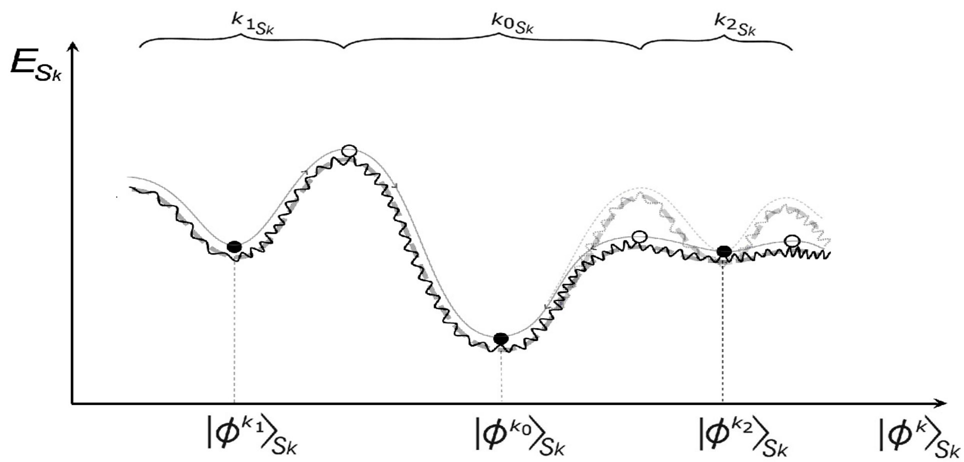


Figure 1. Schematic presentation of the adaptation of memory attractors in the energy-state ($E_{S_k}(\phi^k)$) hypersurface of the quantum-holographic memory / propagator of various hierarchical levels of biological macroscopic open quantum systems S_k (local cell's biomolecular protein / target, local acupuncture system / consciousness, or nonlocal out-of-body consciousness / collective consciousness) (Raković, 2008, 2009, 2011; Raković, Škokljev, Djordjević; 2009; http://www. dejanrakovicfund.org):

$$G(r_2,t_2;r_1,t_1) = \sum_{i=1}^{P} \phi^{k_i}(r_2,t_2)\phi^{k_i *}(r_1,t_1) = \sum_{i=1}^{P} A_{k_i}(r_2,t_2)A_{k_i}^{*}(r_1,t_1)e^{\frac{i}{\hbar}(\alpha_{k_i}(r_2,t_2)-\alpha_{k_i}(r_1,t_1))}$$

It should be pointed out that Nature presumably has chosen elegant room-temperature solution for quantum-holographic information processing, permanently fluctuating between quantum-coherent $\left|\phi^k(t)\right\rangle_{S_k} = \sum_i c_{k_i}(t)\left|\phi^{k_i}\right\rangle_{S_k}$ and classically-reduced $\hat{\rho}^k_{S_k}(t) = \sum_i \left|c_{k_i}(t)\right|^2 \left|\phi^{k_i}\right\rangle_{S_k S_k}\left\langle\phi^{k_i}\right|$ states of the biological macroscopic open quantum system S_k, via non-stationary bioresonance interactions with out-of-body farther environment and through decoherence by bodily closer environment. Thus quantum neural holography combined with quantum decoherence might be very significant element of the feedback bioinformatics, from the level of cell – to the level of organism – and further to the level of collective consciousness, with backward dynamic influence on the expression of genes. This implies necessity of quantum-informational successive bioresonant balansing of all unwilling side memory attractors (like ϕ^{k_2} in Figure), which would cause development of psychosomatic diseases on the individual level, and interpersonal fights in this and further generations on the collective level.

The above problem is of fundamentally-theoretical physical significance, as it tackles the question of *universality of quantum mechanics*, i.e. the question of general validity of the quantum-physical laws for *macroscopic phenomena* as well, mostly treated by the methods of classical physics. Although this question was raised in the early phase of founding of quantum-mechanical theory (and temporarily put aside for very different reasons, being considered as a difficult scientific problem), in this respect the situation is not much better today, and it can be said freely that the problem of universal validity of quantum mechanics is still open (Leggett, 1980; Leggett and Garg, 1985; Ghirardi, Rimini, Weber, 1986; Zurek, 1991, 2003; Penrose, 1996; Giulini et al, 1996; Raković and Dugić, 2002; Raković, Dugić, Ćirković, 2004; Dugić, 2004; Kofler and Brukner, 2007, 2008; Vedral, 2010; Dugić et al, 2012).

On this line, it should be pointed out that Sit'ko with coauthors have revealed *necessary and sufficient conditions* for existence of *macroscopic selfconsistent potentials* (of so called Landau-Haken type) alongside acupuncture meridians, with EM MW *eigenfrequencies* of healthy and disordered states of the *acupuncture system* (Andreyev, Bely, Sit'ko, 1982; Sit'ko, Andreyev, Dobronravova, 1988; Sit'ko and Gizhko, 1991; Sit'ko and Mkrtchian, 1994; Sit'ko, 2012), pointing out that living systems are the fourth level of quantum ladder of Nature (nuclear-atomic-moleculal-biological), governed by specific macroscopic quantum laws of the *Physics of the Alive*.

Also, it is worth pointing out that Umezawa with coauthors and Del Giudice with coauthors, by applying fundamental quantum-field theoretical formalism of *spontaneous symmetry breaking*, have pointed to biological room-temperature macroscopic condensates of virtual quasiparticles of the effective mass and charge, so called *evanescent photons in water* (nonpropagated / tunneling longitudinal modes of quantum EM field embedded by biological macroscopic ordered locallizations of the electric dipole field of water), as a possible quantum basis of functioning of *cells* in general (Ricciardi and Umezawa, 1967; Stuart, Takahashi, Umezawa, 1978, 1979; Umezawa, 1993; Del Giudice, Doglia, Milani, 1982; Del Giudice et al 1986, 1989; Del Giudice, Preparata, Vitiello, 1988; Preparata, 1995; Montagnier et al, 2010), while Jibu and coauthors have pointed to them as a possible quantum basis of *consciousness* in brain (Jibu et al, 1994; Jibu and Yasue, 1995, 1997; Jibu, Pribram, Yasue, 1996).

According to such a theoretical concept, as evanescent photons in water are not related to propagating waves (in EM RF range (Del Giudice, Doglia, Milani, 1982; Del Giudice et al 1986, 1989; Del Giudice, Preparata, Vitiello, 1988; Preparata, 1995; Montagnier et al, 2010)) they cannot be detected externally – so in the region of biological macroscopic ordered localizations of the electric dipole field of water special probes must be inserted, to enable embedded quanta of non-propagating modes of the EM RF field to be scattered in detectable propagating modes, which were detected experimentally in the EM RF region (Ho, Popp, Warnke, 1994).

On the other hand, Popp and coauthors have conducted EM optical measurements in darkness by specially designed detector and discovered that *biological systems*, from bacteria to biological tissues, *continuously emit ultra-weak photon emission* (mainly in the *visual range of* EM spectrum, of non-exponential attenuation and specific frequency and phase and amplitude modulation for all basic biological and physiological activities), so photons of such non-standard characteristics are called *biophotons* (Complete issue, 2003). It was discovered that biophoton emission reflects the following *important characteristics*: health as a symmetry between left and right sides of body; illness via disordered symmetry between left and right sides of body; light channels within body which regulate transfer of energy and information between different parts; biological rhythms such as 14-days, 1-month, 3-months i 9-months.

Especially, Sit'ko and coauthors have conducted EM MW measurements via specially designed radiometric system (on the level of inherent noises ~ $5\cdot10^{-23}$ W/Hz·cm^2), which enabled obtaining of the following *important characteristics of the acupuncture channels and points* (Complete issue, 1998): *channels* have diameter of 3÷5 mm in their surface exits in the acupuncture points; *refraction index* within channels is $n = 1$ as in the air, while being 5÷6 in the body outside channels; in case of functional disorders of channels, upon external EM MW flux of $10^{-21}\div10^{-20}$ W/Hz·cm^2 the corresponding *acupuncture points* completely absorb radiation, while upon flux greater than 10^{-19} W/Hz·cm^2 acupuncture points completely reflect external EM MW radiation (so in natural conditions the effects of solar radiation on biological systems are neglecting in the very sensitive EM MW regulatory region, being intensely absorbed by atmosphere, which was presumably of evolutional significance in natural selection of biological species).

4. CONCLUSION

The presented integrative quantum-holographic framework for psychosomatics might have significant holistic implications, providing fundamental quantum-informational framework for better understanding of the *nature of stress-induced psychosomatic diseases* as well as *limitations and methods of their anti-stress prevention and healing*, which might help in *developing strategies for integrative psychosomatic medicine in the 21st century.*

Thus, on the basis of integrative quantum-holographic framework it might be said that *three front lines of integrative psychosomatic medicine do exist*: (1) *Spirituality and circular (psycho / energy) therapies from all relevant meta-positions*, with possibility of permanent erasing of mutual memory attractors on the *level of collective consciousness*; (2) *(Quantum) holistic medicine and non-circular (psycho / energy) therapies*, whose efforts temporary erase memory attractors on the *level of acupuncture system / individual consciousness*, and prevent or alleviate their somatization, as a consequence of the indolence on the first level; and (3) *Conventional symptomatic medicine*, whose activities on the *somatic level* via immunology, pharmacology, biomedical diagnostics and surgery hinder or soothe somatized consequences of the carelessness on the first two levels.

Hence, it should be pointed out that *necessary activities* on the second and third front lines, with *neglect of the first front line*, might have a consequence of *further transfer of memory attractors* on the level of individual and collective consciousness in this and further generations, thus *accumulating quantum-holographic loads* which afterwards might cause not only illnesses, but also inter-personal fights, wars, and other troubles.

Acknowledgements. This paper was partly financed by the Serbian Ministry of Science, Technology and Development, Project No. 178027.

REFERENCES

Andreyev, Ye. A., Bely, M. U., Sit'ko, S. P. (1982). Manifestation of characteristic eigenfrequencies of human organism. *Application for the Discovery to the Committee of Inventions and Discovery at the Council of Ministers of the USSR, No. 32-OT-10609*, 22 May, in Russian.

Bartlett, R. (2009). *Matrix Energetics: The Science and Art of Transformation*. Hillsboro: Beyond Words Publ.

Bedričić, B., Stokić, M., Milosavljević, Z., Milovanović, D., Ostojić, M., Raković, D., Sovilj, M., Maksimović, S. (2011). Psycho-physiological correlates of non-verbal transpersonal holistic psychosomatic communication. In: *Verbal Communication Quality Interdisciplinary Research I* (S. Jovičić, M. Subotić, eds.). Belgrade: LAAC & IEPSP.

Bellavite, B., Signorini, A. (2002). *The Emerging Science of Homeopathy: Complexity, Biodynamics and Nanopharmacology.* Berkeley: North Atlantic Books.

Blagajac, M. (1992). *Programmed Active Relief.* Belgrade, in Serbian.

Brennan, B. A. (1987). *Hands of Light: A Guide to Healing Through the Human Energy Field.* New York: Bantam.

Callahan, R. J. Callahan, J. (1996). *Thought Field Therapy and Trauma: Treatment and Theory*. Indian Wells.

Chopra, D. (1989). *Quantum Healing: Exploring the Frontiers of Mind/Body Medicine*. New York: Bantam.

Cohen, K. S. (1999). *The Way of Qigong: The Art & Science of Chinese Energy Healing*. Random House of Canada.

Complete issue (1998). *Physics of the Alive* (*Фізика живого*) 6(1).

Complete issue (2003). *Indian J. Exp. Biol.* 41(5) *Proc. Symp. Biophoton*.

Cosic, I. (1994). Macromolecular bioactivity: Is it resonant interaction between macro-molecules? – Theory and applications. *IEEE Trans. Biomed. Eng.* 41(12), 1101-1114.

Cosic, I. (1997). *The Resonant Recognition Model of Macromolecular Bioactivity: Theory and Applications*. Basel: Birkhauser Verlag.

Del Giudice, E., Doglia, S., Milani, M. (1982). A collective dynamics in metabolically active cells. *Phys. Lett.* 90A, 104-106.

Del Giudice, E., Doglia, S., Milani, M., Preparata, G., Vitiello, G. (1986). Electromagnetic field and spontaneous symmetry breaking in biological matter. *Nucl. Phys. B* 275, 185–199.

Del Giudice, Preparata, G., Vitiello, G. (1988). Water as a free electric dipole laser. *Phys. Rev. Lett.* 90A, 104-106.

Del Giudice, E., Doglia, S., Milani, M., Smith, C. W., Vitiello, G. (1989). Magnetic flux quantization and Josephson behaviour in living systems, *Phys. Scripta B* 40**,** 786–791.

Devyatkov, N. D., Betskii, O., eds. (1994). *Biological Aspects of Low Intensity Millimetre Waves*. Moscow: Seven Plus.

Djordjević, D. (2008). *Influence of Magnetic Fields on Mechanisms of Neurohumoral Regulation*. PhD Thesis. Belgrade: Faculty of Medicine, in Serbian.

Dossey, L. (1993). *Healing Words: The Power of Prayer and the Practice of Medicine*. San Francisco: Harper.

Dugić, M. (2004). *Decoherence in Classical Limit of Quantum Mechanics*. SFIN XVII(2). Belgrade: Institute of Physics, in Serbian.

Dugić, M., Raković, D., Jeknić-Dugić, J., Arsenijević, M. (2012). The ghostly quantum worlds. *Neuro Quantology* 10(4), 618-628; Preprint available at arXiv:1101.4133v2 [quant-ph].

Fishman, W., Grinims, M. (1979). *Muscle Response Test*. New York: Richard Marek.

Fröhlich, H. (1968). Long-range coherence and energy storage in biological systems. *Int. J. Quantum Chem.* 2, 641-649.

Ghirardi, G. C., Rimini, A., Weber, T. (1986). Unified dynamics for microscopic and macroscopic systems. *Phys. Rev. D* 34, 470-491.

Giulini, D., Joos, E., Kiefer, C., Kupsch, J., Stamatescu, I.-O., Zeh, H. D. (1996). *Decoherence and the Appearance of a Classical World in Quantum Theory*. Berlin: Springer.

Gotovskiy, M. Yu., Perov, Yu. F., Chernecova, L. V. (2010). *Bioresonance Therapy*. Moscow: IMEDIS.

Grabovoi, G., Smirnova, G. S., Jelezky, S. (2012). *Methods of Healing through the Application of Consciousness.* Hamburg: Rare Ware Medienverlag.

Grof, S., Grof, C. (2010). *Holotropic Breathwork*: *A New Approach to Self-Exploration and Therapy.* Sunny Press, Albany: Series in Transpersonal and Humanistic Psychology.

Group of authors (1999). *Anti-Stress Holistic Handbook, with Fundamentals of Acupuncture, Microwave Resonance Therapy, Relaxation Massage, Airoionotherapy, Autogenic Training, and Consciousness*. Belgrade: IASC, in Serbian.

Hadži-Nikolić, Č. (2011). Entheogenic shamanism: Anthropological category, transpersonal dimension or psychotherapeutic model. In: *Proc. Symp. Quantum-Informational Medicine QIM 2011: Acupuncture-Based & Consciousness-Based Holistic Approaches & Techniques* (D. Raković, S. Arandjelović, M. Mićović, eds.). Belgrade: QUANTTES & HF & DRF, http://www.qim2011.org.

Harris, W. S., Gowda, M., Kolb, J. W., Strychacz, C. P., Vacek, J. L., Jones, P. G.,. Forker, A., O'Keefe, J. H., McCallister, B. D. (1999). A randomized, controlled trial of the effects of remote, intercessory prayer on outcomes in patients admitted to the coronary care unit. *Arch. Intern. Med.*159, 2273-2278.

Hay, L. L. (1984). *You Can Heal Your Life.* Carlsbad: Hay House.

Hecht-Nielsen, R. (1990). *Neurocomputing*. New York: Addison-Wesley.

Hellinger, B., ten Hevel, G. (1999). *Acknowledging what is: Conversations with Bert Hellinger.* Zeig, Tucker & Theisen, Phoenix, AZ, see also http://www.curezone.com/Hellinger.

Ho, M.-W., Popp, F.-A., Warnke, U. (1994). *Bioelectrodynamics and Biocommunication*. Singapore: World Scientific.

http://www.atpweb.org; Official website of The Association for Transpersonal Psychology (ATP), concerned from early 1970ies with the study of humanity's highest potential, and with the recognition, understanding, and realization of unitive, spiritual, and transcendent states of consciousness (making transpersonal psychology the fourth force in psychology, alongside with psychoanalysis, behaviorism, and humanistic psychology, after one of its founders, A. Maslow).

http://www.dejanrakovicfund.org; Official website of Dejan Raković Fund (DRF) for Promoting Holistic Research and Ecology of Consciousness, with available relevant author's books, proceedings, papers, communications, and links to recommended websites.

http://www.energy-medicine.info; Official Inergetix website with contemporary critical review of technologies in the wider field of quantum-informational medicine, including information on Rife's early research in the field of bioresonance medicine in 1930s, which was not recognized at that time.

http://www.imconsortium.org/prod/groups/ahc/@pub/@ahc/@cahcim/documents/asset/ahc_asset_391689.pdf; Official website of the Consortium of Academic Medical Centers for Integrative Medicine, founded by the end of 1990s, which includes over 50 highly esteemed US academic health centers and affiliate institutions, in order to transform medicine and healthcare through rigorous scientific studies, new models of clinical care, and innovative educational programs that integrate biomedicine, the complexity of human beings, the intrinsic nature of healing, and the rich diversity of therapeutic systems.

http://www.issseem.org; Official website of The International Society for the Study of Subtle Energies and Energy Medicine (ISSSEEM), founded by the end of 1980s.

Jahn, R. G., Dunne, B. J. (2011). *Consciousness and the Source of Reality: The PEAR Odyssey*. Princeton: ICRL.

Jerotić, V. (1998). *Individuation and (or) Deification*. Belgrade; Ars Libri & Priština: National and University Library, in Serbian.

Jibu, M., Hagan, S., Hameroff, S. R., Pribram, K. H., Yasue, K. (1994). Quantum optical coherence in cytosceletal microtubules: Implications for brain function. *BioSystems* 32, 195-209.

Jibu, M., Yasue, K. (1995). *Quantum Brain Dynamics: An Introduction*. John Benjamins.

Jibu, M., Pribram, K. H., Yasue, K. (1996). From conscious experience to memory storage and retrieval: The role of quantum brain dynamics and boson condensation of evanescent photons. *Intern. J. Mod. Phys.* 10, 1735-1754.

Jibu, M., Yasue, K. (1997). What is mind? Quantum field theory of evanescent photons in brain as quantum theory of consciousness. *Informatica* 21, 471-490.

Johari, H. (1989). *Breath, Mind, and Consciousness*. Rochester: Destiny Books.

Jovanović-Ignjatić, Z. (2010). *Quantum-Holographic Medicine: Via Acupuncture and Microwave-resonance (Self) Regulatory Mechanisms.* Belgrade: Quanttes, in Serbian.

Keković, G., Raković, D., Satarić, M., Koruga, Dj. (2005). Model of soliton transport through microtubular cytoskeleton in acupuncture system. *Mater. Sci. Forum* 494, 507-512.

Keković, G., Raković, D., Tošić, B., Davidović, D., Cosic, I. (2010). Quantum-mechanical foundations of Resonance Recognition Model. *Acta Phys. Polon. A* 17(5), 756-759.

Kinslow, F. J. (2008). *The Secret of Instant Healing.* Carlsbad: Hay House.

Kofler, J., Brukner, Č. (2007). Classical world arising out of quantum physics under the restriction of coarse-grained measurements. *Phys. Rev. Lett.* 99, 180403.

Kofler, J., Brukner, Č. (2008). Conditions for quantum violation of macroscopic realism. *Phys. Rev. Lett.* 101, 090403.

Leggett, A. J. (1980). Macroscopic quantum systems and the quantum theory of measurement. *Prog. Theor. Phys. Suppl.* No. 69, 80-100.

Leggett, A. J., Garg, A. (1985). Quantum mechanics versus macroscopic realism: Is the flux there when nobody looks? *Phys. Rev. Lett.* 54, 857-860.

Lindemann, H. (1982). *Anti-Stress Program – How to Overcome Stress*. Zagreb: Prosvjeta, Serbocroat translation from German.

Lindemann, H. (1973). *Relieve Tension the Autogenic Way*. New York: Wyden.

Mantak Chia (1983). *Awaken Healing Energy through the Tao*. Santa Fe: Aurora Press.

Markides, K. C. (1990). *Fire in the Heart. Healers, Sages and Mystics*. New York: Paragon.

Master Choa Kok Sui (2006). *The Origin of Modern Pranic Healing and Arhatic Yoga*. Institute for Inner Studies Publishing Foundation Inc.

Mihajlović Slavinski, Ž. (2000) *PEAT and Neutralization of Primeval Polarities*. Belgrade, see also http://www.spiritual-technology.com.

Milenković, M. (2010). *Reiki – The Road to Self*. 2nd ed. Belgrade: Booking, in Serbian; see also http://www.reiki.org.

Milenković, S. (1997). *Values of Contemporary Psychotherapy*. Belgrade: Narodna knjiga – Alfa, in Serbian.

Montagnier, L., Aissa, J., Del Giudice, E., Lavallee, C., Tedeschi, A., Vitiello, G. (2010). DNA waves and water, arXiv:1012.5166v1 [q-bio.OT].

Murphy, J. (2007). *The Power of Your Subconscious Mind*. Radford: Wilder.

Newton, M. (1994). *Journey of Souls*. Woodbury: Llewellyn.

Orme-Johnson, D. W., Farrow J. T., eds. (1977). *Scientific Research on the Transcendental Meditation Program*. Collected papers Vol. 1. Rheinweiler, W. Germany: MERU Press.

Øverbye, B. J. (2009). The divided self as understood by shaman natural healers! An effort of transcultural research to understand altered states of mind. *Med. Data Rev.* 1(3), 69-76.

Panajotović, D. (2011). *Buddhism: Guide to Theravada Buddhism*. Belgrade: Udruženje srpskih izdavača, in Serbian; see also http://www.accesstoinsight.org.

Paramhansa Yogananda (1946). *Autobiography of a Yogi*. New York: The Philosophical Library.

Pearl, E. (2001). *The Reconnection: Heal Others, Heal Yourself*. Carlsbad: Hay House, see also http://www. thereconnection.com.

Penrose, R. (1996). On gravity's role in quantum state reduction. *Gen. Rel. Grav.* 28, 581-600.

Peruš, M. (1996). Neuro-quantum parallelism in mind-brain and computers. *Informatica* 20, 173-183.

Petrović, S. (2000). *Tibetan Medicine*. Belgrade: Narodna knjiga – Alfa, in Serbian; see also http:// en.wikipedia.org/wiki/Traditional_Tibetan_medicine.

Potehina, Yu. P., Tkachenko, Y. A., Kozhemyakin, A. M. (2008). *Report on Clinical Evaluation for Apparatus EHF-IR Therapies Portable with Changeable Oscillators CEM TECH*. Nizhniy Novgorod: CEM Corp.

Preparata, G. (1995). *QED Coherence in Matter*. Singapore: World Scientific.

Pribram, K. (1971). *Languages of the Brain: Experimental Paradoxes & Principles in Neuro-Psychology*. New York: Brandon.

Pribram, K. (1991). *Brain & Perception: Holonomy & Structure in Figural Processing*. Hillsdale: Lawrence Erlbaum.

Radin, D. (2006). *Entangled Minds: Extrasensory Experiences in a Quantum Reality*. New York: Paraview.

Raković, D., Dugić, M. (2002). A critical note on the role of the quantum mechanical 'collapse' in quantum modeling of consciousness. *Informatica* 26(1), 85-90.

Raković, D., Dugić, M., Ćirković, M. M. (2004). Macroscopic quantum effects in biophysics and consciousness. *NeuroQuantology* 2(4), 237-262.

Raković, D., Dugić, M., Plavšić, M., Keković, G., Cosic, I., Davidović, D. (2006). Quantum decoherence and quantum-holographic information processes: From biomolecules to biosystems. *Mater. Sci. Forum* 518, 485-490.

Raković, D. (2008). *Fundamentals of Biophysics*. 3rd ed. Belgrade: IASC & IEFPG, in Serbian.

Raković, D. (2009). *Integrative Biophysics, Quantum Medicine, and Quantum-Holographic Informatics: Psychosomatic-Cognitive Implications.* Belgrade: IASC & IEPSP.

Raković, D., Škokljev, A., Djordjević, D. (2009). *Introduction to Quantum-Informational Medicine, with Basics of Quantum-Holographic Psychosomatics, Acupuncturology and Reflextherapy*. Belgrade: ECPD, in Serbian.

Raković, D. (2011). Quantum-holographic framework for consciousness and acupuncture: Psychosomatic-cognitive implications. *Medical Data Rev.* 3(3), 303-313, Invited paper; Reprinted in: *Proc. QIM 2011 Round Table Knowledge Federation* (D. Karabeg, D. Raković, S. Arandjelović, M. Mićović, eds.). Belgrade: QUANTTES & HF & DRF, http://www.qim2011.org.

Raković, D., Arandjelović, S., Mićović, M., eds. (2011). *Proc. Symp. Quantum-Informational Medicine QIM 2011: Acupuncture-Based and Consciousness-Based Holistic Approaches & Techniques.* Belgrade: QUANTTES & HF & DRF, http://www.qim2011.org.

Ricciardi, L. M., Umezawa, H. (1967). Brain and physics of many-body problems. *Kybernetic* 4, 44-48.

Samohin, A. V., Gotovski, Y. V. (2007). *Electroacupuncture Diagnosis and Treatment by the Method of R. Voll*. 5th ed. Moskva: IMEDIS, in Russian.

Selye, H. (1974). *Stress without Distress.* Stouphton: Hodder.

Simonovska, S. (2011). Quantum transformation. In: *Proc. Symp. Quantum-Informational Medicine QIM 2011: Acupuncture-Based & Consciousness-Based Holistic Approaches & Techniques* (D. Raković, S. Arandjelović, M. Mićović, eds.). Belgrade: QUANTTES & HF & DRF, http://www.qim2011.org.

Sit'ko, S. P., Andreyev, Ye. A., Dobronravova, I. S. (1988). The whole as a result of self-organization. *J. Biol. Phys*. 16, 71-73.

Sit'ko, S. P., Gizhko, V. V. (1991). Towards a quantum physics of the living state. *J. Biol. Phys*. 18, 1-10.

Sit'ko, S. P., Mkrtchian, L. N. (1994). *Introduction to Quantum Medicine.* Kiev: Pattern.

Sit'ko, S. P. (2012). The realization of genome in the notions of Physics of the Alive. *Medical Data Rev.* 4(2), 207-215, Invited paper; Reprinted from: *Proc. Symp. Quantum-Informational Medicine QIM 2011: Acupuncture-Based and Consciousness-Based Holistic Approaches & Techniques* (D. Raković, S. Arandjelović, M. Mićović, eds.). Belgrade: QUANTTES & HF & DRF.

Stambolović V. ed. (2003). *Alternative Approaches to Health Improvement*. Belgrade: ALCD, in Serbian.

Stibal, V. (2006). *Theta Healing: Go Up and Seek God, Go Up and Work with God*. Idaho Falls: THInK, see also http://www.thetahealingserbia.com.

Stuart, C. I. J. M., Takahashi, Y., Umezawa, H. (1978). On the stability and non-local properties of memory. *J. Theor. Biol.* 71, 605-618.

Stuart, C. I. J. M., Takahashi, Y., Umezawa, H. (1979). Mixed-system brain dynamics: Neural memory as a macroscopic ordered state. *Found. Phys.* 9, 301-327.

Swami Sada Shiva Tirtha (2007). *The Ayurveda Encyclopedia. Natural Secrets of Healing, Prevention and Longevity*. 2nd ed. New York: Sat Yuga Press.

Swami Satyananda Saraswati (1982). *Yoga Nidra.* 4th ed. Monghur, Bihar, India: Bihar School of Yoga.

Tart C., ed. (1992). *Transpersonal Psychologies*. 2nd ed. San Francisco: Harper.

Todorović, B. (2005). *Scientific Bases of Homeopathy: Bioinformatics and Nanopharmacology*. Novi Sad: Prometej, in Serbian.

Tomšić Akengen, M. (2011). Abiku phenomenon: Spiritual origin and treatment of self-destructiveness. In: *Proc. Symp. Quantum-Informational Medicine QIM 2011: Acupuncture-Based & Consciousness-Based Holistic Approaches & Techniques* (D. Raković, S. Arandjelović, M. Mićović, eds.). Belgrade: QUANTTES & HF & DRF, http://www.qim2011.org.

Umezawa, H. (1993). *Advanced Field Theory: Micro, Macro, and Thermal Physics*. New York: American Institute of Physics.

Vedral, V. (2010). *Decoding Reality: The Universe as Quantum Information*. Oxford: Oxford Univ. Press.

Vlahos, J. (1998). *Orthodox Psychotherapy: The Holy Fathers Science*. Belgrade: Missionary School of St. Alexander Nevskiy Church, Serbian transl from Greek.

Voll, R. (1975). Twenty years of electroacupuncture diagnosis in Germany. A progress report. *Am. J Acup*. 3(1), 7-17.

Vujičin, P. (1995). States of consciousness in esoteric practice. In: *Consciousness: Scientific Challenge of the 21st Century* (D. Raković, Dj. Koruga, eds.). Belgrade: ECPD, and refs therein.

Zhang, Y. (1987). *ECIWO Biology and Medicine: A New Theory of Conquering Cancer and Completely New Acupuncture Therapy*. Beijing: Neimenggu People Press.

Zurek, W. H. (1991). Decoherence and the transition from quantum to classical. *Phys. Today* 44(10), 36-44.

Zurek, W. H. (2003). Decoherence, einselection, and the quantum origins of the classical. *Rev. Mod. Phys.* 75, 715-765.

HOLISTIC APPROACH TO SPEECH INTERACTION IN NORM AND PATHOLOGY

DIMITAR POPOV, VELKA POPOVA
Laboratory of Applied Linguistics, Konstantin Preslavsky University of Shumen
labling@shu-bg.net

Abstract: The goal of this paper is to present the advantages of the holistic paradigm in the investigation of speech interaction in norm and pathology. The focus is on the use of modern multimedia devices for the study of human communication as a frame structure in on-line performance. Some of the opportunities offered by interactive platforms such as TALKBANK and CHILDES are presented, which are most frequently used.

Key words: linguistic resources, computer corpora, child language

INTRODUCTION

According to holistic approach human consciousness is defined as a whole inseparable part which is characterized by a number of fundamental principles. With respect to the holistic cognitive theory language is viewed not as an autonomic sub-structure but as an epiphenomenon of cognition (Anderson 1983; 1985).

Holistic linguistics dwells on the inseparable convergence of common linguistic and cognitive principles and rules. Cognitive linguistics on its part makes an attempt to explain which linguistic rules and principles have a universal character and in what way one could reach to the linguistic cognitive system and its processor. It is necessary not only to examine the grammar learning but it is also necessary to take into consideration certain ontogenetic aspects of all language components.

In that respect it is rather natural to apply the holistic research paradigm to the speech interaction in norm and pathology.

In the recent decades the linguistic resources, organized in corpora, have been extensively used in language modeling and the speech behavior of the language bearers besides the fact that the processes of formation and maintenance of computer resources is an extremely time-consuming and costly occupation. The establishment of modern technologies posed a new, more efficient standard in their introduction and processing. In that way the range of every separate corpus is likely to extend to million linguistic units and is able to optimize the options of their annotation (linguistic analysis), unification, standardization, and multiple forms of exploitation. Admittedly, it is simply enough to add here the application of the modern computer programmes in automatic processing of the huge masses of data in order to depict the picture of the new quality of research work which the cognitive perspective of modern humanity studies as a whole suggests. The present paper dwells on the various possibilities of application with respect to cognitive linguistics when exploring the child speech which can be arguably defined as an extremely unique linguistic phenomenon. A Bulgarian computer corpus is presented in which the linguistic resources are transcribed and annotated in terms of CHILDES system. The paper also makes an attempt to outline the advantages and perspectives of that new research paradigm in linguistic ontogenesis modeling on the basis of specific research work carried out on an empirical platform of solid database.

Corpus paradigm – necessity or mode in the sphere of child speech research work

The paper dwells on the following question: *Is the application of corpus paradigm in the sphere of child speech research works a mode or necessity?* We should immediately point out here that the creation and formation of computer corpora is an extremely time-consuming and costly occupation. This directly arouses the suspicion whether the exotics of child speech as a linguistic phenomenon is worth analyzing and whether it could be a sufficient motive to the realization of self-administered and hard to examine research works. The answer could be traced in two directions and namely: *Is it actually necessary for the child speech to be examined at all?* and *What are the advantages of corpus paradigm over the traditional approaches that were used to explore the linguistic ontogenesis?*

In linguistic tradition there has been a long-lasting interest in the phenomenon of child speech and that namely is not as a result of single-handed interest and pure human curiosity on the part of the researchers. On the contrary, the data of linguistic ontogenesis can be discussed in the boundaries of multiplicity of branches – the obligatory “external proofs” which aim to test a hypothesis or test a theoretical construct. Along with the fact that they are crucial in clarifying certain problems of linguistic typology and universalia, they also provide possibility for the adequate problem solving in the early speech pathology and linguistic education. In the recent decades characterized by the rapid development of psycholinguistics and cognitive linguistics, child speech has turned to be a clue to revealing the secret of the human perceptive and cognitive apparatus. In that way the research works on linguistic ontogenesis apply completely to the common trend of modern linguistics excluding itself from the language learning itself and focusing mainly on speech interaction (this refers to holistic approach).

The importance of child speech, roughly presented above, undoubtedly asks for the necessity of creating an adequate model of linguistic ontogenesis, which on its part discusses problems concerning the (non)-efficiency of the previous approaches aiming to confute the myths not only in linguistics, but in psycholinguistics and the methods in language education. Consequently another question arises concerning the supply of certain models with reliable empirical material. Traditionally in linguistics and psycholinguistics there are three basic models of collecting the linguistic data, classified and specialized with respect to the location of the researcher (*in the study, on a terrain* or *in the laboratory*), and namely: *introspective, observation* and *experiment*. Any of these models has its positive and negative points which in itself is already a guarantee for optimal results and adequacy. Their place can be determined in every single case with respect to the specificity of the exact research unit. Typically every research work usually starts from the working study, then it obligatory goes through a probation on the terrain or in the laboratory. Definitely there are cases in which it could remain domineering or the single approach. In other cases it would be rather risky especially when linguistic phenomena are discussed which people “don’t have memories of” such as child speech. In that case the work of introspective is limited to the formation of hypotheses which, however, when being operated on the data from the observation and experiments are of basic use. It should be also mentioned here that their wide set of database is of crucial importance which guarantee a solid empirical basis for the approbation of the exact model.

In that respect it is natural to point out here the problem concerning the methods of collecting enough qualitative and quantitative empirical material so that the child speech could be adequately explored. A brief excurse will be presented which aims to outline the main demands and will make an attempt to find the place of the corpus paradigm in the previous research platforms.

A brief excurse

Loads of empirical data were used before the appearance of corpus linguistics. Its rise as a kind of methodology is closely connected to the history of linguistics as an empirical science. Most of the technologies applicable to corpus linguistics are rooted in the traditions from the end of XVIIIth and XIXth century, when linguistics for the first time was claimed to be "real", that is - an empirical science. In that way a great number of areas of linguistic research works stand in the basis of corpus linguistics. In that respect we can find traces of the first systematic surveys of linguistic ontogenesis. They show great interest and preference towards the act of collecting empirical material, that is, the description of child language in its specific manifestations and accumulation of the child's first words and phrases. There was a practice from the middle of XIXth century to the middle of XXth century specific registers to be kept which focused on the chronological development of the child speech and basically these registers were rather descriptive. Philosophers, naturalists, linguists, psychologists took detailed notes of the speech development of their children. It is simply enough to mention here the names of: Hyppolite Taine, Charles Darwin, D. Tideman, V. Leopold, Gregoire, Jan Baudouin de Courtenay, A. N. Gvozdev, I. Georgov. A bigger part of the works of these scientists were either partially or completely published until the 30-40s of XXth century. Even today these unique "baby's biographies" do not fail into insignificance. The modern scientists constantly turns back to their collected data.

In the 30s of XXth century in the boundaries of behaviorism the first cross-sectional surveys were carried out (in German - Transversalstudien), in which samples of a great number of children of the same age could be compared and contrasted and diverse statistical methods could be applied, different experiments could be planned and implemented.

In the 60s parallel to the formation and establishment of corpus linguistics in the sphere of child linguistics the epoch of "longitudinal cross-sectional research" started. There are documental recordings of speech fragments on a type which were carried out following a special timetable with preliminary fixed time intervals which aimed to avoid fragmentariness and accidental gaps typical to the registers and cross-sectional data of the previous stages.

It should be pointed out here, however, that regarding the objectives which the different models have set the models have their strong and weak points: the registers are extremely useful when examining the ontogenesis of the lexicon though they are not suitable if our aim is to achieve reliable quantitative results; the cross-sectional research works can provide a large database, but they cannot define effectively the individual aspect in language mastering (and mainly the speed of assimilation with different children). Longitudinal surveys provide a comparatively exact picture for any separate child, but because of the fact that collecting data is a rather long process and the methods of transcribing or of data processing turn to be quite different and more complicated the comparison with other longitudinal research works is becoming even harder; besides, a separate single corpus could be quite misleading since it could contain certain individualistic disparities in the process of speech mastering.

A new, better-quality level in the research of linguistic ontogenesis becomes explicit in the invention of computer systems in accumulation and automatic processing of huge masses of child speech data. They for the last few decades have established favourable conditions for the successful realization of colossal cross-linguistic projects, focusing on ontogenesis of multiplicity of languages. One of the most popular computer systems is **CHILDES** (**C**hild **L**anguage **D**ATA **E**xchange **S**ystem. It was established in the 80s of XXth century by the American scientists B. Mcqueeny and K. Snow. The CHILDES system is free online zone (http://childes.psy.cmu.edu), which is easily available and open for any researcher.

CHILDES system – opportunities and perspectives

The database of CHILDES consists of a great amount of information for mastering multiplicity of languages such as: English, African, Danish, Dutch, French, German, Hebrew, Hungarian, Italian, Polish, Spanish, Turkish and others. There is a special section in the database on the abnormalities in the language development and second language mastering. Apart from the database CHILDES provides the researchers with a packet of specialized CLAN programmes, which on their part could implement different types of analysis of the inserted dialogues (phonetic, morphologic, syntactic) and the commentaries respectively. In that respect CLAN automatically can provide diverse statistical and substantial results out of the transcribed and coded data such as word frequency, lexical diversity and combinations, about specific user's words and forms (for example, child linguistic errors such as specific deviations from the norm of the given language: the units of the so called BABY TALK, onomatopoeia, super-generalizations, child and family occasionals) and so on.

Undoubtedly the automatized computer system for linguistic data exchange CHILDES is of great use and importance. The reasons why it was created are obvious for those who have created and analyzed recordings. Such a system can provide the user with the possibility to reach a greater precision in collecting, transcribing and coding of data as well as in automatizing the analysis of large quantities of conversational material which on its part expends substantially the empirical base that the new theories have to comply with. All the above mentioned contributes extensively to the high quality of the research product. Undoubtedly one of the advantages of CHILDES is the number of more than 3000 published research works on different languages based on the data and information of this system.

CHILDES system is especially needed at present when significant integrative surveys are carried out with respect to child speech in the boundaries of international scientific projects (such as cross-linguistic projects *Pre- and Protomorphology in Language Acquisition*[2]; *Syntaktische Konsequenzen des Morphologieerwerbs*[3]; *Erwerb sprachlicher Markierungen zur Differenzierung von ±Begrenztheit*[4]; *Spracherwerb: Acquisition and Disambiguation of Intersentential Pronominal Reference*[5] and others). In that respect mainly the universal model of presenting and analyzing the data in CLAN provide the scholars, who investigate a number of languages, with efficient and reliable information and help them when dealing with comparative-typological surveys and build solid modern theories.

Bulgarian corpus of child speech data

Bulgarian corpus is already a fact, developed in the terms of CHILDES. It comprises two types of speech resources: CORPUS A, comprising spontaneous speech of four children at their early age (from 1 to 3 years old), and CORPUS B, comprising stories based on a series of pictures with 90 children at pre-school age (from 3 to 6 years old). This empirical material has not been included yet in the common bank of CHILDES system since it is still being loaded with new data as well as with raw materials which are still being collected and prepared.

Until now in the area of CORPUS A the collected and prepared computer based data have comprised audio recordings of spontaneous speech of four Bulgarian children (transformed in computer WAV-files) which are transcribed and coded in CHAT-format. In the core of the database there are 33 hours of recordings (digitalized and saved in 32 *.wav-files) and transcribed in 355 pages. During the process of creating the *.cha-files the data

---

[2] See http://www.oeaw.ac.at/ ling/kimo/international_prepro.html)
[3] See http://www.zas.gwz-berlin.de/fileadmin/material/ jahresberichte/jb2000.pdf
[4] See http://www.zas.gwz-berlin.de/fileadmin/ material/jahresberichte/ jb2003.pdf
[5] See http://www.zas.gwz-berlin.de/fileadmin/material/jahres berichte/jb2007.pdf

from certain short-lived files were summarized in a single document. The corpus of data comprising the results given by the four children is saved in 30 files in CHAT-format.

The children in question were born and live in the town of Shumen, north-east part of Bulgaria. They were recorded in common situations (games, when dressing, eating, going to sleep, going through children's pictorial books and others) in the process of their daily interaction surrounded by their relatives. All individuals who were signed in the database in their role as participants in dialogues are monolingual with their first language – Bulgarian. The adults in the surroundings have a sufficient level of proper education (either secondary or higher university education). The audio-recordings of the three of the children (ALE, TEF, IVE) were made by the researcher (the author of the present research work and a mother of one of the children –ALE) and of BOG – by one of the mothers (a linguist too). Transcription and codings of the material were carried out by the author of the present paper.

CORPUS B includes also the **stories** of children between 3 and 6 years of age from Shumen and Varna. They were recorded on dictaphone then transformed into computer WAV-files which were transcribed and coded in CHAT-files according to the requirements of CHILES system. In the database there are three hours of recordings (digitalized and saved in 30 *wav-files) and 60 transcriptions of 62 pages. The recordings were made by three teachers in kindergartens from the town of Shumen, the transcriptions and annotation - by the author of the present paper.

The application and reliability of the already described base comprising speech data and information by Bulgarian children is partially approbated in the boundaries of discussions and comparative analyses of Bulgarian and the other languages (in particular, German and Russian), carried out in the sphere of cross-linguistic programme for examining the early adoption and mastering of the aspect [comp. Kuhnast, Popova, Popov 2004]; [Bitner, Gagarina, Popova, Kuhnast 2005]. The corpus also stresses on the empirical base and the multiplicity of particular research works on different aspects of the early-age ontogenesis of Bulgarian grammar (see: [Popova, Popov 2007]; [Popova 2010]; [Popova 2011] and others, as well as certain surveys on child language at pre-school age which are still in process.

CONCLUSION

In the paper hereby presented the authors attempt to dwell on the corpus perspective as a basic line in the sphere of research in language ontogenesis since the time of Charles Darwin till today. In that respect the accumulation of empirical data has always been, still is and will be domineering as it is provided with a great set of data. In the course of time and technical advance, however, the empirical products reach a new level of quality with respect to their processing. The card-files and registers are replaced with electronic speech arrays, the time-consuming and exhausting work regarding the registration, transcription and statistic processing of the data is provided by various modern technological devices and programme products.

In view of the closing words it should also be mentioned here that the climax of this evolutionary process was the creation of CHILDES. The typological diversity of the linguistic data included in the survey, the unified format of the transcription, the packet of CLAN programme resources for automatic processing turn this system into an extremely useful and convenient platform for research work. Additionally, the optimal empirical possibilities could guarantee the achievement of high level of objectivity and adequacy of the results as well as turn them into a solid set of database for approbation of the models of language ontogenesis.

Last but not least, it is necessary also to add here that the unified available technical devices used in the process of annotation of the extra-linguistic data which go along with the speech of the individuals in question as well as the constant connection between the transcripts and the respective audio and video-files provide certain possibilities and perspectives not only for further research work in all aspects of speech interaction but also in interaction as a whole on the part of the other scientific fields. In that respect by using CHILDES explorers and researchers from different spheres of humanities could successfully fulfill and realize their searches and also join in the interdisciplinary projects. Following the logic of what has already been said it could be expected that the exchange data system CHILDES is highly likely to turn into one of the most successful professional ON-LINE networks for humanitarians which on its part could lead to stable and modern inter-disciplinary surveys.

REFERENCES:

Anderson, J. R. (1983): *The Architecture of Cognition*. Cambridge, Mass., Harvard University Press.

Bittner, D., N. Gagarina, V. Popova, M. Kühnast.(2005) Aspect before Tense in the acquisition of Russian, Bulgarian, and German. – In: V. Solovyev, V. Polyakov (Eds.). Text Processing and cognitive Technologies. Moskow

Kühnast, M., V. Popova, D. Popov. (2004) Erwerb der Aspektmarkierung im Bulgarischen. – In: N. Gagarina, D. Bittner (Eds.). ZAS-Paper in Linguistics 33, 2004: Studies on the development of grammar in German, Russian and Bulgarian, 63-87 (http://alphalinguistica.sns.it/Riviste/ZAS/ 33_2004.pdf)

Popova, V. Popov, D. (2007) The emergence of verb grammar in two Bulgarian-speaking children. – In: V. Solovyev, V. Polyakov (Eds.). Text Processing and cognitive Technologies. Moskow, 2007.

Popova, V. (2010). Corpus research work of the grammatical metamorphosis of the early child language – In: Language, culture, identity. Veliko Tarnovo: Faber, 2010, 101-115.

Popova, V. (2011). The role of onomaotpeia in early verbal ontogenesis– Litera et Lingua. Spring 2011, Sofia, 2011. - http://slav.unisofia.bg/lilijournal/index.php/ bg/issues/spring2011

BASES OF (PRENATAL) COMMUNICATION

MIRJANA SOVILJ
Institute for Experimental Phonetics and Speech Pathology Belgrade, Belgrade, Serbia
Life Activities Advancement Center, Belgrade, Serbia

Abstract. The author's long and extensive researches of interconnections and interdependencies of children's speech, language, behaviour and learning through holistic psychophysiological – sociobiological approach, resulted in this paper aimed at shifting the borders of understanding human communication with oneself as well as with others. This is a pilot research in which the author presented and compared results of:
1. prenatal hearing screening (PHS), with the particular emphasis on the direction of reactibility of prenatal children (positive – increased speed of blood flow in a.cerebri media and negative direction – decreased speed of blood flow in a.cerebri media) in N=120 pregnant women
2. drawings and displayed emotions obtained in a designed experiment
"Draw the moment when you were created and write down the first three emotions which appeared", which was conducted on N=174 examinees with a university degree, aged 25-56.
The aim of the experiment "Draw the moment when you were created and write down the first three emotions which appeared" represents the author's attempt to observe "deep memory prenatal traces", which she considers to be in the sphere of subconsciousness and to analyse them through drawings and kinds of displayed emotions.
The results of global analyses of drawings and kinds of displayed emotions indicated that 75% examinees had positive emotions about "the moment they were created", 21% had mixed (both positive and negative), whereas 4% examinees had completely negative emotions. When these results were compared to the direction of reactibility of prenatal children on the PHS, there was an unexpected congruence between the percentage of adult examinees with positive emotions about "the moment of their creation" (75) and the percentage of positive direction of reactibility on PHS (increased blood flow in a. cerebri media in 75% prenatal children) mixed and negative emotions in adult examinees (21% + 4%), and negative direction of reactibility on the PHS (decreased blood flow in a.cerebri media in 25% prenatal children).
The results direct us towards the possibilities of studying more subtle regularities of the origin and development of communication, behaviour and learning.
Key words: prenatal development, PHS, speech and language, behaviour, learning, drawing, emotions

Holistic approach to contemporary studies of human communication indicates that it needs to be perceived as a complex system, which is not a simple summary expression of characteristics of psychophysiological, sociobiological and sociolinguistic factors, but is highly influenced by their network of interactions, i.e. their feedback connections, selfregulation and newly created characteristics. In human communication, our attention is directed towards speech-language communication as a dynamic system.

Observing speech and language as a complex system of astro-geophysical, climatic, socio-linguistic, socio-biological and psychophysiological factors sublimated in it, as well as in an individual and people speaking that language, its development must be studied from the moment of an individual's conception i.e. from the prenatal period. (Sovilj, 2009)

Nowadays, it is an irrefutable fact that a human baby brings a significant experience of feelings and sensations from her intrauterine life, which significantly influence her psyche, her ability to communicate with herself, with her parents and the world that surrounds her, i.e. that in the prenatal period besides hereditary, innate reactions develop as well, depending on the inner environment (mother's organism) and her interaction with the outer environment, onto which reactions form the postnatal period of development are superimposed. Thus, hereditary and innate prenatal reactions represent the basis of behaviour throughout life (Chamberlain, 1988; Brekhman, 2000, 2001; Sovilj, Ljubic, Milenković, Đokovic, 1992; Sovilj, 2009).

Observing communication from the moment of conception and distribution of basic personality types in the world population) we can notice a very complex system of the relation of natural and social environment, characterized by nonlinearity, dynamism, multicomponency etc, expressed in the observed connection of prenatal reaction to sound, mother's behaviour throughout pregnancy and percentage ratio of personality types (extrovert- introvert) in the researches of the world population.

The researches at the IEPSP resulted in the method of Prenatal Hearing Screening (PHS), whose application from 28th to 31st gestation week can detect disorders in auditory reaction to a defined sound stimulus, monitoring values of pulsatility inndex (Pi) during the ultrasound measurement of the speed of blood flow in a. cerebri media of a prenatal child. The results of PHS measurements indicate that 75% of prenatal children react with the increased speed of blood flow, and 25% with the decreased speed of blood flow. This means that in 75% of prenatal children defined sound stimulus from the outer environment caused dilatation of a blood vessel (a. cerebri media) and the decreased Pi, i.e. the speed of blood flow is increased in relation to the basic Pi value (value before auditory stimulation). In 25% of prenatal children (defined GW) there is an increase of Pi (after auditory stimulation), constriction of a blood vessel and the decrease in blood flow speed in relation to the basic Pi value.

The extroverts have higher blood flow in the frontal cingular temporal lobe, gyrus and the posterior thalamus, which are included in the sensory and emotional experience (Johnson, Wiebe, Gold, Andreasen, 1999).) This study and other researches indicate that introversion/extroversion is related to individual differences of brain function.

At the age of 3,6 - 4,6, the type of a child's personality was assessed in the examined population: 80% of children were assessed as extrovert and 20 % as introvert, which coincided with their mothers' assessments regarding the basic tipology of their children's personality. It should be noted that these were basic classifications, with full awareness that between these basic classifications there is a large number of combined personality types (literature states different classifications depending on their goals) and the classification depends on a very large number of factors, so one person can have both characteristics, or one or the other, depending on the state and conditions.

Realizing the project Prenatal Researches, which, besides PHS, monitors all risk factors during pregnancy, we also examined the degree of anxiety of a mother-pregnant woman by Spielberg tests 1 and 2. Spielberg anxiety test 1 assesses the current condition of a mother-pregnant woman, whereas Spielberg test 2 assesses her condition within a longer period of time, i.e. the frequency of the listed conditions in her life. The obtained results indicated that at the moment of testing, 71% of mothers-pregnant women demonstrated high and moderate anxiety, whereas 29% had low anxiety (Spielberg test 1) In Spielberg test 2, 78,6% of mothers-pregnant women demonstrated high and moderate anxiety, and 21,4% low anxiety (Brekhman, 2000, 2001)

Within the same project, we were interested in the kind of memories, emotions and conditions of adult examinees regarding the moment they were conceived. For this purpose, an experiment was carried out in which the examinees (aged 25-56 with high education) were required to draw the moment when they were conceived (concept) and to write down the first three emotions they felt at that moment (when they heard the task and imagined the picture). The results of the experiment indicated that 75% of examinees showed positive emotions regarding the moment of their conception, whereas 25% had mixed and negative emotions. The results of analysis of drawings according to how they used the free surface of paper indicate that 97% of examinees with positive emotions use the middle or the right side of the base (paper), which indicates optimistic attitude, openness to change, curiosity.., and 77% used the left side of the surface, which indicates closeness, a problem with establishing contact with others etc, which confirmed concordance between visualization of an event and an emotional experience. Certain researchers emphasize that the extroverts express optimism more often compared to the introverts, and that their work space is arranged so as to call for interaction with the environment etc (Sharma, 1980).

In addition to the listed research results, in order to perceive the complex multidimensional and dynamic system of interactive connections in the definition of development and causal-consequential relations, communication and behaviour of an individual-society, we considered the researches which generally indicate that 75% of the world population is basically extrovert and 25% introvert ((Briggs, McCaulley, Mary, Quenk, Hammer, Mitchell, Wayne, 2009; Tieger &Tieger, 1995; Myers, 1990; Briggs, 1980; Briggs, Mary, McCaulley, Quenk, Hammer, 1998).

Summarizing the results it can be noted that in almost all of the relations the observed parametres unmistakably indicate the frequency rule of 75% : 25%

• **75% of prenatal children react to the defined sound stimulus with the increased blood flow** and 25% with the decreased blood flow in a.cerebri media.

• **68% of pregnant women is highly and moderately anxious** , whereas 32% had low anxiety level at the moment of testing(C1),

• **78,5% of pregnant women is highly and moderately anxious**, whereas 21% is highly anxious in a longer period (C2)

• **75% of examinees had positive emotions connected with the moment of creation**,whereas

• 25% had mixed and negative emotions

• **75% of population is basically extrovert and**

• 25% is introvert

Conclusion

We know that a prenatal child has memory and is capable of learning, and that prenatal experiences create the basis of behaviour throughout life, onto which later events are superimposed. In this light, we can notice that the basis of a complex system of causal-consequential relations of communication and behaviour of an individual-society develops through hereditary and innate process of intrauterine development.

Applying PHS we can detect basic personality type (introvert/extrovert) of a child after the 28th gestation week, which corresponds to the percentage ratio in adult population, anxiety degree of a mother-pregnant woman and positive attitude of adults regarding the conception. These facts open new possibilities of scientific and expert approach in the promotion of the improvement of communication and behaviour through a range of activities which should take care of the development of an individual and society, such as: health care, education, social welfare, media (TV and newspapers).

Researches require more subtle approaches in discovering regularities in human development, who is the “consequence” of previously experienced conditions and states of his ancestors, as well as his own state and conditions of the environment in which he grows and develops.

If we do not perceive these facts when considering the development of communication and behaviour, then a Person (consequence) cannot have essential insight into his own condition and behaviour, much less into the condition and behaviour of others.

For the essential understanding of the development of human conscience, speech and language, behaviour and learning, we must apply holistic psychophysiological and sociobiological approach from the prenatal period - conception, because a man is is a unique expression of a large number of hereditary features of his ancestors and interaction with narrower and wider environment.

Acknowledgements: This research study was supported by the Ministry of Science and Technological development of the Republic of Serbia within the project no. 178027**.**

REFERENCES

Chamberlain D. (1988). *Babies Remember Birth*. New York: Ballantine Books.

Verny T., Weintraub P. (20002). *Tomorrow's Baby*. New York: Simon&Schuster.

Janus L. (2001). *The Enduring Effects of Prenatal Experience*. Heidelberg: Mattes.

Brekhman G. (2001). The conception of the wave multiple-level interaction between the mother and her unborn child. *Int. J. of Prenatal and Perinatal Psychology and Medicine* 2001; 13(1/2).

Brekhman G. (2000). The conception of the multiple level co-ordinated action between the mother and her unborn child: The methodological approach and the methods of research. Cagliari, Sardinia, IT: *ISPPM Congress*, June 22-24, 2000.

Bakhmutsky A, Brekhman G, Bukreev V, et al. (2010). Latent roots of violence: unconscious motives, mentality, ways to prevent. Haifa: *Council of Scientists' House*.

Briggs M. I., McCaulley M. H., Quenk N. L., Hammer A. L., Mitchell W. D. (2009). *MBTI Step III Manual: Exploring Personality Development Using the Myers-Briggs Type Indicator Instrument*, p.119. Consulting Psychologists Press.

Tieger P., Tieger B B. (1995). *Do what you are: discover the perfect career for you through the secrets of personality type*. Boston: Little, Brown. ISBN 0-316-84522-1.

Johnson D. L., Wiebe J. S., Gold S. M., Andreasen N. C. (1999). Cerebral blood flow and personality: A positron emission tomography study. *American Journal of Psychiatry* 156 (2): 252–7.

Sharma R. S. (1980). Clothing behaviour, personality, and values: A correlational study. *Psychological Studies*, *25*, 137–142.

Myers I. (1990). *Introduction to Type: A Description of the Theory and Applications of the Myers-Briggs Type Indicator*. Center for Applications of Psychological Type Inc. ISBN 0-935652-06-X.

Briggs I. (1980). *Gifts Differing: Understanding Personality Type.* Davies-Black Publishing; Reprint edition (May 1, 1995). ISBN 0-89106-074-X.

Briggs M. I., McCaulley M. H., Quenk N., Hammer A. (1998). *MBTI Handbook: A Guide to the development and use of the Myers-Briggs Type Indicator* Consulting Psychologists Press, 3rd edition. ISBN 0-89106-130-4.

Sovilj M. Ljubic A. Milenković V. Djokovic S. (1992). Possibilities of Prenatal Researches of Reaction to Sound in Fetus with Congenital Infections, Collection of abridged works, X Jubilee Symposium – Section for perinatal medicine. S.L.D., Belgrade, 17-18.

Sovilj M. Jelicic Lj. Vujovic M. Barlov I. (2004). Development of Senses and Fetal Behaviour and Researches on Auditory Perception and Prenatal Auditory Stimulation, chapter in the monograph: S. Jovicic, M. Sovilj (editors): *Speech and Language: Interdisciplinary Researches on Serbian Language, I*, IEPSP, Belgrade

Sovilj M. (1998). Sound, Hearing and Consciousness, *Downward Processes in the Perception Representation Mechanisms*, Napoly, 487-493

Sovilj M. (2009). Prenatal basis of the development of speech and language and prenatal stmulation, *Speech and Language, Interdisciplinary Research III*, Editors: Jovičić S. T., Sovilj M., ISBN 978-86-81879-27-6, LAAC IEPSP, Belgrade, str 1-18 (18 страна).

Adamovic T. Sovilj M. Subotic M. (2004). Prenatal Memory and Learning, chapter in the monograph: S. Jovicic, M. Sovilj (editors): *Speech and Language: Interdisciplinary Researches on Serbian Language, I,* IEPSP, Belgrade.

Radičević Z., Vujović M., Jeličić Lj., Sovilj M. (2008). Comparative findings of voice and speech: language processing at an early ontogenetic age in quantitative EEG mapping, *Experimental Brain Research.* Vol. 184; 529-532.

FETAL AUDITORY STIMULATION AND THE CHANGE OF PULSATILITY INDEX OF THE FETAL MIDDLE CEREBRAL ARTERY

SNEZANA PLESINAC [1,2], SVETLANA JANKOVIC[1,3], DARKO PLECAS[1,2], OLGA ANTONOVIC[1,2], TATJANA ADAMOVIC [4,5], MIRJANA SOVILJ [4,5]

[1] Medical Faculty, University Belgrade, Belgrade, Serbia,
[2] Clinic for Gynecology and Obstetrics, Clinical Center Serbia, Belgrade, Serbia,
[3] Clinic for Gynecology and Obstetrics Narodni Front Belgrade, Belgrade, Serbia,
[4] Institute for Experimental Phonetics and Speech Pathology Belgrade, Belgrade, Serbia
[5] Life Activities Advancement Center, Belgrade, Serbia

Abstract. Purpose: An aim was to determine fetal acoustic response after the constant sound stimuli. Method: Study included 343 patients divided in two groups. Group 1: low risk pregnancies and group 2: gestational hypertension. Ultrasound prenatal auditory screening was performed after the 27th week of gestation. Results: The percentage of fetuses with increase of cerebral blood flow was slightly higher in the pregnancies with hypertension. Conclusion: An average change of PI of median cerebral artery was higher in this group

INTRODUCTION

During intrauterine development in the third week of gestation, otic placode and otic vesicle are formed. In the next two weeks, cochlear part of otic vesicle elongates (for humans 2.5 times). Mesenchyme surrounding membranous labyrinth (otic capsule) chondrifies in the ninth week. From the 12th to 16th week, capsule adjacent to membranous labyrinth undergoes vacuolization to form a cavity (perilymphatic space) around membranous labyrinth and fills with perilymph. From week 16–24, centers of ossification appear in remaining cartilage of otic capsule and form petrous portion of temporal bone which continues to ossify to form mastoid process of temporal bone. In the 3rd Trimester, vibration acoustically applied of maternal abdominal wall induces startle response in fetus. The development of audile tract in fetus begins at 20th week, but the peak function reaches between 30th and 32nd week of pregnancy (1).

Tomatis developed an idea that fetus can hear in the 4^{th} month of gestation and not only hear by auditory system but with somatosensory cortex and vestibular system (1981). Birnholz and Benacerraf detected the first fetal response to external auditory stimulus by ultrasound (1983). In Serbia, the first investigations about fetal behavior after the sound stimulation were held in 1992 by Sovilj and Ljubic (2).

MATERIAL AND METHODS

Congenital hearing impairment, if not noticed soon after the delivery, can cause difficult auditory and verbal disturbances in the childhood. Certain effort has been made in the previous years to define sensitive and specific screening prenatal test. An aim of the first phase of our prospective clinical trial was to determine the degree and the mode of variation of PI of middle cerebral artery in low risk pregnancies and in pregnancies with gestational hypertension, after the constant sound stimuli. Due to vascular changes in gestational hypertension, it was expected that they would alter Doppler parameters in cerebral circulation.

Study has been organized as multi centric prospective clinical trial under the supervision of Ministry of health and education of Republic of Serbia in 4 years time frame, from 2011 till 2014. Project included Clinic for gynecology and obstetrics, Clinical Center in

Serbia, Clinic for gynecology and obstetrics, Narodni Front in Belgrade, and Institute for Experimental Phonetics and Speech Pathology in Belgrade.

Institute for Experimental Phonetics and Speech Pathology in Belgrade developed basic part for experiment called MIMS-GENERATOR SOUND STIMULANT. Production: INKOMARK, Belgrade, Serbia. Patent No. P 2010/0519. Generator provides a sound stimulus generating a defined sound stimuli required for detection of fetal hearing response. The device is portable, battery powered, easily manipulating, and easy to handle. Generated sound parameters are invariant, which ensures rapid repetition of measurements. Technical characteristics of the device are the following: intensity L (dB) = 90 dB at a distance of $s = 50$ mm perpendicular to the propagation of sound with frequency range between 1500–4500 hz and the effective duration of the stimulus is 0.21 seconds.

Assessment of fetal cortical circulation was made by ultrasound Doppler measurements on Toshiba with 3.5 MHz probe at the beginning of median cerebral artery before and immediately after the sound stimuli proposed near the fetal head, at the distance of no more than 10 cm. We measured PI before (PI1) and after the stimuli (PI2).

Study included 343 patients from both Clinics for gynecology and obstetric form Clinical Center, Serbia and Narodni front. The patients were divided in two groups. Group 1 included 268 women with low risk pregnancies and group 2 included 75 patients with gestational hypertension. Ultrasound prenatal auditory screening was performed after the 27th week of gestation, following the Protocol established in 1992. (Ljubic, Sovilj) included following procedures:

– Creation of medical documentation by trained perinatologist.

– Standard procedure for ultrasonic inspection.

– Set the antiphons lice on pregnant women, to turn off the sound effect of stimulus auditory system through the mother.

– Determination of fetal head position.

– Positioning of median fetal cerebral artery (MCA).

– Reading the basic values of Doppler parameters PI1.

– Generation of a defined digitized sound stimulus.

– Reading the peak values of Doppler parameters PI2.

Defined sound stimulus was digitally generated sound intensity 90 dB, frequency range 1500–4500 Hz and duration 0.2 seconds. Speaker is placed horizontally at 5 cm distance in relation to the abdominal wall of pregnant women. Ear type EP-107 in the form of ear shells that cover the entire ear, were placed on the mother's ears to eliminate the influence of a defined sound stimuli over auditory system of the mother to the fetal auditory response. Defined acoustic stimulus is presented only once, in order to investigate changes in cerebral cortical circulation of the fetus, given that the repetition of the stimulus in the short period leading to fetal habituation to the same (2). Other studies have confirmed that the fetus during the third trimester of pregnancy is clearly able to adapt to repeated stimuli applied to the mother's abdomen, as it also gives the response when the stimulus change (3).

RESULTS

We performed Shapiro–Wilk test for testing normality of distribution in our sample. In all our cases, the *P* values of the Shapiro–Wilk tests were close to zero and we had to use non-parametric tests. For testing the difference between two independent samples, we used Wilcoxon rank sum test with continuity correction. For testing independence, we used the chi-square test and the Fisher's exact test. We report below the values of the test statistics and their *P* values (4).

The first group had 268 patients while the second had 75 patients. The observational values were captured for nearly all women. We failed to capture the age of 5 women and in our opinion this does not affect the outcome of the statistical analysis.

Age of pregnant women in two groups showed that the mean age for group 1 is 30.05323 and median age for group 1 is 30. Mean age for group 2 is 32.84 and median age for group 2 is 33. The statistics of the Wilcoxon test is $W = 6823.5$ and P value = 4.505e –05. Therefore, we can say that there is high statistical difference in the age of the two groups. This completely correlates with the fact that increased age is one of the hypertension risk factors during pregnancy. Only 2.5% of patients were younger than 20 years and 3% older than 40.

Analysis of the gestational age (in weeks) in two groups revealed the median gestational age in weeks for group 1 is 39. Median gestational age in weeks for group 2 is 36.04. The statistics of the Wilcoxon test is $W = 13145$ and P value = 3.641e-05. Therefore, we can say that there is high statistical difference in the gestational age between the two groups. The explanation for this result is that, we monitor gestational hypertension in pregnancy with regular check up every month. So, prenatal fetal auditory screen was performed as soon as the 28th week of gestation. Low risk pregnancies were usually admitted in the delivery room and that means in the term pregnancies.

The number of previous pregnancies in two groups was as follows: mean number of previous pregnancies for group 1 is 0.5634 and median number of previous pregnancies for group 1 is 0. Mean number of previous pregnancies for group 2 is 0.88 and median number of previous pregnancies for group 2 is 1. The statistics of the Wilcoxon test is $W = 8000$ and P value = .002479. Therefore, we can say that there is high statistical difference in number of previous pregnancies between the two groups. This result confirmed that hypertension is repeated in pregnancies.

The Pulsatility Index (PI.1) value in two groups was as follows: mean PI.1 value for group 1 is 1.4751 and median PI.1 value for group 1 is 1.44. Mean PI.1 value for group 2 is 1.5089 and median PI.1 value for group 2 is 1.42. The statistics of the Wilcoxon test is $W = 9561.5$ and P value = .5203. Therefore, we cannot say that there is any statistical difference in the PI.1 value between the two groups (Figure 1).

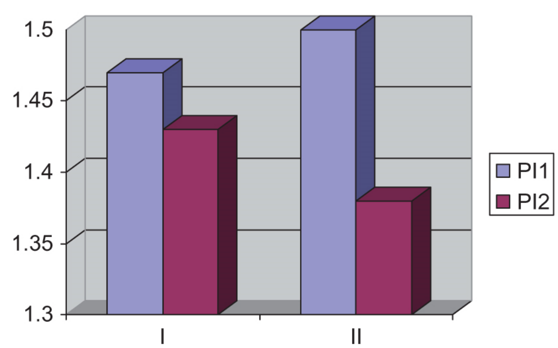


Figure 1. The mean values of PI1 and PI2.

The PI.2 value in two groups was as follows: mean PI.2 value for group 1 is 1.438 and median PI.2 value for group 1 is 1.38. Mean PI.2 value for group 2 is 1.4644 and median PI.2 value for group 2 is 1.45. The statistics of the Wilcoxon test is $W = 9189.5$ and P value = .2572. Therefore, we cannot say that there is any statistical difference in the PI.2 value between the two groups. However, bearing in mind that the *P* value is the probability of two groups having equal median and that, in this case it is not high, i.e. 0.2572, one can suspect that with larger sample in the group 2, one might get a different answer. So, in the second phase of the trial with increasing number of patients, we will probably get statistical significance.

That is, a rate of change of PI indexes, both pre and post, sound stimuli. The "–" type mean that, PI2 is bigger than PI1 and that is the result of decrease of cerebral circulation after the sound. The "+" is the opposite situation. Increase of PI2 is the result of decrease of circulation in median cerebral artery after the sound stimulation. There were 115 women in group 1 classified as "–" and 147 as "+". There were 31 women in group 2 classified as "–" and 43 as "+". The statistics of the Pearson's Chi-squared test is $X^2 = 0.0302$ with DF (degree of freedom) = 1 and P value = .862. The P value of the Fisher's Exact test is = .7917. Therefore, we cannot say that there is any statistical difference in the proportion of "–" and "+" between two groups (Figure 2).

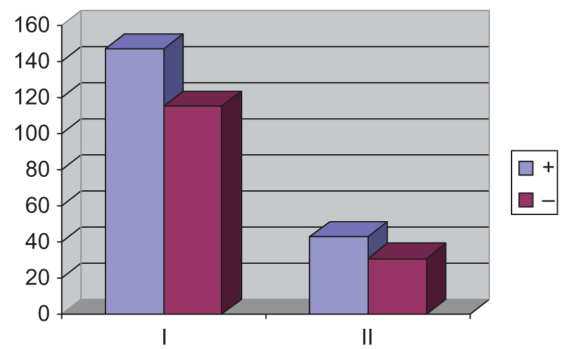


Figure 2. The rate of change of PI1 and PI2.

If we look for the percentage of fetuses with increase of cerebral blood flow after the sound stimuli, we can notice that the incidence of them in the first group of low risk pregnancies was 55% and in pregnancies with hypertension was 58%. Fetuses of mothers with hypertension had better reactivity and faster response to external factors, which is the consequence of adoptive mechanisms. Looking in the average change of PI before and after the sound stimuli, we noticed that in the first group it was 18.7% and in the second group it was 23.2%. That also showed greater circulatory response in fetuses with maternal hypertension (Figure 3).

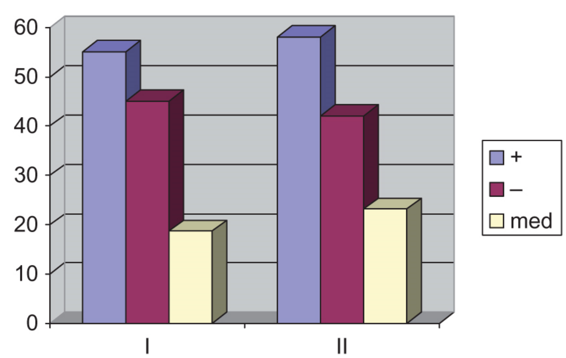


Figure 3. The percentage of change of PI1and PI2.

DISCUSSION

This area of fetal behavior was rarely investigated, probably due to difficulty to create constant auditory stimulus. Ljubic and Sovilj (1992) demonstrated fetal response to external auditory stimulus by changes in PI of median cerebral artery after the 28th week of gestation. The auditory stimulation was 80–90 dB of intensity and 1500–3000 Hz in frequency. After 5 times repeated sound, fetus got used to it and had no changes in cerebral circulation (2).

Scibetta and Rosen in 1971(5) studied fetal auditory response during the labor and detected the influence of peripartal distress on decrease of it (4). Luz and Pereira Lima in 1980 and 1985 tried to implement this test in detection of fetal hypoxia and fetal distress during delivery (6). Kisilevsky 1998 studied complete physical activation or relaxation of fetuses after different sound stimulation (7).

Jelicic and Sovilj 2007 demonstrated different modes and relative changes of PI of median cerebral artery after defined external sound stimulus in low risk and in high risk pregnancies. They proposed this method as prenatal hearing screening test, as routine procedure during the ultrasound follow up of fetuses (3).

Our results add Doppler analysis of fetal median cerebral artery after constant acustic stimulation in pregnancies after the 27th week of gestation in low risk pregnancies and in gestational hypertension. They also introduce the second stage of investigation correlated to the newborn and adequate postnatal hearing and neurology tests. This will probably help us in detection of various hearing and verbal defects in an early childhood.

CONCLUSION

The percentage of fetuses with increase of cerebral blood flow after the sound stimuli, was slightly higher in the pregnancies with hypertension. An average change of PI of median cerebral artery, before and after the sound stimuli was also higher in this group.

Fetuses of mothers with gestational hypertension had better reactivity and faster response to external stimuli and, although not statistically significant, these facts are opening new area of investigation of fetal behavior and probably in the near future will establish reliable hearing screening test.

REFERENCES

Hill M. Development of the Organs of Audition and Equilibrium (2010). Stage 22 Embryo (selected). UNSW Embryology ISBN: 978 0 7334 2609 4.

Sovilj M, Ljubic A, Milenkovic V. i sar. Mogucnost prenatalnog ispitivanja reakcije na zvuk kod fetusa sa kongenitalnim infekcijama. Zbornik radova sa simpozijuma za perinatalnu medicinu. 1992:17–18.

Jelicic Lj, Sovilj M, Vujovic M. The examination of fetal auditory perception and importance of prenatal auditory stimulation. XVII International Congress of the International Society of Pre and Perinatal Physiology and Medicine. Moscow, Russia, October 2007.

Bauer DF. Constructing confidence sets using rank statistics. J Am Stat Assoc 1972; 67:687–690.

Scibetta JJ, Rosean MG, Hochberg CJ, Chik L. Human fetal brain response to sound during labor. Am J Obstet Gynecol 1971; 109:82–85.

Luz NP, Lima CP. Luz SH, Feldens VL. Auditory evoked response of human fetus-behavior during labor. Acta Obstet Gynecol Scand 1980; 59:395–399.

Kisilevsky BS, Fearon I, Muir DW. Fetuses differentiate vibroacustic stimuli. Infant Behav Dev 1998; 21(1):25–46.

Read More: http://informahealthcare.com/eprint/zv9tPjyEPkEXkmuMQ632/full

VOCAL TRACT SHAPE ESTIMATION FOR CHILDREN AGES TO ONE YEAR

MILAN VOJNOVIĆ
Life Activities Advancement Center
vojnovicmilan@yahoo.com

Abstract: For a more complete and more comprehensive analysis of vowel formant frequencies, it is necessary to know the physical shape of the vocal tract. This is especially important if we need to do modeling of vowel pronunciation, or the estimation of maximum vowel space (MVS). Analysis of atypical pronunciation of vowels in children is a complex issue and needs to be analyzed from several aspects: simulation and modeling of sound propagation through the vocal tract, simulation of vowel pronunciation, MVS estimation etc. For all of this analysis it is necessary to know the shape of the vocal tract. Classical techniques for vocal tract shape estimation (X-ray, magnetic resonance, etc.) are not appropriate for children. One possibility is to use the shape of the vocal tract adults and, after that, correct it on the basis of anatomical and articulatory differences between children and adults. This paper presents a method for vocal tract shape estimating the shape of the child aged one year. The initial shapes of the vocal tract refer to the Russian vowels spoken by an adult male. We analyzed all the relevant anatomical and articulation parameters that influence the formant frequencies. Finally we got the configuration of the vocal tract for the five vowels that can be used for the initial analysis of the pronunciation of vowels children aged one year. These results are very useful for define the MVS for children of this age.

Keywords : maximal vowel space, vocal tract model, vocal tract shape, vowel formant frequencies

1. INTRODUCTION

Speech modelling involves synthesis and analysis of human voice. With well-modelled speech process we can better and properly understand the mechanisms and specificity of voice generating. Early detection of atypical pronunciation of certain phoneme, and speech in general, is very important because it provides an opportunity for action at the very beginning of the speech development. The practice of speech therapist work shows that the largest success are achieved in cases of early detection of voice and speech problems. In the earliest stages of child development, motor skills and speech are the main indicators of undisturbed growing up. The absence or abnormal development of usual speech phases (babbling, cooing, the pronunciation of some phonemes, making one and two syllable sounds, imitation, etc.) indicates a problems not only in voice but may be also result of atypical in other areas of child development.

Starting with the simplest speech model, known as "source-filter model" [Dudley, 1939], there are two important things: generating the primary voice and its filtration by passing through the vocal tract (the VT). The term primary voice has general meaning and depends on the type of voice that is generated: vibration of the vocal cord in vowel pronunciation, friction of ear stream in fricatives pronunciation, micro explosions in plosive pronunciation and the combination in pronunciation of the complex phonemes. From the point of intelligibility, the transfer characteristics of VT and its resonances are more important. The position of the resonances depends on the shape of VT, which is defined by the position of the articulators.

Vowels and plosives are among the first voices that occur in the early stage of the children language development. The vowels are more interesting for the analysis as their pronunciation follows vocal fold vibration. The analysis of vowel pronunciation provides an overview of the articulation and phonation capacities development of the child. However, the first step in modelling the vowel pronunciation is to define VT shape since it contains information about the spoken vowels. Distinguishing of vowels depends on formant frequencies, i.e. the vowels perceptual differ because they have different formant frequencies. The VT shape and degree of freedom of articulation organs determines formant frequencies variational space (maximal vowel space - MVS).

2. VOCAL TRACT MODELING IN CHILDREN

The VT transfer characteristic and its physical shape are directly connected. This fact is one of the arguments for the declaration of speech as a biometric parameter and is the basis of forensic speaker identification. In the case of vowel analysis then the resonant frequencies of VT are called formant frequencies. In short, the analysis of vowel formant frequencies means analyzes the VT shape, or the position of articulation organs.

In the fifties and sixties of last century, VT shape was obtained using X-rays. During the pronunciation of steady vowels, the lateral and frontal side of VT were filmed. Later, these pictures were used to determine VT cross-sectional area. Today, the reconstruction of the VT shape, with pronunciation of steady vowel, has been performing with magnetic resonance.

When it is about children, we cannot use X-rays or magnetic resonance imaging for the VT estimation. In these cases estimation of VT shape starts from data of adults VT. Of course, we should be careful, because there are certain rules and restrictions in conversion of VT adults in the VT child.

In engineering practice, theory of analogy is used in modelling pronunciation of certain phoneme. As a first step, the acoustic model of VT is converting into an equivalent electrical model. The further analyses are performing using standard methods of the theory of electrical circuits [Fant, 1970] [Flanagan, 1972]. Acoustic model of VT is in the form of short cylindrical tubes (cascade connected), with defined cross-sectional area. Therefore, the only parameter that must be known in order to realize the modelling is the VT cross-sectional area in function of distance from the glottis.

If we want to estimate the VT shape of children based on data for adults, we should keep in mind the following facts:

- the length of children VT is less,
- the cross-sectional areas of VT are lower in children,
- articulations of children and adults differ and
- VT morphology of adults and children are different.

According to the available data from the literature [Ménard *et al.,* 2007], the average length of VT is: 7.1 cm for the newborn, 10.5 cm for the four year old child, 16 cm for an adult female person and 17.3 cm for an adult male person.

Smaller VT in children implies a smaller length and lower volume, i.e. smaller cross-sectional area. A linear scale of VT adults cannot approximate the children VT, because there are important differences in the shape (different morphological structure). Difference in the VT shape resulting from it's a non-linear growth as well as the different articulation of adults and children. It is well known [Goldstein, 1980] that the length ratio of the pharyngeal and oral cavity differs in children and adults. This ratio is 0.5 in the newborn and 1.1 for adult men. This means that during the growth of the child, the pharyngeal cavity increases more than oral cavity. This fact means that a shape of VT adults have to be "compress" in the region of the pharyngeal cavity, if one wants to estimate the shape of VT child.

Children ages one year have not still adopted the mechanisms of pronounce certain sounds, so it is not reasonably to talk about "articulation". Pronunciation of vowels is significantly centralized, and they are very similar in perceptual domain. Discrimination of spoken vowels is quite complicated. In terms of physical VT shape, this means that the dynamic of cross-section area changes (cross-section area perturbation) will be smaller and the shape of VT will looks like a uniform tube.

All of these listed factors must be taken into account when modelling the VT children in order to obtain sufficient precision formant frequencies variational space, known as a maximal vowel space. The introduced term "maximum vowel space" (MVS) [Boe *et al.*, 1989] [Ménard & Boe, 2001] means an area of formant frequencies spreading for all vowels. Usually, only the first three formants are taken into account.

Some global rules related to the shape of VT and formant frequencies can be seen using simple models. One of the most popular models is the four-tube model. In this model, the first tube simulate mouth opening, the second tube represent oral cavity, the third tube simulate constriction "tongue-palate", and the fourth tube simulate pharyngeal cavity. For some of the vowels even four-tube model are simplified and reduced to the two-tube model [Stevens, 1989] [Stevens, 1998]. However, the consequence of such a drastic simplifications of VT shape is the impossibility of harmonizing the real dimensions (particularly length) and real formant frequencies. If simulated and measured formant frequencies are similar it is possible that the length of modelled and real VT differ by 2-3 cm. This difference in length of VT is the price of simplifying its shape.

3. VOWELS FORMANT FREQUENCIES CHANGES FOR DIFFERENT VT SHAPES

The first case to be analyzed is simply scaling of VT shape. Starting from Fant's vowels [Fant, 1970], the formant frequencies are estimated for the following cases:

- unchanged length of VT,
- VT was reduced by 12.5%,
- VT was reduced by 25%,
- VT was reduced by 37.5% and
- VT was reduced by 50%.

The simplest way to do this is to change the length of tube segments which approximates VT. In unchained case length of tube segment is 5 mm, while in other cases the lengths are: 4.375 mm, 3.75 mm, 3.125 mm and 2.5 mm, respectively.

We used the VT model with losses in which the impedances of the VT wall, glottis and sub glottis system are infinitely. Radiation impedance is approximated by radiation circular piston set in a spherical baffle [Vojnovic & Mijic, 2005]. Formant frequencies (resonant frequencies and transfer characteristics of VT) were calculated by program FFOR [Vojnovic, 2008], which is based on algorithms given in [Badin & Fant, 1984]. This model of VT was used in all following simulations.

All three vowel formant frequencies increase linearly: if the length of VT is reduced by 50% (two times shorter VT) formant frequencies are increased by about 100% (two times higher formant frequencies). Among the all analyzed parameters below, change the length of VT has the greatest impact on the formant frequencies.

Next simulation will be shown how formant frequencies depend on linear changes of VT cross-sectional area. Similar to the previous case, the cross-sectional area of each cylindrical segment (tube) is reduced by: 0%, 12.5%, 25%, 37.5% and 50%, respectively.

The results show that there are no significant changes in formant frequencies when the cross-sectional area of VT reduced by the same percentage value. If the cross-sectional area of VT is reduced by 50%, formant frequencies are increased by less than 1%. In this case, as in the previous, there is a linear relationship between the percentage of scaling the cross-sectional VT area and vowel formant frequencies change.

Somewhat larger changes of formant frequencies were obtained with reduced cross-sectional area over 50%. All this confirms the well known fact that formant frequencies do not vary significantly from the VT volume, but only on its shape. Decrease or increase the volume VT does not affect the formant frequencies, if the VT length is unchanged and VT has the same shape, i.e. relations between the cross-sectional areas are unchanged.

As can be seen, formant frequencies are same as long as relative ratio of the VT cross-sectional area is unchanged. However, it is much more interesting the case of non-uniform changes in the VT cross-sectional area. With these non-uniform changes differences in the articulation of children and adults can be simulated. Certainly, in children aged up to a year or two the ability to move articulation organs is less than in adults. In the domain of the VT physical dimensions that means the range of cross-sectional area change is smaller in children. The shape of VT children looks like a uniform tube.

The "grade" of articulation is simulated by the gradually changed VT shape to a uniform tube; transforming VT in a uniform cylindrical tube same length. For an adult male mean value of the VT cross-sectional area is 5 cm^2. In this simulation the cross-sectional area of each cylindrical segment is changed in five linear steps. At the end of transformation each of the segments has a cross-sectional area of 5 cm^2.

Gradually transformation of VT shape to uniform cylindrical tube leads to drastic changes in formant frequencies. The first three formant frequencies gravitate to the following frequencies: 480, 1440 and 2400 Hz. These frequencies correspond to quarter wave resonances for tube of length 17.5 cm. The mean VT length for five Russian vowels is 17.6 cm.

The percentage changes are significant at lower formant frequencies (the first two formants) than the higher formants.

In children under the age of one year pronunciation of vowels is very centralized as a result of "shallow" articulation, VT shape looks like a uniform tube. Besides that, the mobility of articulation organs is limited. Because of that, there are not significant differences in the VT shape when the child speaks different vowels.

In the simulation of different articulations of adult man and child we must not forget the protruding lips. In practice this means that, together with a decrease in cross-sectional area perturbation (shallow articulation), to simulate smaller range of VT length changes (less lips protruding).

Finally, a simulation of different larynx height index (LHI) [Goldstein, 1980] is done. This index in fact shows the length ratio of the pharyngeal and oral cavity, and it is 0.5 for the newborn and 1.1 for an adult male.

In pronunciation of different vowels it is not always clearly defined boundaries between oral and pharyngeal cavity, so this part of the simulation will be partially simplified. We assume that the first two centimetres above the glottis is larynx. The following eight centimetres is the pharyngeal cavity and the remainder is oral cavity. Simulation of LHI values of 0.5 will be done by the "compressing" VT shape in the pharyngeal cavity region by factor of 0.7 and "stretch" it by factor 1.4 in the region of the oral cavity.

The process of converting VT with different LHI is illustrated in Figure 1. The above diagram shows the initial (unchanged) VT shape during the pronunciation of vowels /a/ [Fant, 1970]. On the diagram below, the lengths of all cylindrical segments in the range from 2 cm to 10 cm are increased 0.7 times, and the length of remaining cylindrical segment increased 1.4 times. Lengths of the first four cylindrical segments (range from 0 cm to 2 cm) are unchanged.

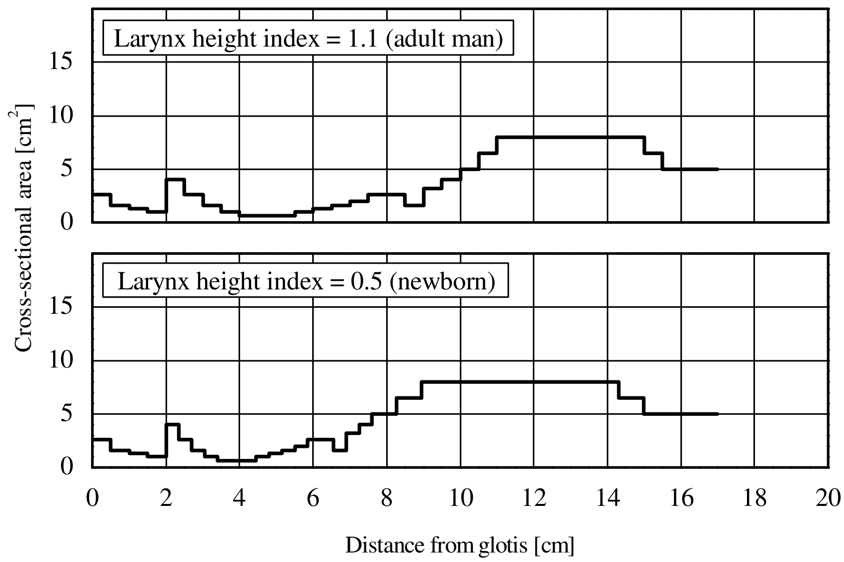


Figure 1. Dependence of the VT cross-sectional area in function against the distance from the glottis for two values of the larynx height index (pronunciation of Russian vowel /*a*/).

The second formants for the middle and back vowels (/*a*/, /*o*/ and /*u*/) have the biggest changes. Percentage change of these formant frequencies are about 10%.

4. VOCAL TRACT SHAPE ESTIMATION

The starting point is the VT shape of adult man for cases when he pronunciation the Russian vowels. The first step in estimation of the child VT shape is length scaling. According to the data available in the literature [Ménard *et al.*, 2007], the average length of child VT is about 8 cm. To simplify estimation, it was choose twice-shorter VT length in compare to adult male. This principle of shortening the VT length was applied for each vowel. Practically that means, in calculation of the transfer characteristics of the VT adult male the length of the cylindrical segment is 5 mm, but in case of one-year-old child, the length is 2.5 mm.

The next step is to change the LHI value from 1.1 to the value of 0.5. This means that the pharyngeal cavity is compressed and stretched oral cavity.

VT children are shorter and have a smaller volume and cross-sectional area is smaller. It is taken that the cross-sectional area is four times smaller in compare with adult male. In addition, the larynx of one-year-old child was modeled with four 0.25 cm long cylindrical tubes with next cross-sectional areas: 0.125, 0.125, 0.25 and 0.25 cm^2 [Goldstein, 1980].

In order to better simulate the centralized vowel pronunciation in children, the cross-sectional area was increased by 20% in cases where the surface was less than some referent (mean) value. Opposite, the cross-sectional area was reduced by 20% were the surface was greater than the referent values. Mean cross-sectional area in adult male man is 5 cm^2 and 1.25 cm^2 (5/4 = 1.25) in the one-year-old child. With this correction of cross-sectional area, the shape of VT is "smoother", i.e. it has become more like a uniform cylindrical tube.

With Regard to the different articulations in adults and one-year-old child, a correction of the VT length was made in the sense of simulating less ability of protruding lips in children. The average length of an adult male VT is about 17.5 cm. According to the criteria adopted in this paper, average length of one-year-old child VT is 8.75 cm (17.5/2=8.75). Limited lips protruding, in some way, involve equalizing the VT length in the case of vowel pronunciation. We use the following principles of equalization VT length: If the length of the VT, during the pronunciation of a vowel, is greater than 8.75 cm, then the VT length is reduced. On the other side, if the length of VT less than 8.75 cm, then its length increased.

Figure 2 shows estimated VT shapes of one-year-old child, and the first three formant frequencies of these configurations VT are in Table 1.

Table 1. Formant frequencies of Russian vowels spoken by adult male and estimated formant frequencies for one-year-old child.

Vowels Formants	Adult male [Hz]	One-year-old child [Hz]	Ratio of frequencies
F_1 [*a*]	641.3	1244.9	1.941
F_2 [*a*]	1083.8	2928.5	2.702
F_3 [*a*]	2468.9	5035.6	2.040
F_1 [*e*]	419.4	911.5	2.173
F_2 [*e*]	1973.4	3746.6	1.899
F_3 [*e*]	2819.1	5770.3	2.047
F_1 [*i*]	226.9	689.7	3.040
F_2 [*i*]	2276.1	3816.5	1.677
F_3 [*i*]	3109.4	6161.7	1.982
F_1 [*o*]	504.2	1090.0	2.162
F_2 [*o*]	866.7	2438.5	2.814
F_3 [*o*]	2390.0	4669.1	1.954
F_1 [*u*]	236.8	784.8	3.314
F_2 [*u*]	599.8	1876.7	3.129
F_3 [*u*]	2383.0	5012.2	2.103

With thin dashed lines are drawn VT shapes for an adult male, but with scaled length (reduced twice) and the cross-sectional area (reduced four times). This scaling is done in order to easy compare VT shapes. As it can be seen, there are different caused by different LHI (pharyngeal cavity is compressed and mouth cavity is stretched) and differences in articulation (less range of changes the cross-sectional area and the total length of VT in the case of one-year-old child).

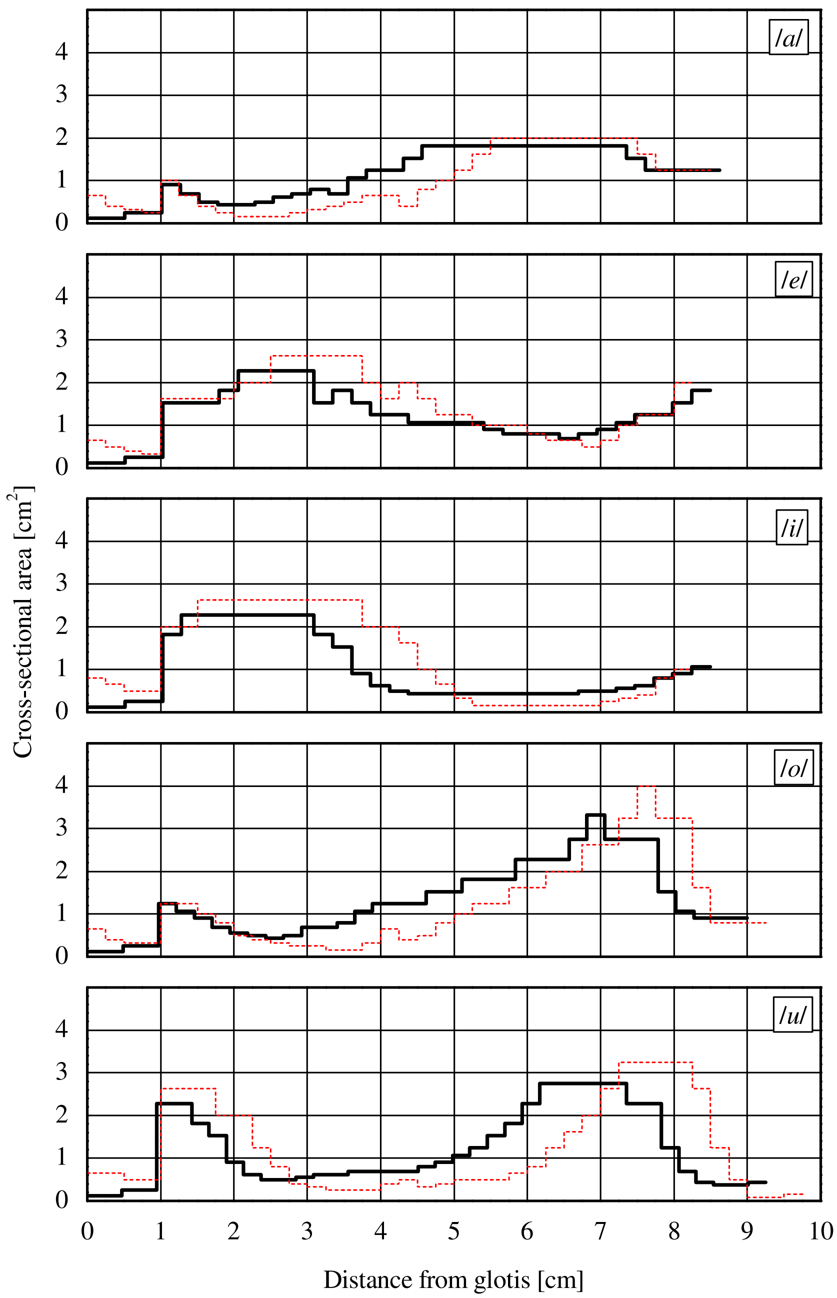


Figure 2. Estimated VT shapes of one-year-old child in the case of vowels pronunciation (thick line) and the scaled VT shapes of adult male (thin dashed line).

Formant frequencies in Table 1 show that the ratio of formant frequencies of one-year-old child and adult males is about 2. However, there are exceptions, where the ratio is much higher:

- first formants of vowels /*i*/ i /*u*/ and
- second formants of vowels /*a*/, /*o*/ and /*u*/.

This fact shows that the estimation of vowel formant frequencies, spoken by children, cannot be applied the simple principle of formant frequency scaling.

5. DISCUSSION

In previous chapters, we analyzed the vowel formant frequencies changes for the four most important parameters: the VT length, VT volume, articulation and larynx height index. Some of these parameters have a larger or smaller effect on the formant frequencies, but all of them have to be involved in the estimation of one-year-old child VT shape.

Modeling different articulations of children and adults may be used for finely adjust the differences between simulated and real measured formant frequencies. Simulation of centralized pronunciation leads to a shift of formant frequencies to a single point in the F_1-F_2-F_3 space: 910, 2750 and 4630 Hz. For an adult male, this point is defined with frequencies: 480, 1440 and 2400 Hz. On the other hand, the equalization of the VT length increases the formant frequencies of middle and back vowels (/*a*/, /*u*/ i /*o*/). At the same time, that process decrease the formant frequencies of front vowels (/*i*/ i /*e*/).

Shape of VT for the newborn [Goldstein, 1980] are slightly different from the results presented in this paper. In [Goldstein, 1980] only three VT configurations are presented: for vowels /*i*/, /*a*/ and /*u*/. Figure 3 shows the VT configuration for these vowels together with VT configurations resulted from this work.

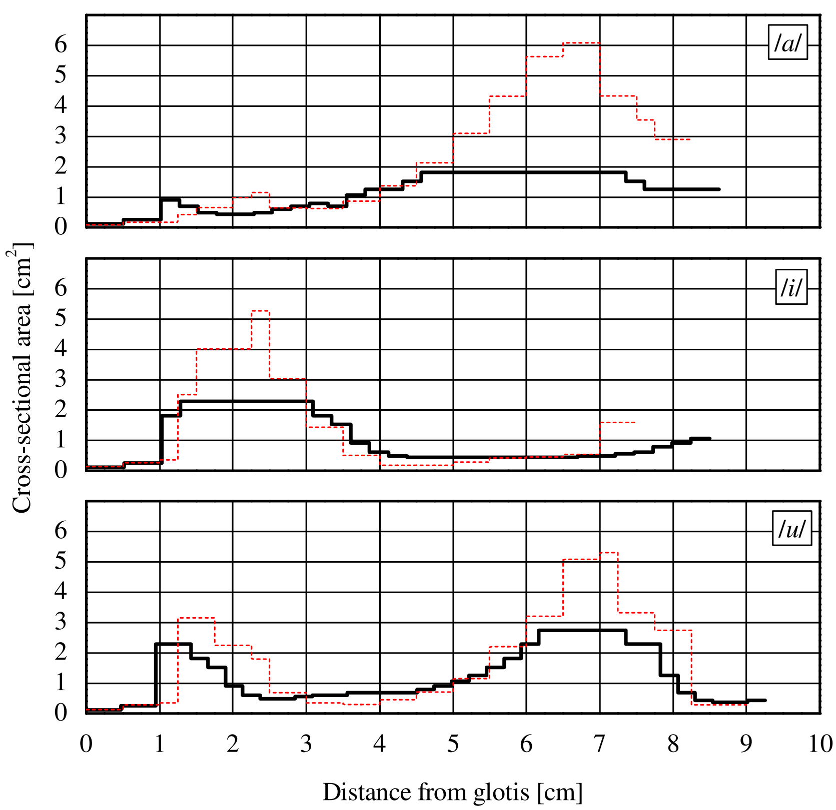


Figure 3. Estimirani oblici VT jednogodišnjeg deteta (debela linija) u poređenju sa rezultatima iz [Goldstein, 1980] (tanka isprekidana linija).

The biggest differences between the estimated VT shapes are value of cross-sectional area. They are considerably higher in estimated configurations of [Goldstein, 1980]. There are significant differences in the VT length, for example. vowel /*i*/. In principle, [Goldstein, 1980] have shorter VT because it is newborn VT model. It is interesting to note that the general shapes of VT are similar.

Table 2. Vowel Formant frequencies pronunciation by a one-year-old child (the results of this paper) and newborn (results presented in [Goldstein, 1980]).

Vowels Formants	One-year-old child [Hz]	Newborn [Goldstein, 1980] [Hz]
F_1 [*a*]	1244.9	1542.2
F_2 [*a*]	2928.5	2843.5
F_3 [*a*]	5035.6	5899.9
F_1 [*i*]	689.7	571.0
F_2 [*i*]	3816.5	4752.0
F_3 [*i*]	6161.7	7804.9
F_1 [*u*]	784.8	671.9
F_2 [*u*]	1876.7	1434.5
F_3 [*u*]	5012.2	5859.3

Formant frequencies for the two cases VT shape estimation are given in Table 2. It can be seen that there are significant differences in the formant frequencies. Differences are of the order 20%. Results of real vowel formant frequencies, which pronounce the one-child, should be considered for possible correction VT shape. In any case, the main corrections should be pointed to the value of cross-sectional area and VT length.

6. CONCLUSION

Estimation of VT shape of children aged one year is not an easy task, because they cannot use the traditional imaging methods, such as X-rays and magnetic resonance. It remains only to perform estimation based on the data on the VT shape of adults. In doing so, the child VT shape may not get by simple scaling VT adults. It must be taken into account the different anatomical, morphological, articulation, etc. parameters that affect speech.

This paper analyzes relevant parameters that are different for adults and children, and that influence vowel pronunciation. This analysis was used to evaluate which is the articulation and anatomical factors must be taken during the transformation of VT adults to VT child. The final result is estimated VT shapes pf one-year-old child in case of pronunciation five vowels.

It is a VT shape estimation, so we cannot talk about the degree of VT configuration accuracy. The results are subject to revision, so in the future research should conclude the degree of overlap between measured formant frequencies and vowel formant frequencies obtained by modeling.

There are many parameters that can be used for correcting modeled formant frequencies, and thus the VT shape, in order to obtain a better match with the real measurements.

ACKNOWLEDGMENTS

The work was partly funded by the Ministry of Science and Technological Development of Serbia through the project "E-Speech therapist" number TR32032.

REFERENCES

Dudley H. (1939): *The vocoder*, Bell Labs Rec., Vol. 18, 122-126.

Fant, G. (1970). *Acoustic theory of speech productionitle*, Mouton, The Hague.

Flanagan, J. (1972). *Speech analysis, synthesis and perception*, Springer-Verlag, New York, 1972.

Ménard, L., Schwartz, J. -L., Boë, L. -J., Aubin, J. (2007). *Artyculatory-acoustic relationships during vocal tract growth for French vowels: Analysis of real data and simulations with an articulatory model*, Journal of Phonetics 35, 1-19.

Goldstein, U. G. (1980). *An articulatory model for the vocal tract of the growing children*, Thesis of Doctor of Science, MIT, Cambridge, Massachusett.

Boë, L.-J., Perrier, P., Guérin, B. and Schwartz, J.L. (1989). *Maximal vowel space*, Eurospeech 89, 281-284.

Ménard, L., Boë, L. -J. (2001). *Perceptual categorization of maximal vowel space from birth to adulthood*, European Conference on Speech Communication and Technology (Eurospeech), Aalborg, Danemark, 167–170.

Stevens, K.N. (1989). *On the quantal nature of speech*, Journal of Phonetics 17, 3-45.

Stevens K.N. (1998). *Acoustic phonetics*, MA: The MIT Press, Cambridge.

Vojnović, M., Mijić, M. (2005). *An improved model for the acoustic radiation impedance of the mouth based on an equivalent electrical network*, Applied Acoustics 66, 481-499.

Vojnović, M. (2008). *Uticaj maske na akustičke i artikulacione karakteristike govora*, Ph.D. dissertation, Elektrotehnički fakultet, Beograd.

Badin, P., Fant, G. (1984). *Notes on vocal tract computation*, STL-QPSR 2-3/1984, 53-108.

Boë, L. -J., Heim, J. -L., Honda, K., Maeda, S., Badin, P., Arby, C. (2007). *The vocal tract of newborn humans and Neanderthals: Acoustic capabilities and consenquences for the debate on the origin of language. A reply to Lieberman (2007a)*, Journal of Phonetics 35, 564-581.

ESTIMACIJA OBLIKA VOKALNOG TRAKTA DECE UZRASTA DO JEDNE GODINE

APSTRAKT

Za potpuniju i svestraniju analizu formantnih frekvencija vokala, potrebno je znati i fizički oblik vokalnog trakta. Ovo je posebno bitno ako se, uporedo sa analizom, radi i simulacija, modelovanje izgovora vokala, ili ako se estimira maksimalna oblast vokala (MOV). Kod analize atipičnog izgovora vokala radi se simulacija, odnosno modelovanje prostiranja zvuka kroz vokalni trakt. Klasične tehnike estimacije oblika vokalnog trakta (rendgen, magnetna rezonansa i sl.) nisu primerene za decu. Jedna od mogućnosti je da se koristi oblik vokalnog trakta odrasle osobe i da se on koriguje na bazi anatomskih i artikulacionih razlika dece i odraslih osoba. U radu je prikazan postupak estimacije oblika vokalnog trakta jednogodišnjeg deteta. Početni oblici vokalnog trakta se odnose na ruske vokale koje izgovara odrasla muška osoba. Analizirani su svi relevantni anatomski i artikulacioni parametri koji imaju uticaja na formantne frekvencije. Kao krajnji rezultat, dobijene su konfiguracije vokalnog trakta za pet vokala koji mogu da posluže za početnu analizu izgovora vokala jednogodišnjeg deteta, kao i za definisanje MOV.

Milan Vojnović, Centar za unapređenje životnih aktivnosti

MOVEMENT AND SPEECH

TATJANA ADAMOVIĆ[1,2], MIRJANA SOVILJ[1,2], KSENIJA RIBARIĆ-JANKES[3]

[1] Life Activities Advancement Center, Belgrade, Serbia
[2] The Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia
[3] Euromedic Hospital Belgrade, Belgrade, Serbia
tadus3@gmail.com

Abstract: Speech recognition as a movement, stresses the importance of preservation of sensory processing systems. The vestibular system, as the most complex sensory system, affects motor control and motor planning, coordinates body movements, balances and helps children to develop normal muscle tone required for the production of clear speech. The aim of this study was to examine the links and interdependence of movement and speech, by testing vestibular function in children with developmental dysphasia and children with normal speech and language development. The study sample was comprised of N = 40 children of both genders, aged 5 to 6 years. Experimental (E) group consisted of 20 children diagnosed with developmental dysphasia who are undergoing treatment at the Institute for Experimental Phonetics and Speech Pathology in Belgrade, and the control group (C) consisted of 20 children with normal speech and language development from kindergarten " Roe " in New Belgrade. For the assessment of vestibular function in mentioned sample, 5 standardized tests have been applied. The obtained results were recorded by means of a digital camera, then scored and statistically and descriptively processed. The research results suggest the existence of statistically important difference regarding parameters of tested vestibular function in the E and C group.
Key words: movement, speech, sensory integration, vestibular system

1. INTRODUCTION

A growing number of researches have suggested a relationship between vestibular function and speech-language development (Magrun et al, 1981; Ray et al, 1988; Tomatis 1996; Ayres, 2005; Kranowitz, 2006; Niklasson et al, 2010; Emami et al, 2012).

Tomatis (1997), recognized the vestibular function as the primary sensory integrator and as the first system of communication phylogenetically. The vestibular system detects motion and gravity, and controls all motor functions, plus muscle tone, balance, coordination (including coordination of eye movements and coordination of movements between the two sides of the body), and body image. Because the vestibular system allows individuals to have a sense of the relationship between the self and space, it lays the groundwork upon which visual images are superimposed. Finally, it is the "programming unit" of the nervous system, which is directly connected to the cerebral cortex - the portion of the brain responsible for higher order processes such as speech, language, reading, writing, and logical thought.

Moving activates the ability to speak. Occupational therapists have found that when they treat a child for vestibular disfunction, speech and language skills can improve along with balance, movement and motor planning skills (Kranowitz, 2006).

Decreased vestibular processing can impact on the area of speech and language development, particularly auditory processing. Therapy aimed to improve the function of the vestibular system could also result in improved language development (Tomatis, 1997; Ayres, 2005).

Movement is a nonverbal response for children who do not yet have language ability. The vestibular system (part of the ear related to balance and movement) must be activated for learning to take place. Disturbance to the vestibular system can cause learning difficulties. This highlights the importance of movement in the beginning years to strengthen the vestibular system and ready the brain for learning (Hannaford, 1995).

Movement helps to provide oxygen and another wonderful thing happens with movement - the brain produces a neuro-chemical called endorphins. This chemical causes a feeling of energy and makes the brain more conducive to learning. Movement and rhythm stimulate the frontal lobes, important in language development. This portion of the brain grows between the ages of two and six (Campbell, 2000).

A child, who cannot stand on one foot, probably can't read and write because standing on one foot demonstrates the ability to balance and being able to balance is the result of a strong vestibular system. The vestibular system is strongly related to language abilities. (Hannaford, 1997).

Children with bilateral loss of vestibular function at birth or in childhood, show considerable delay in motor development. These kids start to stand, to walk and to speak later than children whose vestibular function is preserved (Angeli, 2003).

Assessment of balance in children has long been recognized as an important link in the evaluation of child development. Some disorders of vestibular function that is detected only in adulthood, have their origin since childhood. Clinical testing of vestibular function includes evaluation of eye movements, body posture and walk (Camarda et al, 1981).

2. AIM

The aim of this study was to examine the links and interdependence of movement and speech, by testing vestibular function in children with developmental dysphasia and children with normal speech and language development.

3. RESEARCH METHODOLOGY

The study sample was comprised of N = 40 children of both genders, aged 5 to 6 years. Experimental (E) group consisted of 20 children diagnosed with developmental dysphasia who are undergoing treatment at the Institute for Experimental Phonetics and Speech Pathology in Belgrade, and the control group (C) consisted of 20 children with normal speech and language development from kindergarten" Roe " in New Belgrade. For the assessment of vestibular function in mentioned sample, 5 standardized tests have been applied. Each test is examined in three attempts. The interval between each trial was 5 seconds. Depending on success of the performance of the task, each attempt is scored on a scale range from 0 to 2 points.

3.1. Romberg test (RT)

The child is calm, centered head, with feet pressed together, the eyes are closed. Child was asked to stay in that position 10 to 15 seconds. As this is a test of balancing without visual control, the movements of the body, arms, legs and feet were observed. The test was graded as follows:

2 – good balance without movement

1 – balance is possible only with slight movements of ankles, toes, or with slight movements of the whole body

0 – there is no balance with closed eyes, the child moves feet toward the other side to keep from falling.

3.2. The reaction of balance in standing position (BSP)

A child stands still, his head is centered, with hands that hang down beside the body and feet spaced 5cm. The examiner gently pushes child's shoulder, first to one and then to the other side. The intensity of pushing scaled up according to the age of the child. The whole procedure is repeated three times to the left and three times to the right.

(You should keep the child an upright position without moving the legs to the contralateral side. The child will try to maintain balance by changing body position to the ipsilateral side. If it fails, it can distort to the contralateral side with outstretched arms, or can even make a step to the side. By keeping his free hand on the contralateral side, at some distance from the child, the examiner may prevent the falling of a child who has poor balance). Scoring of this test was as follows:
2 – maintain a balance, not moving except to prevent some sudden sway movements
1 – take a step sideways or spreads his arms and shoulders
0 – fall sideways and the examiner must keep him

3.3. Assessment of walking on the line (WOL)

The child is required to walk in a straight line 20 steps ahead and then back to the starting position. Toes of one foot may not accurately touch the heel of the other leg. At the age of 5 to 7 years, 3 deflections are allowed. The described test is graded as follows:
2 – walk without deviation from the line
1 – 4 to 6 deviations from the line
0 – can not walk in a line, there are more than 6 deviations from the line

3.4. Standing on one leg (SOL)

The child is required to stand on one leg for 20 seconds, the hands are extended ahead with palms facing up. The same procedure is repeated 3 times, standing on the left and on the right leg. Scoring of the mentioned test was the following:
2 – stable standing on one leg 10-12 seconds or more
1 – trying to stand but descends foot to the floor, withstands up to 3 seconds
0 – can not stand on one leg

3.5. Test of touching fingertip (TFT)

The child is seated with the arm flexed at the elbow at an angle of 90 °. The examiner holds his index finger in front of the child (pointing to the child), and the child is required to touch examiner`s tip of finger with its fingertip. Distance from examiner to the child shall be such that child always extends and flexes his hand at the elbow while make a contact with the tip of examiner`s finger. The examiner holds his finger statically all the time of testing. The precision of touching of examiner`s fingertip is observed. The procedure is repeated 3 times with one and 3 times with the other hand. The test is scored:
2 – touch the tip of examiner`s finger accurately
1 – touching with uncertainty and 1 failure
0 – a failure in touching of examiner`s finger, the fingertip of the child goes to one or to the other side

The obtained results were recorded by means of a digital camera, then scored and statistically and descriptively processed. The following statistical measures and procedures were applied: frequencies and percentages, arithmetic mean and standard deviation, significance of differences between the arithmetic means.

4. RESULTS AND DISCUSSION

Table 1 - Romberg's test in C and E group

Group	AM	SD	N
Control	1,68	0,35	20
Experimental	1,28	0,48	20
	t-test = 3,03 (level 0,01)		

Table 1 shows the achievements of the two mentioned groups on Romberg's test of balancing. The average achievement of children from the C group is 1.68 points, and it is 0.40 points higher compared to children in the E group who have gained 1.28 points on average. The difference between average values of 0.40 points, on the scale range of 0 to 2 points, is statistically significant on the level of 0.01, which is indicated by t-test value of 3.03 with conclusion certainty of 99%. Thus, children with normal speech and language development have significantly better ability to maintain balance without visual control compared to children with developmental dysphasia.

Table 2 – The reaction of balance in standing position in C and E group

BSP	C group (20)		E group (20)		t-test significance
	AS	SD	AS	SD	
Left	1,57	0,51	1,03	0,53	t = 3,25 (level 0,01)
Right	1,87	0,23	1,28	0,52	t = 4,58 (level 0,01)
Total	1,72	0,32	1,16	0,48	t = 4,31 (level 0,01)

The reaction of balance in a standing position, was tested three times in the left and three to the right side. By calculating the average score for the left and the right sides, the average score for the test as a whole was calculated. The results of this analysis, shown in table 2, suggest that the ability to maintain balance in a standing position is significantly better in C group compared to E group, both for the left and the right side of the body, and at the test as a whole. The respondents with normal speech and language development, achieved 1.57 points on average for the left and 1.87 points on average for the right side, which was 0.54 and 0.59 points higher than those in the E group. At the same time, the test results as a whole, suggest that the average score in the E group was lower by 0.56 points compared to the average grade children from C group. All three differences between arithmetic means are significant at the level of 0.01 which is indicated by t-test value of 3.25; 4.58 and 4.31 with reliability of conclusions of 99%.

Data in table 3 show the results of achievement in C and E group regarding assessment of walking on the line. The difference of 0.37 points on average (higher average value in C than in E group), on a scale range from 0 to 2 points, is statistically significant at the level of 0,01 as indicated by a t-test of 3, 24 with conclusion certainty of 99%.

Table 3 – Assessment of walking on the line in C and E group

	WOL		
Group	AS	SD	N
Control	1,87	0,25	20
Experimental	1,50	0,44	20
	t-test = 3,24 (level 0,01)		

Therefore, children with developmental dysphasia have significantly poorer ability to maintain balance during walking in a straight line compared to children with normal speech and language development.

Table 4 – Standing on one leg in C and E group

SOL	C group (20)		E group (20)		t-test significance
	AS	SD	AS	SD	
Left	1,53	0,49	0,78	0,41	t = 5,27 (level 0,01)
Right	1,60	0,45	1,17	0,43	t = 3,12 (level 0,01)
Total	1,57	0,43	0,98	0,36	t = 4,69 (level 0,01)

Table 4 shows the results of SOL test in C and E groups. SOL procedure was repeated three times on the left and three on the right leg, then the result for the test as a whole has been calculated. Respondents from C group, achieved 1.53 points on average for the left and 1.60 points on average for the right side, which was 0.75 and 0.43 points higher than those in the E group. At the same time, the test results as a whole suggest that the average score in C group is higher for 0.59 points compared to the average grade children in the E group. All three differences between arithmetic means are significant at the level of 0.01 which is indicated by t-test value of 5.27; 3.12 and 4.69 with the reliability of conclusions from 99%. Thus, ability to maintain balance on one leg is significantly less developed in children with developmental dysphasia compared to children with normal speech and language development.

The fifth test assesses the accuracy of the child to touch examiner`s fingertip. The procedure is performed first with one and then with the other hand, in three attempts for each hand. The total test score is the average success of performing by left and by right hand. As in the previous four tests, the results of the C group were significantly better compared to E group. The differences between the arithmetic means, in this case, are statistically significant at the level of 0.01 which is indicated by t-test values given in table 5.

Table 5 – Test of touching fingertip in C and E group

TFT	C group (20)		E group (20)		t-test significance
	AS	SD	AS	SD	
Left	1,83	0,30	1,30	0,49	t = 4,14 (level 0,01)
Right	1,90	0,24	1,47	0,46	t = 3,70 (level 0,01)
Total	1,87	0,20	1,38	0,42	t = 4,62 (level 0,01)

Regarding the left forefinger, the difference between the C and E group is 0.53 points on average (AS_C = 1,83 points, AS_E = 1,30 points), and as for the right index finger difference is 0.43 points (AS_C = 1,90 points, AS_E = 1,47 points). The average score of the C group for the test as a whole is 1.87 points, and 1.38 points for the E group, or difference of 0.49 points on a scale range from 0 to 2 points. With certainty of 99%, we conclude that the precision of TFT is significantly lower in children with developmental dysphasia compared to children with normal speech and language development, both for the left and for the right index finger, as well as for the test as a whole.

Based on the results achieved in all five tests, the total score was calculated for each respondent. Thus, the scale ranges from 0 to 10 points which presents the overall functioning of the vestibular apparatus of C and E groups, was obtained.

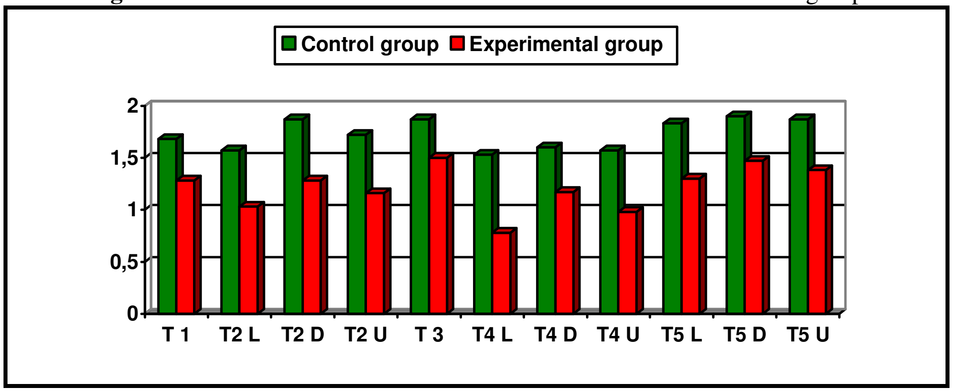
Table 6 – Achievement on tests in total in C and E group

	Tests in total (RT+BSP+WOL+SOL+TFT)		
Group	AS	SD	N
Control	8,70	1,33	20
Experimental	6,30	1,72	20
	t-test = 4,93 (level 0,01)		

The arithmetic mean in E group, calculated on the basis of all the five standardized tests, is 6.30 points. In the C group, the average achievement is 8.70 points. The difference of 2.40 points is statistically significant at the level of 0.01, which is indicated by a t-test of 4.93 with a confidence of 99%. Therefore, the vestibular system is significantly better developed in children with normal speech and language development compared to children with developmental dysphasia at the age of five to six years.

By analyzing the results presented in the previous tables and in Figure 1, it can be seen that of total 11 average values in five tests for assessment of vestibular function, taking into account the results related to the left and to the right side, in the E group, only in one case reached a value of 1.50 points. It's the ability to walk in a straight line. All other arithmetic means in the E group, have a lower value. The score in all five standardized tests ranges from 0 to 2 points. 0 points indicates a failure, 1 point - partially completed task and score of 2 points - successfully executed order.

Figure 1 – Results of the assessment of vestibular function in C and E group



On the other hand, in the group of children with normal speech and language development, none of the 11 average values in all five tests for the assessment of vestibular function, does not have value of 1.50 points, respectively, all arithmetic means have higher value than 1.50 points. Lowest score in the C group is 1.53 points and refers to the SOL. Standard deviation, which emphasize the dispersion of results around the mean, always have a higher value in the E group in comparison to the C group. From this we can conclude that in children with normal speech and language development, there is more homogeneity regarding proper function of vestibular apparatus, while in children with developmental dysphasia, greater individual differences in development of the vestibular functioning are presented.

5. CONCLUSION

The obtained research results enabled the following conclusions:

- children with normal speech and language development have significantly better ability to maintain balance without visual control in relation to children with developmental dysphasia (t = 3,03 and certainty of 99%).
- C and E groups are significantly different regarding the ability to maintain a balance in a standing position, in favor of the control group both for left and right sides of the body, as well as at the test as a whole (t = 3.25 T = 4.58 T = 4, 31; reliability of 99%).
- children with developmental dysphasia have a significantly poorer ability to maintain balance during walking in a straight line compared to children with normal speech and language development (t = 3.24, conclusion certainty of 99%).
- ability to maintain balance on one leg, either left or right as well as at the total achievements on the test, is significantly poorer in E than in C group. All three differences between arithmetic means are significant at the level of 0.01 which is indicated by t-test value of 5.27; 3.12 and 4.69 with the reliability of conclusions from 99%.
- precision of touching fingertip is significantly lower in children with developmental dysphasia compared to children with normal speech and language development, both for the left and the right index finger, as well as for the test as a whole (certainty of 99%).

Research results unambigously showed that there were statistically significant differences in all examined parameters of vestibular function between the control and experimental groups. The vestibular system is significantly better developed in children with normal speech and language development compared to children with developmental dysphasia at the age of five to six years. In children with normal speech and language development, there is more homogeneity regarding proper function of vestibular apparatus, while in children with developmental dysphasia, greater individual differences in development of the vestibular system are presented.

Acknowledgements: This research study was supported by the Ministry of Science and Technological development of the Republic of Serbia within the project no. 178027**.**

REFERENCES:

Angeli, S. (2003). Value of Vestibular Testing in Young Children with Sensorineural Hearing Loss. *Arch Otolaryngol Head Neck Surg*, 129 (4): 478-482.

Ayres, A. J. (2005). Sensory integration and the child: 25th anniversary edition, *Western Psychological Services,* ISBN: 978-087424-437-3, pp. 90-97.

Camarda, V., Moreno, AM., Boschi, V., DiCarlo, A., Spaziani, G., Saponara, M. (1981). Vestibular ototoxicity in children: a retrospective study of 52 cases. *Int J Pediatr Otorhinolaryngol,* 3: pp. 195-198.

Campbell, D. (2000). *The Mozart effect for children*. New York, NY: William Morrow.

Emami, S.F., Pourbakht, A., Sheykholeslami, K., Kamali, M., Behnoud, F., Daneshi, A. (2012). Vestibular Hearing and Speech Processing. *ISRN Otolaryngology,* Hindawi Publishing Corporation, Vol. 2012, Article ID 850629, doi: 10.5402/2012/850629.

Hannaford, C. (1995). *Smart moves: Why learning is not all in the head*. Arlington, VA: Great Oceans Publishing.

Hannaford, C. (1997). *The dominance factor*. Arlington, VA: Great Oceans Publishing.

Kranowitz, K.S., Miller, L.J. (2006). *The Out-of-Sync Child: Recognizing and Coping with Sensory Processing Disorder,* ISBN-13-9780399531651, Penguin Group (USA) Incorporated.

Magrun, W.M., Ottenbacher, K., McCue, S., Keefe, R. (1981). Effect of Vestibular stimulation on Spontaneous Use of Verbal Language in Developmentally Delayed Children. *American Journal of Occupational Therapy*. Amer. Occup. Th. Association, Inc.; Vol. 35 (2): 101-104.

Niklasson, M., Niklasson, I., Norlander, T. (2010). Sensorimotor therapy: Physical and psychological regressions contribute to an improved kinesthetic and vestibular capacity in children and adolescents with motor difficulties and concentration problems. *Social Behavior and Personality,* Society for Personality Research (Inc.), vol. 38 (3): 327-346.

Ray, T.C., King, L.J., Grandin, T. (1988). The effectiveness of self-initiated vestibular stimulation in producing speech sounds in an autistic child. *Occupationa Therapy Journal of Research,* ISSN/ISBN 0276-1599, University of Kansas; Vol. 8 (3): 186-190.

Tomatis, A. A. (1997). *The Ear and Language*. In Eds.:(Billie M. Thompson), ISBN–13: 978-0969707981, Moulin Bub.

POKRET I GOVOR

T. ADAMOVIĆ[1,2], M. SOVILJ[1,2], K. RIBARIĆ-JANKES[3]

[1] Centar za unapređenje životnih aktivnosti, Beograd, Srbija

[2] Institut za eksperimentalnu fonetiku i patologiju govora, Beograd, Srbija

[3] Bolnica Euromedik Beograd, Beograd, Srbija

tadus3@gmail.com

Apstrakt: Mnogi složeni procesi doprinose sposobnosti deteta da govori, uključujući motoričko učenje, motorno planiranje, senzorno procesiranje i senzornu integraciju. Prepoznavanje govora kao pokreta upućuje na važnost očuvanosti senzornog sistema za procesiranje. Vestibularni sistem, kao najsloženiji senzorni sistem, utiče na motornu kontrolu i motorno planiranje, koordinira pokrete tela, uspostavlja ravnotežu i pomaže deci da razviju normalan mišićni tonus neophodan za produkciju jasnog govora. Cilj rada je bio da se ispitaju veze i međuzavisnosti pokreta i govora, kroz testiranje funkcije vestibularnog aparata kod dece sa razvojnom disfazijom i dece sa normalnim govorno-jezičkim razvojem. Uzorak istraživanja je bio sastavljen od N=40 dece, oba pola, uzrasta od 5 do 6 godina. Eksperimentalnu (E) grupu činilo je 20 dece sa dijagnostikovanom razvojnom disfazijom koja se nalaze na tretmanu u Institutu za eksperimentalnu fonetiku i patologiju govora u Beogradu, a kontrolnu (K) grupu je činilo 20 dece sa normalnim govorno-jezičkim razvojem iz vrtića ''Srna'' na Novom Beogradu. Za procenu funkcije vestibularnog čula, primenjeno je 5 standardizovanih testova. Svaki test se ispitivao iz tri pokušaja. Dobijeni podaci su dokumentovani uz pomoć digitalne kamere, statistički i deskriptivno obrađeni. Rezultati istraživanja su ukazali na postojanje statistički značajne razlike u pogledu ispitanih parametara vestibularne funkcije u E i K grupi.

Ključne reči : *pokret, govor, senzorna integracija, vestibularni sistem*

Zahvalnica: Istraživanje je podržano od strane Ministarstva za nauku i tehnološki razvoj Republike Srbije unutar projekta no. 178027.

ON APPLICATIONS OF FUZZY SYSTEMS IN AFFECTIVE COMPUTING

DRAGAN ŠALETIĆ
School of Computing, University ''Union'', Belgrade, Serbia
DZSaletic@gmail.com

Abstract: Machine implementations of emotion models can be of importance in medical practice, especially in an analysis of language and speech disorders. So, applications of fuzzy systems theory in the part of computer science, affective computing, are considered. Basic notions of fuzzy systems and of affective computing are, shortly, given. Emotions are considered. An overview of research in connection with the considered topic is given. A possibility of emotion recognition in natural speech, based on fuzzy expert systems, is discussed. Conclusions are given and possibilities of applications of the approach considered are pointed out.
Keywords: fuzzy systems, afective computing, emotion recognition, natural speech

This paper is supported by Ministry of Education and Science –Serbia, project #32032, "E-logoped''.

1. INTRODUCTION

Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer sciences, psychology, and cognitive science. As the modern branch of computer science the field originated with Rosalind Picard's 1995 paper [Picard, 1995] on affective computing. The basic notion of the field is the notion of human affect: Affect refers to the experience of feeling or emotion [http:://www.wikipedia.org]. It is a key part of the process of an organism's interaction with stimuli. The word also refers sometimes to affect display, which is a facial, vocal, or gestural behavior that serves as an indicator of affect. A motivation for the research in the field of affective computing is the ability to simulate empathy. The machine should interpret the emotional state of humans (and machines) and adapt its behavior to them, giving an appropriate response for those emotions. Detecting emotional information begins with passive sensors which capture data about the user's physical state or behavior without interpreting the input. The data gathered is analogous to the cues humans use to perceive emotions in others. For example, a video camera might capture facial expressions, body posture and gestures, while a microphone might capture speech. Other sensors detect emotional cues by directly measuring physiological data, such as skin temperature and galvanic resistance. Recognizing emotional information requires the extraction of meaningful patterns from the gathered data. This is done using machine learning techniques that process different modalities speech recognition, natural language processing, or facial expression detection, and produce either labels (i.e. 'confused') or coordinates in a valence-arousal space. The problem the paper is dealing with is: how to model emotions in machines, considering that as important in medical practice, especially in an analysis of language and speech disorders.

Modeling emotions is the task that includes dealing with uncertainty, situations where a stimulus can be connected with more causes. Those are situations in which communication with an expert system closer to natural language is needed, where the approach based on classical set theory and two-valued logic is insufficient. Fuzzy sets [Zadeh, 1965] are an alternative to the traditional notion of a set. The basic assumption of the theory of sets that every element belongs or does not belong to the given set, that there is nothing in between, excludes many sets of real objects. Motivated by this, Zadeh extended the notion of a set, to the notion of a fuzzy set. He substituted an rigid or-or relation from sets theory, by a more flexible relation, allowing a membership degree for every object from the universe of discourse, in the form of a numerical characteristic of our (subjective) tendency to accept that object as the member of a (fuzzy) set. Some real situations are difficult (or even impossible) to translate into simulation models using precise language, such as classical sets theory (two-valued logic) without losing some of their important semantic values. Loss of richness of meaning of statement expressed in a natural language is not felt in many situations adapted to the classical approach, but if it is important not to lose that richness of meaning of natural language, the communication with an expert system formulated as close to the natural language as it is possible, is important. As modeling emotions is such a situation, the paper is dealing with an application of fuzzy systems theory in affective computing.

The rest of this paper is organized as follows: Section II provides a short overview of fuzzy systems. Section III presents a short overview of affective computing. Section IV deals with emotions. Section V gives an overview of applications of fuzzy systems in affective computing and considers emotion recognition in natural speech based on fuzzy systems. Section VI summarizes conclusions and possible directions for further research.

2. FUZZY SYSTEMS

2.1. Basic concepts

Fuzzy systems are based on fuzzy logic (or fuzzy sets theory), [for example, Šaletić, 2012]. The central concept is that truth values (in fuzzy logic) or membership values (in fuzzy sets theory) are given by a value on the range [0.0, 1.0], with 0.0 representing absolute Falseness and 1.0 representing absolute Truth. For example, the statement ''Dragan is old'' might be assigned the truth value of 0.80 if Dragan's age was 75. The statement can be translated into set terminology as follows: ''Dragan is a member of the set of old people.'' This statement can be presented symbolically in fuzzy sets notation as:

$$\mu_{OLD}(Dragan) = 0.80,$$

where μ is the membership function operating, in this case, on the fuzzy set of old people, which gives a value between 0.0 and 1.0.

Fuzzy logic and probability deal with different kinds of uncertainty. Both operate over the same numeric range: 0.0 representing False (or non-membership) and 1.0 representing Truth (or membership). However, there is a distinction to be made between the two statements: the probabilistic approach gives the natural-language statement "There is an 80% chance that Dragan is old'', while the fuzzy approach gives ''Dragan's degree of membership within the set of old people is 0.80.'' The semantic difference is significant: the probability view supposes that Dragan is or is not old (still caught in the Law of the Excluded Middle); it is just that one has an 80% chance of knowing which set Dragan is in. On the other hand, fuzzy terminology supposes that Dragan is ''more or less'' old, or some other, but similar, term can be connected to the value of 0.80. Further differences arising from the operations will be noted below.

In fuzzy logic operations of EMPTY, EQUAL, COMPLEMENT (NOT), CONTAINMENT, UNION (OR), and INTERSECTION (AND) are defined.
Definition 1: Let X be some set of object, $X = \{x_1, x_2, \ldots, x_n\} = \{x\}$. Element x is generic element in X. X is called: universe of discourse.
Definition 2: A fuzzy set A in X is characterised by a membership function $\mu_A(x)$ which

maps each element in X onto the real interval [0.0, 1.0]. As $\mu_A(x)$ approaches 1.0, the ''degree of membership'' of x in A increases.

Figure 1 shows graphical representation for a fuzzy set A.

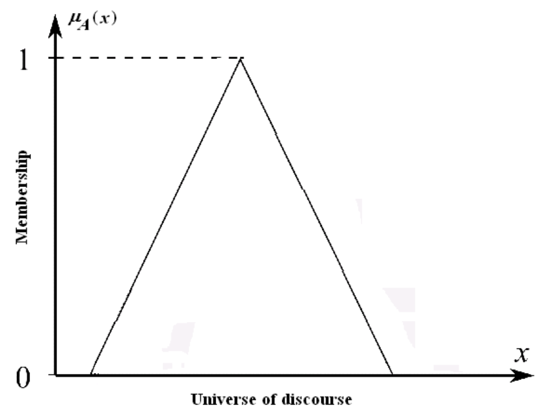


Figure 1. Membership function for a fuzzy set A.

Let A , B and C be fuzzy sets.
Definition 3: A is EMPTY if and only if (iff) for all x from X $\mu_A(x) = 0.0$.
Definition 4: $A = B$ iff for all x in X, $\mu_A(x) = \mu_B(x)$.
Definition 5: Complement of A , denoted as A' is defined by $\mu_{A'}(x) = 1 - \mu_A(x)$.
Definition 6: A is CONTAINED in B iff $\mu_{A'}(x) \leq \mu_B(x)$. (subset)
Definition 7: $C = A$ UNION B , where: $\mu_C(x) = \text{MAX}(\mu_{A'}(x) , \mu_B(x))$.
Definition 8: $C = A$ INTERSECTION B , where: $\mu_C(x) = \text{MIN}(\mu_{A'}(x) , \mu_B(x))$.

The last two operations, UNION (OR) and INTERSECTION (AND), represents those differences between probabilistic theory for sets and fuzzy sets.

Based on fuzzy logic, fuzzy expert systems have been developed, which use IF-THEN rules, and are closer to natural languages than rule-based systems developed using two-valued logic. In fuzzy expert systems rules are usually expressed in the form:

IF *variable* IS *property* THEN *action*

where *property* (for example, old) is expressed by a fuzzy set.

For example, a simple temperature regulator that uses a fan might look like this:

IF temperature IS very cold THEN stop fan
IF temperature IS cold THEN turn down fan
IF temperature IS normal THEN maintain level
IF temperature IS hot THEN speed up fan

In fuzzy expert systems all of the rules are evaluated, because the temperature might be "cold" and "normal" at the same time to different degrees.

Beside fuzzy expert system, a problem solution can be modeled as a fuzzy decision-making system [Šaletić, 2012], and these two classes of systems (fuzzy expert and fuzzy-decision-making) are main classes of fuzzy systems. A fuzzy system can be thought of as an aggregation of models of systems and models of uncertainty.

2.2. Type 2 fuzzy sets

Fuzzy systems have been around for nearly 50 years, and they generated widely accepted applications, among which fuzzy-logic controllers are the most noticeable one. Very soon after introducing fuzzy sets (FS), L. Zadeh, the father of fuzzy logic, in the paper [Zadeh, 1975] in which he introduced many important notions of fuzzy sets, introduced also a generalization of his fuzzy sets now called type-2 fuzzy sets (T2 FS): fuzzy sets with fuzzy membership degree, and, in general, type-*n* fuzzy sets. Now, fuzzy sets with membership degrees that are crisp numbers from $[0,1]$ are called type-1 fuzzy sets (T1 FS). However, T2 FS, that is, Zadeh's generalization of T1 FS have not been actively studied until Zadeh's paper from 1996., [Zadeh, 1996]. Research activities dealing with computing with words based on T2 FS have been intensified, after that Zadeh's paper.

A T2 FS embeds more T1 FSs in order to express their cumulative uncertainty about the word modeled. This is illustrated in the Figure 2, where three triangular T1 FSs are shown. Note that their starting and ending points at the bottom are marked with round, square and curly brackets for easier recognition. The shaded area is called *footprint of uncertainty* (FOU). Its lower boundary is named *lower membership function* (LMF) and its upper boundary is named *upper membership function* (UMF). The real T2 FS is a three-dimensional function built over the FOU. Normally, to each of the n embedded T1 FS $\mu_i(x)$ is assigned another weighting function $W_i(x)$ that signifies the *possibility* assigned to this particular $\mu_i(x)$ for a given x [Mendel, Wu, 2010]. This weighting functions define the third dimension of T2 FSs. For a value x' a T2 FS gives a set of n 3-tuples $\{(x', \mu_i(x'), W_i(x'))\}$. There, the set $J_{x'} = \{\mu_i(x')\}$ is called *primary membership* of the variable x', and the set of 2-tuples $\{(\mu_i(x'), W_i(x'))\}$, is then called its *secondary membership* .

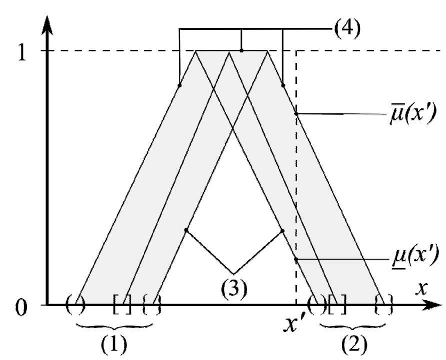


Figure 2. A FOU created out of three T1 FS. The marked items are 1) - uncertainty about left end-point, 2) uncertainty about right end-point, 3) LMF, 4) UMF

The *interval approach* (IA) method can be used to model words. In this approach all $W_i(x)$ are uniform, that is, equal to 1, which makes the third dimension of such T2 FS uninteresting for further discussion. All such T2 FSs are also named *interval type-2 fuzzy sets* (IT2 FS).

In the IA, from each surveyed person is acquired an interval [$x_l^{(i)}$, $x_r^{(i)}$] used to describe how the person understands the word. Then, for each interval a symmetric triangular T1 FS membership function is defined and embedded into an IT2 FS. The set of all {$x_l^{(i)}$} is the uncertainty about the left end-point, and {$x_r^{(i)}$} is the uncertainty about the right end-point (Figure 2).

Like it is the case with T1 FSs, there are also three kinds of IT2 FSs to be considered: left shoulder, interior and right shoulder, as is depicted on the Figure. 3.

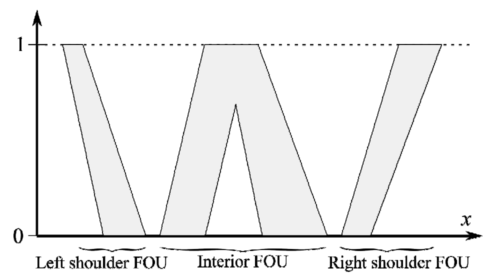


Figure 3. Three considered types of IT2 FS FOU.

The last important concept is the centroid of an IT2 FS. The set {c_i} of all centroids of the embedded T1 FSs can be found. Then the centroid of an IT2 FS is the set of all {c_i}, or rather the interval [c_l, c_r], defined by c_l = min{c_i} i c_r = max{c_i} in the continuous case.

Many words would constitute a *codebook* that can be used as a catalogue for modeling problems being solved, [Šaletić, Anđelković, 2013].

3. AFFECTIVE COMPUTING

Picard [Picard, 1995] submitted, for discussion a set of ideas on what she called affective computing, computing that relates to, arises from, or influences emotions. Affective computing today is also called human-computer interaction (HCI), or “kansei” information processing (Japanese term for human ability to solve problems and process information in personal and quick way, not merely logical ways). Picard suggested models for affect recognition, and present her ideas for new applications of affective computing to computer-assisted learning, perceptual information retrieval, arts and entertainment, and human health and interaction. She also described how advances in affective computing, especially combined with wearable computers (with new affect sensing possibilities – especially through skin-surface sensors that detect muscle tension, skin conductivity, heart activity, temperature, and respiration), can help advance emotion and cognition theory. Emotions play a necessary role not only in human creativity and intelligence, but also in rational human thinking and decision-making. Computers that will interact naturally and intelligently with humans need the ability to at least recognize and express affect. Affective computing is a new field, with results primarily in the recognition and synthesis of facial expression, and the synthesis of voice inflection. Picard has proposed some possible models for the state identification, treating affect recognition as a dynamic pattern recognition problem. She described areas where affective computing may be applied. In particular, with wearable computers that perceive context and environment as well as physiological information, there is the promise of gathering powerful data for advancing results in cognitive and emotion theory, as well as improving our understanding of factors that contribute to human health and well-being. Although Picard has focused on computers that recognize and portray affect, she has also mentioned evidence for the importance of computers that would "have" emotion. Emotion is not only necessary for creative behavior in humans, but without emotion, computers are not likely to attain creative and intelligent behavior There is a challenge in building computers that not only recognize and express (simulate) affect, but which *have emotion* and use it in making decisions.

An affective computer [Picard, 2000] should not be built with only affective abilities, which would lead to infantile behavior at best. An affective computer still needs to have logical reasoning abilities. Additionally, it should have the skills to recognize its user's affective expressions, and to respond intelligently, especially if the user indicates frustration, fear, or dislike of something the computer can change. It should have the skills of emotional intelligence [Goleman, 2008], the ability to recognize and respond intelligently to emotion, the ability to appropriately express (or not express) emotion, and the ability to manage emotions, including an ability to manage its own emotional mechanisms, and to use them for improving its cognitive and rational functioning. Giving computers affective abilities is an effort to bring balance and reason to their logical skills. And having affective computers, technology with emotional intelligence can help people manage emotions, even in medical practice.

Nowadays, affective computing is a branch of artificial intelligence that deals with the design of systems and devices that can recognize, interpret, and process emotions. Since the introduction (1995), the research community in this field has grown rapidly. Affective computing is an important field because computer systems have become part of our daily lives. As computer systems are becoming more complex, there is need for more natural user interfaces for the overwhelmed computer users. Given that humans communicate with each other by using not only speech but also implicitly their facial expressions and body postures, machines that can understand human emotions and display affects through these multimodal channels could be beneficial. If virtual agents and robots are able to recognize and express their emotions through these channels, the result of that will be more natural human-machine communication. This will allow human users to focus more on their tasks at hand.

Affective computing has become an important research area in the last years having as a goal development of emotional artificial intelligence agents.

4. EMOTIONS

Emotions are part of interaction between human beings, and part of interaction of humans with artificial intelligence agents. Also, the importance of emotions in human intelligence has been emphasized in recent decades. It has been shown that people whose traditional logical reasoning is intact but whose emotions are disconnected make poor judgments and decisions. Emotions in humans consist of a constellation of regulatory and biasing mechanisms, operating throughout the body and brain, modulating just about everything a person does. Emotion can affect the way you walk, talk, type, gesture, compose a sentence, or otherwise communicate. Thus, to infer a person's emotion, there are multiple signals you can sense and try to associate with an underlying affective state. Depending on which sensors are available (auditory, visual, textual, physiological, biochemical, etc.) one can look for different patterns of emotion's influence. The most active areas for machine motion recognition have been in automating facial expression recognition (machine vision), vocal inflection recognition (speech recognition), and reasoning about emotion given text input about goals and actions. The research focus originally in affective computing, was on detecting six “basic” facial expressions (anger, sadness, happiness, disgust, surprise, fear) from still images, and then from video. In short, current technology is still far behind what people can recognize from one another’s faces. Most pattern recognition researchers are familiar with a variety of tools for representation of patterns –including discrete categories, fuzzy or probabilistic categories, and dimensioned spaces, to name a few that are particularly relevant to emotion representations. Emotion theorists do not agree upon a definition of emotion, but most of them fall into one of two camps in how they describe emotion – either as basic discrete categories, e.g., fear, sadness, joy, etc., or as locations within a dimensioned space, the two foremost dimensions of which are usually termed “arousal” and “valence.” The arousal dimension tends to refer to the overall excitement or activation of the emotion, while the valence dimension tends to refer to how pleasing (positive) or displeasing (negative) the emotion is. A given emotion can of course be represented in multiple ways. For example, anger can be represented as a discrete category, defined by some collection of attributes, such as by facial actions that typify its expression, or by some bodily parameters that lie within a negative valence, high arousal portion of a dimensioned space. In general, facial expressions are good at communicating valence (positive, negative) while vocal inflection (especially pitch and loudness) is good at communicating arousal. Combinations of facial and vocal analysis tend to strengthen the inference of the underlying emotion.

One of the advantages of a system that can recognize affective expressions, especially those of pleasure or displeasure, is that it can try out different responses on a user, to see which are most pleasing. Indeed, a core property of most learning systems is the ability to sense positive or negative feedback – affective feedback – and incorporate this into the learning routine. When communicating with humans an agent’s emotional behavior has to consider the current human emotions in order to react in a sensible way. Recognition and expression of emotion are essential for effective communication.

5. RELATED WORK

5.1. Some emotional models in robotics based on fuzzy systems

In last fifteen years approaches for emotion recognition in natural language have been developed, as speaker-dependent or speaker-independent systems. Speaker-dependent systems achieved emotion recognition rate from about 70% to 95%, and speaker-independent systems about 50% (humans approximately 60%, for unknown speaker), [Austerman et al., 2005]. Systems are based on following approaches: neural networks, maximum a posteriori probability, hidden Markov models, K-nearest-neighbours-clustering, support vector machines, and others (for example, combination of decision trees and rule-based systems). At Waseda University, Japan, several autonomous robots have been developed with the ability to communicate with humans, among them WAMOEBA-2R, [data from Alvarez et al., 2010]. A neural network with feedback-error-learning algorithm is used in WAMOEBA-2R.At Yale University Nico was developed, a robot with “eyes” (cameras) and gyroscope. The robot, called eMuu was created as a cooperative project between Eindhoven University of Technology and Carnegie-Mellon University, for investigation of user interaction with robots. Kismet and Yuppy, are well known robots from MIT with characteristics of affective computing.

Austermann and her colleagues [Austerman et al., 2005], developed robot head MEXI (Machine with Emotionally eXtended Intelligence), which recognizes emotions from facial expressions and from natural speech and shows artificial emotions by its facial expressions and speech utterances as well. MEXI’s natural speech (prosody) based emotion recognition system; PROSBER uses a fuzzy based approach to distinguish the emotions anger, fear, sadness, happiness and neutral emotional state. For each of emotions a fuzzy expert system is automatically generated from a training data base of speech samples. Two working modes are distinguished, training and recognition. During training, samples with well-known emotion values are used to create the fuzzy models for individual emotions. These fuzzy models are used in the emotion recognition for classification of unknown audio data. In fuzzy classification, the output for each emotion is defuzzified using the center of gravity method. The emotion with the highest degree is returned as recognized. The speech recognition system is implemented in C++, the training algorithm is written in Java, and FFLL-Library is used for fuzzy classification. The system recognizes 84% of the test samples correctly in speaker-dependent mode, and 60% in speaker-independent mode.

Alvarez and her colleagues [Alvarez et al., 2010], considered an emotional model for a robot URBANO operating as tour guide in museums and exhibitions. The model let URBANO show emotional behaviour that can be understood and accepted by humans. The model considers the system dynamic, which is adjustable. All variables can be defined for each emotion under consideration. Fuzzy logic is used for calculation of the matrix coefficients. State matrices are built with rules based on linguistic labels defined for the variables under consideration. This allows an intuitive use of the model. Objective was to integrate intelligent behaviour in guide robot, to make robot sensitive to a stimuli set so that the robot behaves in a different way depending on its emotions at the moment. So, the robot would be sensitive to its surroundings, and its behaviour would be easily accepted in fairs and museums. The model of emotions is simple and flexible, and it does not require specific mathematical knowledge, since the fuzzy rule language is similar to colloquial language. The model is implemented using C++.

5.2. Some other emotional models based on fuzzy systems

Facial expression plays an important role in human's daily life, in face-to-face human communication, only 7% of the communicative message is due to linguistic language, 38% is due to paralanguage, while 55% of it is transferred by facial expressions. Human facial expression has the character of fuzziness. There is also fuzzy relationship between emotion and facial expression. One emotion can be fuzzily expressed by multiple modes of facial expression, and one mode of facial expression can be fuzzily recognized as multiple emotions. In [Mao et al., 2008] a model has been proposed of layered fuzzy facial expression generation (LFFEG) to create expressive facial expressions for an agent in the affective human computer interface. In this model, social, emotional and physiological layers contribute to the generation of facial expression. Fuzzy theory is used to produce rich facial expressions and personality for the virtual character. The known mechanisms of a mapping of many expressions to a few emotions, a given expression mapped to more than one emotional state, and a mapping from one expression to different emotional states are used. The model of fuzzy emotion-expression mapping is given. Based on the correlation of multiple facial expressions of emotions, fuzzy emotion expression mapping is proposed, in which emotion and facial expression are supposed to be fuzzy vectors, and a fuzzy relation matrix consisting of degrees of membership maps the fuzzy emotion vector to the fuzzy facial expression vector.

Words and natural language play a central role in describing and understanding of emotions. [Kazenzadeh et al, 2013] deals with the problem of creating a computational model for the conceptual meaning of words used to name and describe emotions. To do this, they represent the meaning of emotion words as interval type-2 fuzzy sets (IT2 FSs) that constrain an abstract emotion space. They present two models that represent different views of what this emotion space might be like. The first model consists of the Cartesian product of the abstract scales of valence, activation, and dominance. The second model is based on scales derived from answers to yes/no questions, where each scale can be seen as the truth value of a proposition. In each model, the meaning of an emotion word is represented as a fuzzy set in an emotion space, but the two models represent different theoretical organizations of emotion concepts. In IT2 FS model for the meaning of emotion words, an emotion space and emotional variables are introduced as follows: let E be an emotion space, an abstract space of possible emotions. An emotion variable f represents an arbitrary region in this emotion space, i.e., $f \subset E$, with the subset symbol $\subset$ used instead of set membership ($\in$) because intention to represent regions in this emotion space in addition to single points. The intentional meaning of an emotion word can be represented by a region of the emotion space that is associated with that word. An *emotion codebook* $C = (W_C, \text{eval}_C)$ is a set of words W_C and a function eval_C that maps words of W_C to their corresponding region in the emotion space, $\text{eval}_C : W_C \to E$. Thus, an emotion codebook can be seen as a dictionary for looking up the meaning of words in a vocabulary. Words in an emotion codebook can also be seen as constant emotion variables. The region of the emotion space that eval_C maps words to is determined by interval surveys. Two basic relations on emotion variables: similarity and subsethood, are considered. A translation is a mapping from the words of one vocabulary (W_1) to another (W_2), as determined by the corresponding codebooks (C_1, C_2):

$$\text{translate} : W_1 \times C_1 \times C_2 \to W_2 ,$$

which is a perceptual computer, [Šaletić, Anđelković, 2013].

.

6. CONCLUSSION

In last fifteen years affective computing has been constituted as a branch of artificial intelligence that deals with the design of systems and devices that can recognize, interpret, and process emotions. As computer systems are becoming more complex, there is need for more natural user interfaces. Given that humans communicate with each other by using not only speech but also emotions, machines that can understand human emotions and display affects through these multimodal channels could be beneficial. If artificial intelligence agents are able to recognize and express their emotions through these channels, the result of that will be more natural human-machine communication. This will allow human users to focus more on their tasks at hand. Also, machine implementations of emotion models can be of importance in medical practice, especially in an analysis of language and speech disorders.

The research presented in the paper has shown that fuzzy systems theory offers good foundations for development of models of emotions that can be used for machine implementations of affective computing systems. In those models both T1 FS and T2 FS have their place. Those results are the base for further work.

REFERENCES

Alvarez, M., R. Galán, F. Matia, D. Rodrigez-Losada, A. Jiménez, (2010) An Emotional Model for a Guide Robot, *IEEE Trans. On Systems, Man and Cybernetics – Part A: Systems and Humans*, vol. 40, no. 5, Sept. 2010, pp. 982- 992.

Austermann, A., N. Esau, L. Kleinjohann, B. Kleinjohann, (2005) Fuzzy Emotion Recognition in Natural Speech Dialogue, *Proc. 14th IEEE Int. Workshop on Robot and Human Interactive Communication*, 2005, 13-15 August 2005., Nashville, USA, pp. 317-322

Goleman, D, (2008) *Emocionalna inteligencija*, ,Geopoetika, Beograd
http:://www.wikipedia.org
Kazemzadeh, A. S. Lee, S. Narayanan, (2013) Fuzzy Logic Models for the Meaning of Emotion Words, *IEEE Computational Intelligence Magazine*, Vol.8, No. 2, May 2013, pp.34-49
Mao X., Y. X., Zheng Li and H. Bao (2008) Layered Fuzzy Facial Expression Generation: Social, Emotional and Physiological, in Or, J., editor: *Affective computing, Focus on Emotion Expression, Synthesis and Recognition*, I-Tech Education and Publishing, Vienna, Austria
Mendel, J. M. , D. Wu, (2010) "*Perceptual Computing: Aiding people in Making Subjective Judgments*" John Wiley & Sons Inc., Hoboken, New Jersey, 2010, ISBN 978-0-470-47876
Picard, R. W.(1995), *Affective computing*, MIT Technical Report #321
Picard, R. W.(2000), *Affective computing*, MIT Press paperback edition, 2000, (1997 MIT)
Šaletić,D.Z., (2012). *Rasplinuti skuupovi i rasplinuto-logički sistemi*.Eduka, Beograd
Šaletić D. Z, M. Anđelković, (2013) An Object Oriented Realization of Perceptual Computer,´in E. PAP (editor), Inntelligent Systems: Models and Applications , Springer Heidelberg New York Dordrecht London , pp. 155-173
Zadeh, L. A, (1965), "Fuzzy Sets", *Information and Control* 8, pp. 338-353
Zadeh, L.A. (1975): The concept of linguistic variable and its application to Approximate Reasoning.I*nformation Sciences* 8, part I, 199–249
Zadeh, L.A.(1996): Fuzzy logic = Computing With Words. *IEEE Trans. on Fuzzy Systems* 4, 103–111

PRIMENA RASPLINUTIH SISTEMA U AFEKTIVNOM RAČUNARSTVU

APSTRAKT

Računarska realizacija modela emocija može biti od značaja u medicinskoj praksi, naročito u analizi nepravilnosti u govornom jeziku i samom govoru. Stoga, razmatra se primena teorije rasplinutih sistema u oblasti afektivnog računarstva. Ukratko su dati osnovni pojmovi rasplinutih sistema, kao i afektivnog računarstva. Razmatraju se emocije. Dati su podaci o istraživačkom radu u vezi sa razmatranom temom. Potom, razmatra se mogućnost raspoznavanja emocija u prirodnom govoru na osnovu rasplinutih ekspertskih sistema. Ukazuje se na mogućnosti primene pristupa.

Dragan Šaletić, Računarski fakultet, Univerzitet ,,Union'', Beograd, Srbija

COMPARATIVE ANALYSIS OF UNDERSTANDING VERBAL ORDERS IN COCHLEAR IMPLANTED CHILDREN COMPARED TO NORMAL HEARING CHILDREN

SELENA TODOROVIC [1], SANJA DJOKOVIC [2]
Institute for Experimental Phonetics and Speech Pathology [1]
University of Belgrade, Faculty of Special Education and Rehabilitation [2]
todorovic.selena @ gmail.com
ingo@eunet.rs

Abstract. One of the most important functions of speech is the realization of human communication, to share their thoughts, views, wishes and needs with others in the social world. In recent decades in most countries, developed and implemented programs cochlear implant to improve hearing ability of deaf and therefore the understanding of speech. The aim of this study was to examine the understanding of verbal orders of cochlear implanted patients, and to examine whether there are differences in terms of population of hearing. The sample included 20 children of both sexes 8 cochlear implanted children and 12 children with normal hearing between the ages of 10 and 18. To test verbal comprehension was used Token Test (De Renzi, Vignolo, 1962). Statistical analysis showed that there were statistically significant differences in the understanding of verbal orders between cochlear implantation and normal hearing children. Differences increase with raising the linguistic complexity of verbal tasks. Also was observed large dispersion of results in the group of cochlear implanted children, and this is not the case with the results of the hearing population.
Keywords: cochlear implant, understanding, Token test

1. INTRODUCTION

One of the most important functions of speech is the realization of human communication, to share their thoughts, views, wishes and needs with others in the social world. In recent decades in most countries, developed and implemented programs of cochlear implantation to improve hearing ability of deaf and therefore the understanding of speech. The aim of this study was to examine the understanding of verbal orders of cochlear implanted patients, and to examine whether there are differences in terms of population of hearing. The sample included 20 children of both sexes 8 cochlear implanted children and 12 children with normal hearing between the ages of 10 and 18. To test verbal comprehension was used Token Test (De Renzi, Vignolo, 1962). Statistical analysis showed that there were statistically significant differences in the understanding of verbal orders between cochlear implantation and normal hearing children. Differences increase with raising the linguistic complexity of verbal tasks. It was also observed large dispersion results in a group of cochlear implanted children, and this is not the case with the results of the hearing population.

The most widely accepted theory is that speech perception takes place in several stages: detection, differentiation, and recognition is finally understanding (Djokovic, 2004). In order for this to be achieved, requires preservation of the auditory sensory system. Hearing impaired children has undermined the acceptance speech signals leading to a complete or partial inability formation of auditory patterns underlying the understanding, as the final act in the process of speech perception, and the beginning of the realization of communication.

In recent decades, cochlear implant as a type of hearing aid is extensively developed and implemented with the aim of improving hearing in deaf people. Most research has shown that there is a significant improvement in speech perception and production of cochlear implanted people (Plant, Moor, 1992.; Svirsky, 2004.; Ostojic, 2007.; James, 2007.; Mikic, 2008.). In pragmatic terms, cochlear implant contributed significantly to the improvement and at the same time facilitated the performance of software rehabilitation /habilitation. It should be noted that despite significant advances in the field of audiology and surd logy initiated by the appearance of the cochlear implant, the effects of benefits are not the same for all users.

Among the numerous studies that studied the importance of the cochlear implant speech development are those that speak of the importance of early implantation (Yvonne S. Sininger and co. 2010). Early implantation is often cited as an important factor in predicting the results of measuring speech-language performance. In a similar study investigated the ability of perception, production and linguistic characteristics CI schoolchildren. Children whom the implant is embedded between two and five years showed significant improvement in speech perception and production, lip-reading and language skills (Davidson et al., 2011.).

Davel (Dowell et al., 2002) in his research suggests some specificity in auditory perception and auditory emphasizes that age affects the perception of phonemes and words, but not the perception and understanding of the sentence. These results suggest that besides the well-known and well- studied demographic factors, there are others that affect the perception of voice messages, such as learning, memory, and other cognitive abilities. Research (Djokovic, Todorovic, 2013) which dealt with the influence of age on the auditory comprehension of verbal orders showed similar results of Dowel. Specifically hearing age did not show a statistically significant impact on the understanding of verbal orders. Length of cochlear implant use, has the greatest impact on improving the perception supra segmental and segmental structure of language while understanding the verbal order is not the case (Djokovic, Todorovic, 2013).

2. THE AIM

The aim of this study was to examine the understanding of verbal orders of different complexity levels in children with cochlear implants, and the comparison with the results of hearing population. Specific objectives were to test comprehension of verbal orders CI children compared to a time of demographic factors such as chronological age, age of implantation, hearing age.

3. METHODOLOGY

The sample included 20 children of both sexes, aged 10 to 18, of which eight cochlear implantation (40%) and 12 children with normal hearing (60%). All the children had a normal intelligence with no problems and disturbances. Before the start of testing the examiner is checked whether the children are children able to recognize all the hallmarks of test`s materials such as size, shape and colour. The average chronological age of the children with cochlear implants (CI) was 13.8 years; the youngest child had 10.5 and the oldest 17 years. The hearing group average chronological age was 12.9; the youngest child had 10.1 and the oldest 17 years. The average chronological age of the total sample was 12.8 years.

CI children were subjected to surgical intervention at the age of 16 months to 13 years. The average age of implantation was 6 years and 5 months. Length of hearing children in the group of cochlear implanted children was 2 years and 2 months to 9 years and 7 months. The average age in the group of hearing children CI was 6 years and 7 months.

The instrument used in this study is the Token Test (De Renzi, Vignolo, 1962.). Test contains five subtests sorted by weight, with a total of 62 items. The first four are subtests of 10, and the fifth has 22 verbal orders. Items in the test are ranked according to the complexity of the grammatical and syntactical structures. For the implementation of the necessary testing material is as follows: 20 coins of different sizes, colours and shapes. The chips are small and large, in blue, red, green, yellow and white, in the shape of circles and rectangles. Testing is carried out by the participants' line up in front of tokens and provides certain orders. Every order gets executed exactly 1 point, and the test is not provided giving negative points.

Processing data for presentation of basic statistical parameters were applied to descriptive statistics, and to determine the significance of the relationship between the independent and dependent variables, the analysis of variance (ANOVA).

4. RESEARCH RESULTS AND DISCUSSION

Based on the analyzed results obtained are significant indicators that point to the differences between the groups as well as some specific understanding of verbal orders CI children.

Table 1 - Distribution of results to percentage success in understanding the verbal orders of CI children and hearing children.

PERCENTAGE IN PERFORMANCE ON THE TOKEN TEST					
			CI	Hearing	Total
	53.23	n	1	0	1
		%	12.5%	.0%	5.0%
	82.26	n	1	0	1
		%	12.5%	.0%	5.0%
	83.87	n	1	0	1
		%	12.5%	.0%	5.0%
	85.48	n	1	0	1
		%	12.5%	.0%	5.0%
	87.10	n	1	0	1
		%	12.5%	.0%	5.0%
	90.32	n	1	0	1
		%	12.5%	.0%	5.0%
	91.94	n	1	1	2
		%	12.5%	8.3%	10.0%
	93.55	n	0	1	1
		%	.0%	8.3%	5.0%
	98.39	n	1	2	3
		%	12.5%	16.7%	15.0%
	100.00	n	0	8	8
		%	.0%	66.7%	40.0%
Total		н	8	12	20
		%	84.07	98.50	91.28

Table 1 shows the distribution of the results in relation to the percentage achievement of understanding verbal accounts of CI children and hearing children. In the group of cochlear implanted children expressed great dispersion of results ranging from 53.23 % to 98.39 % success. In the group of cochlear implanted children there were no children with 100 % success in understanding verbal orders. It should also be noted that in this group of all children achieve different percentages of achievement on tasks of verbal understanding. In the group of hearing children, results are considerably more homogeneous and clustered in the range of 91.94 to 100 % success. Eight children with normal hearing had 100 % successfully completed the tasks on the understanding of verbal orders and four in the range of 91.94% to 98.39 %.

Figure 1 - Overall Results comprehension of verbal orders of CI children and children with normal hearing

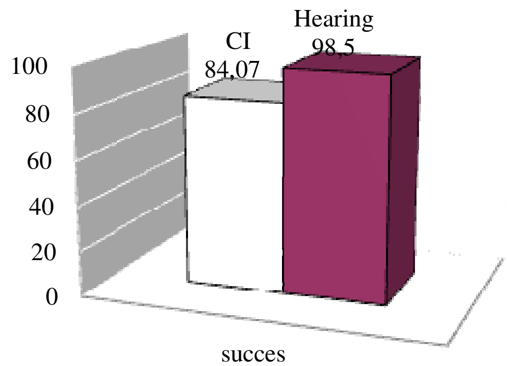


Figure 1 shows the percentages of achievement results in tasks of verbal understanding in CI children and hearing. CI children achieved 84.07 % successfully solved problems and 98.5% of children with normal hearing. The results show a high correlation with respect to group membership (r = 0.652), which was statistically significant (p = 0.002).

Table 2- Results comprehension of verbal orders in relation to the Token Test subtests of CI and children with normal hearing

TOKEN TEST				
Sub. 1	CI		hearing	
score	n	%	n	%
10.00	8	100	12	100
Total	8	100	12	100
Sub. 2	CI		hearing	
score	n	%	n	%
9.00	1	12,5	0	0
10.00	7	87,5	12	100
Total	8	100	12	100
Sub. 3	CI		hearing	
score	n	%	n	%
6.00	1	12,5	0	0
10.00	7	87,5	12	100
Total	8	100	12	100
Sub. 4	CI		hearing	
score	n	%	n	%
6.00	1	12,5	0	0
10.00	7	87,5	12	100
Total	8	100	12	100
Sub. 5	CI		hearing	
score	n	%	n	%
2	1	12,5	0	0
11	1	12,5	0	0
12	1	12,5	0	0
13	1	12,5	0	0
14	1	12,5	0	0
16	1	12,5	0	0
17	1	12,5	1	8,3
18	0	0	1	8,3
21	1	12,5	2	16,6
22	0	0	8	66,6
Total	8	100		12

Table 2 shows the results of understanding verbal orders in subtests of KI and children with normal hearing. Subtest is best done subtest 1 and both groups of children did it with

100 % success. This is an expected result because the complexity of the easiest subtest (Touch the red circle). Following the success is a subtest 2**.** Hearing children are and this subtest done with 100 % success, and children with cochlear implants 7 with 100 % and 1 child with a 90 % success rate. This subtest is somewhat more complicated than in the previous (Touch the small yellow circle). On subtests 3 and 4 with normal hearing children had 100 % success and the children with cochlear implants , 7 of them as 100 % and hearing loss, and one child in each subtest has achieved 60 % success (subtest 3 -Touch the yellow circle and red rectangle ; subtest 4 - Touch the little yellow circle and a large green rectangle). The worst results with normal hearing and with CI children evidenced in the most complex subtest 5 (Put the red circle on the green rectangle). Normal hearing children in group 8 of them had a 100 % success rate, and 4 tasks were implemented with successfully from 91.94 to 98.39 %. In the group of CI children were not of those who have achieved 100 % success. The best result is achieved CI 1 child with success rates of 95.45 %, other children ranged from 9,09 % to 77.27 % success rate.

Table 3 - Comparative analysis of verbal comprehension subtests between the CI and children with normal hearing

	AS	F(1)	p
Subtest 1	0.00	/	/
Subtest 2	.075	1.543	.230
Subtest 3	1.200	1.543	.230
Subtest 4	1.200	1.543	.230
Subtest 5	294.533	21.34	**.000**
Score	.300	3.600	.074

Table 4 - Results of statistically significant differences in individual subtests between CI and children with normal hearing

	AS	F(1)	p
Task 136 Pick up the blue circle before the red rectangle	.300	6.000	**.005**
Task 142 When I touch the green circle, take the white rectangle	.361	7.222	**.002**
Task 143 Put the green rectangle next to the red circle	.228	4.556	**.013**
Task 146 With the exception of the green only, touch circuits	.450	9.000	**.001**
Task 150 After raising the green rectangle, touch the yellow circle	.411	8.222	**.001**

Table 4 presents the results of statistically significant differences in the individual tasks of understanding verbal orders between CI children and children with normal hearing. Statistically significant differences were found in tasks 136 - R = 0.005, 142 - R = 0.002, 143 - R = 0.013, 146 r = 0.001 and 150 - R = 0.001 . On all tasks r <0,05 which means that the differences are statistically significant.

5. CONCLUSIONS

Understanding verbal accounts is a complex pathophysiological process that involves preservation of the sensory system and the ability to use different cognitive strategies to account successfully completed. If we look at the understanding and execution of verbal orders in a broader context, then we will conclude that this process is one of the basic underlying the entire study. When verbal understanding is not a quality person may not obtain a sufficient amount of information that are relevant to the communicative or cognitive functioning. This paper investigated the verbal understanding of instructions cochlear implanted children to determine the level of attainment within the population and the level of achievement compared to children with normal hearing. The results showed that cochlear implantation leads to improved comprehension of verbal orders given that this population of children achieve high overall achievement (84.07%) compared to the very prominent population (98.5 %). There is also a significant correlation between the performances on the understanding of verbal orders in relation to membership in a particular group, in this case the group membership cochlear implanted children.

Conceptually Token test is so formed that it can measure the influence of complexity (linguistic and cognitive) verbal orders to the achievement of understanding. The results were clear indications that CI and children with normal hearing and showed high correlation between the complexities of verbal orders. The difference between these two groups is that the results that homogeneous groups with large differences in the minimum and maximum achievement, which is not the case with normal hearing children. With this confirms the findings of many studies that cochlear implant does not provide the same efficiency for all users, and in addition to the cochlear implant a large number of other deciding factor affecting the achievement CI children. Statistically significant differences between CI children and hearing appeared only in the implementation of the most complex verbal orders. This means that CI like children realize simple verbal orders as normal hearing and that difficulties arise in the implementation of complex verbal orders.

Task analysis showed a statistically significant difference between the CI and children with normal hearing occurring in five tasks that are in 5.subtest. The analysis of these tasks led to the conclusion that this is a very linguistically and cognitively complex tasks which consist of 5 to 8 members of sentence that each task has a polysyllabic words that are difficult perceptible, sentences are composed of at least two clauses, and more.

The value of this work is in addition to the results that have led to a conclusion of understanding verbal accounts of CI children is that it gives some guidance for the design of future research as well as general guidelines for the approach to the rehabilitation / habilitation process of children with CI . The results suggest that future research on this subject to be significantly more structured, the sample should be higher, to understand verbal orders studied in relation to the general and specific demographic factors such as age of implantation, hearing age, shape and dynamics of the rehabilitation/habilitation programs, modes of communication, intellectual skills , etc. General recommendations for rehabilitation/habilitation approaches to the understanding of speech and practiced continuously in treatment and out of treatment conditions, there is a gradual overcoming certain level of understanding, the understanding of certain concepts rehearsal done through various sentence construction questionable forms and more.

REFERENCES

Amici S., Simon M., David P. (2007). Anatomical Correlates of Sentence Comprehension and Verbal Working Memory in Neurodegenerative Disease. *The Journal of Neuroscience 27* (23), 6282-6290 .

Dowell C., Shani D. Dettman P., Blamey J., Barker E., Graeme C. (2002). Speech perception in children using cochlear implants: prediction of long- term outcomes . *Cochlear Implants International 3*, 1-18 .

Davidson S., Geers E. (2011). Factors contributing to speech perception scores in long -term pediatric cochlear implant users . *Ear and Hear* . 32,19 S- 26S .

Yvonne S., Sininger, A. Grimes, Elizabeth C. (2010). Auditory Development in Early Amplified Children: Factors Influencing Auditory -Based Communication Outcomes in Children with Hearing Loss. *Ear and Hear*. 31 (2), 166-185 .

Jovicic S .(1999). *Voice communication, physiology, psychoacoustics, and perception.* Science , Belgrade.

Just M., Carpenter P. (1992). A capacity theory of comprehension: individual differences in working memory. *Psychol Rev* 99:122-149 .

Just M. Carpenter P., Keller T., Eddy W., Thulborn K. (1996). Brain activation modulated by sentence comprehension . *Science* 274:114 -116 .

Djokovic S. (2004). Individual treatment of hearing impaired children . CIDDI, Belgrade.

Djokovic S., Todorovic S., (2013). Hearing the age and understanding of verbal orders cochlear implanted children. *Special Education and Rehabilitation* . Vol.12 , No.3 ; 275-289 .

Ostojic S., Djokovic., Mikic B., (2007) . Cochlear implantation - review of research EARS test battery . *Special Education and Rehabilitation*, No.3 -4, 61-71 .

Ostojic S., Djokovic S., Dimic N., Mikic B., (2011). Cochlear implant - speech and language development of deaf and hard of hearing after implantation. *Military Medical Review 68* (4) , 349-352 .

Pisoni, D., (2004). Speech perception in deaf children with cochlear implants. *Dept. of Psychology* , Indiana University, Bloomington .

Slavnic S., Vujanovic I. (2005). Rehabilitacija slusanja i govora nakona kohlearne implantacije. *Beogradska defektoloska skola* 3/2005.

Slavnic S., Miric D. (2007). Opseg auditivne memorije kod dece ostecenog sluha. *Specijalna edukacija i rehabilitacija 3-4,* 41-52.

Svirsky M., Robbins A., Kirk K., Pisoni D., Miyamoto R., (2000). Language development in profoundly deaf children with cochlear implants. *Psychological Science 11*, 153-158.

Svirsky M., Teoh S., Neuburger H. (2004). Development of Language and Speech Perception in Congenitally, Profoundly Deaf Children as a Function of Age at Cochlear Implantation. *Audiol&Neurotology 9*, 224–233.

Todorovic S., Milicevic I., (2012). Govorna percepcija nakon kohlearne implantacije. III Medjunarodna naucno-strucna konferencija,Unapredjenje kvaliteta zivota djece i mladih, *Tematski zbornik,* Tuzla.str..617-623.

IMBALANCED LEARNING APPROACH TO THE CATEGORIZATIONOF ARTICULATION DISORDERS

DRAŠKO FURUNDŽIĆ[1], SLOBODAN JOVIČIĆ[2], MIŠKO SUBOTIĆ[3], SILVANA PUNIŠIĆ[3]

[1]Mihajlo Pupin Institute, Volgina 15, 11000 Belgrade,Serbia
[1]e-mail: fudra07@gmail.com,

[2]University of Belgrade, School of Electrical Engineering, Bul. kralja Aleksandra 73, 11120 Belgrade, Serbia

[3]Institute for Experimental Phonetics and Speech Pathology,
Gospodar Jovanova 35, 11000 Belgrade,Serbia

Abstract: This paper presents a study of several methods for balancing uneven distribution of data, related to disorders of pronunciation of phonemes, whose main purpose is improvement of prediction performance of the various related data balancing algorithms. Essential feature of supervised learning based classification algorithms is generalization ability that is manifested in prediction performance. Actual ability of the mentioned algorithms becomes worse when information balance between training set classes is violated. Class imbalance problem occurs when the classes in the training set are represented by considerabllydifferent number of realizations. This imbalance phenomenon apears in many classification tasks in different research areas, such as speech recognition and speech pathology categorization. Cause of the imbalance data in case of speech disorders lies in the uneven distribution of different categories of disorders.Another cause could be improperly designed training set, which is not uncommon. Learning process in such a conditions is called imbalanced learning. Advantages and disadvantages of the two main approaches to balancing data, oversamplingand undersampling, and their improved variants, are presented in this paper. Our study showed that all classification algorithms trained on balanced data sets show a significant improvement of prediction performance compared to the learning with imbalanced data.

Keywords: neural networks, imbalanced learning, feature extraction, phoneme, articulation disorders

1. IMBALANCED LEARNING PROBLEM

The rapid development of information technology (IT) has led to a rapid increase in the amount of data available in all areas of human activity , which contributed to a better understanding of the importance of data and their widespread use. Databases are numerical-symbolic presentation of various types of systems, from the technical (Ezawa et al., 1996) , to the biological (Radivojac et al., 2004) . These advantages have led to the development of diverse technologies for the extraction of knowledge from databases under the general name of "data mining" (Marban et all., 2009). Development of IT is strongly corelated to the development of so called artificial intelligence (AI), which is based on the model of the adaptive behavior of entities in the information environment: machine learning and neural networks. These models are also known as "data driven models" that best reflects their nature and highlights the importance of data in forming their parameters. Adaptive models only in causal interaction with the environment, based on different training algorithms, gets a chanse to develop an intelligent response to stimuli from the environment. Important features of intelligence are ability of recognition, discrimination, classification and categorization of objects in the environment. Unbalanced presentation of data objects from the environment by learning models during training, leads to an increase in their propensity to easily identify entities that are over represented during the training that results in misclassification in the operational phase (Chawla et al., 2002). Imbalance of datasets related to different classes can be due to various natural distributions of the observed phenomena, or xcan be otherwise conditioned. The imbalance can also occur within a single class Classifier performance depends not only on the balance between the different classes of data but also on the representativeness of the data classes themselves and the complexity of the processes of underling generator. The importance of the phenomenon of unbalanced data resulted in a recently organized a number of workshops (Japkowicz, 2000b, Chawla et al., 2003a, Dietterich et al., 2003, Ferri et al., 2004) , and Special Issues (Chawla et al., 2004a), the the Data Mining Comunity on the subject. Since insufficient / excessive representation of certain classes in the data set during the training leads to neglect / favoring those classes by the classifiers in the exploitation inspired a developement of various techniques balancing data. Another problem arose as a result of an imbalanced sets is the need for appropriate criteria for assessing the performance of classifiers. Namely, in a situation where the percentage of positive cases very small compared to the negative, for example 2 % to 98%, then the classifier that classifies all cases as negative had an accuracy of 98 % which would be a great result if the relationship class was 50 % to 50%. Since the recognition of the importance of positive cases usually much greater than the negative cases, this classifier is unacceptable. An example that supports the preceding paragraph is the classification of malignant cells in a normal class, as is the appearance of cancer cells much thinner than normal cells. Therefore, the accuracy expressed in this way, as a measure of performance of the classifier is useless in the case of imbalanced sets.

1.1 Overview of Various Techniques for Data Balancing

The question that naturally arises in the case of unbalanced sets is: What is the proper distribution of a class of learning algorithm applied? Weiss and Provost presented a detailed analysis of the impact of the distribution of classes in the training process of classifier and its performance (Weiss and Provost, 2003). Their conclusion is that the natural distribution of the analysed class of phenomena is not suitable for training the classifier and the need to implement an appropriate method of balancing is evident.Many resampling techniques have been used in data balancing, such as random under sampling, random oversampling with replacement, focused under sampling, focused oversampling, generation of new synthetic samples based on the known information, and combinations of different techniques (Chawla et al., 2004b). Japkowicz (2000) discussed the possible effect of imbalance in a learning dataset.Japkowicz evaluated two next sampling methods: under sampling and oversampling. She used artificial one dimensional data set to simplify presentation of the complex concept of data balancing. Random oversampling assumes resampling the smaller class at random repetition until it contained equal number of samples in both classes while focused resampling consisted of resampling only specific minority examples placed on the boundary between the majority and minority classes. Random under sampling involved rejection of the majority class samples at random until their numbers reduced to the number of minority class examples while focused under sampling involved under sampling the majority class samples lying further away from the class border. She asserted that both approaches were very effective when compared with other sophisticated sampling techniques in the domain (Japkowicz, 2000). Ling and Li (1998) combined oversampling of the minority class with under sampling of the majority class and they report that this approach did not give any visible advantage. The problem of imbalanced data sets in oil slick classification was presented by Solberg and Solberg (1996). They used oversampling and under sampling methods to improve the oil slicks classifier performance. Their training data had a distribution of 42 real oil slicks and 2,471 false ones, having a prior probability of nearly 0.98 for look alike. This imbalance leads the learner to classify false examples correctly misclassifying many of the real oil slick samples (Solberg & Solberg, 1996). To overcome this imbalance problem, they used oversampling technique with replacement to produce 100 samples from the real oil slick, and randomly sampled 100 samples from the false examples to create a new well balanced dataset having equal representation probabilities. They learned a classifier tree on balanced data set achieving a 14% error rate on the true oil slicks examples. On the false examples they achieved an error rate of 4% (Solberg & Solberg, 1996). Among the techniques described for balancing data, a special place belongs Smote (Synthetic Minority Oversampling Technique), as the first to introduce a method for generating synthetic samples in the area of minority class features based on interpolation using the k nearest neighbours(KNN), (Chawla et al., 2002).

1.2 SMOTE Algorithm

Because of the importance that SMOTE algorithm has in classification problem here we present the concept of this technique in a couple of algorithmic steps.

- For each sample from minority set find its *p* nearest minority neighbours and randomly select *q* of these neighbours.

-Randomly generate synthetic samples along the lines connecting actual minority sample and its *q* selected neighbours in *n* dimensional sample feature space, where *q* depends on the amount of oversampling desired.

Comparing to simple random oversampling, this technique enables the larger and less specific regions to be learned, focusing attention on minority class samples preventingover fitting. This algorithm currently yields the best results compering toother oversampling and under samplingmethods (Chawla, 2003).Improved, technique, borderline SMOTE,(Han et al., 2005), is more sophisticated algorithm which is based on focused resampling of minority class examples in the borderline aria.

1.3 Performance Measure

As the researchers in data mining area continue to develop a new imbalanced learning algorithm, it becomes necessary to standardize evaluation metrics forthe proper assessment of the effectiveness of such algorithm so here we present a review of the main assessment metrics for imbalanced learning.The most often used metrics are accuracy and error rate. Here we present a basic two class classificationproblem as proper example. Let P and N be the class labels for true positive and true negative classes respectively, while Y and N are the hypothetically predicted positive and negative class labels. Then, classification performance can be represented by a confusion matrix presented in Fig. 1. In thisexample and following real example in this paper, we assumethat the minority class is the positive class and the majority class is the negative class. True positive (TP) is equivalent with a hit, true negative (TN) is equivalent with correct rejection, false positive (FP) represents false alarm and false negative represents the miss and has the most serious consequences.According to proposed convention, accuracy and error rate are defined in the following way:

$$Accuracy = \frac{TP+TN}{P+N};\; ErrrorRate = \frac{FP+FN}{P+N}; \qquad (1)$$

Equation (1) contains next relation: $ErrorRate = 1\text{-}Accuracy.$ (2)

These measures give a simple description a classifier's performance on an actual data set. In this way obtained results can be deceiving in great amount of practical situations and are highly sensitive to changes in data.

		True class	
Hypothesis class		P	N
	Y	TP	FP
	N	FN	TN

Figure 1.1 Confusion matrix of a simple two class problem.

Let us consider the simplest situation where a given data set includes 2 percent of minority class examples and 98 percent of majority class examples. A simple approach of classifying every example as a majority class example would give a98 percent accuracy. The 98 percent accuracy on the entire data set seemsexcellent but this description avoidspresentingthe fact that 0 percent of minority examples are identified. The accuracy metric in similar cases does not give adequate information on classifierfunctionality.The fundamental problem can be explained by evaluating of confusion matrix for classifier performance evaluation presented in Fig.1. The left column represents positive cases of the data set and the right one stands for the negative instances. Thus, the proportion of the two columns represents the class distribution of the complete data set, and any measure that uses values from these columns will be sensitive to class imbalances. In such a situation other evaluation metrics are adopted in the research field to provide adequate assessments of imbalanced learning problems. Some of frequently used metrics are sensitivity,specificity, precision and recalldefined as:

$$Sensitivity = \frac{TP}{TP + FN}, \tag{3}$$

$$Specificity = \frac{TN}{TN + FP}, \tag{4}$$

$$Precision = \frac{TP}{TP + FP}, \tag{5}$$

$$Recall = \frac{TP}{TP + FN}. \tag{6}$$

Precision is an indicator of exactness and shows how many of the examples labelled as positive, are labelled correctly. Recall is an indicator of completeness showing how many of true positive examples were labelled correctly. Sensitivity represents true positive rate and specificity stands for true negative rate.

1.3.1 Receiver Operating Characteristics (ROC) Curves

In order to solve the classification metrics problem, the ROC assessment technique (Fawcett, 2006) uses the proportion of two following metrics: true positives rate and false positives rate.

The ROC graph is created by plotting TP rate over FP rate, Fig. 2. The ROC curve is veryconvenient visual representation of the relative trade-offs between the benefits (true positives) and costs (false positives) of classification in regards to data distributions. You can compare performance of several classifiers using ROC curve. Quite often AUC, area under curve, is calculated as numerical representation of the classification performance measure.General attitude referring to classifier comparison according to proposed metrics is: The classifier is better than another when its corresponding point in ROC space is closer to ideal point (upper left corner in the ROC space) compering to than another. Classifier, whose corresponding ROC point is close to the diagonal line, represents a random guess classifier.

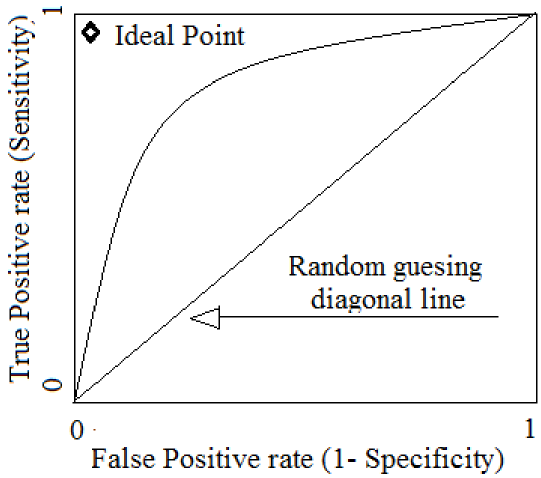


Figure 1.2. ROC curve.

So, any classifier that appears in the lower right ROC area behaves worse than random classifier. According to above presented facts, we have established an adequate measure of performance of the classifier in the situation where classes are imbalanced.

2. ENTROPY AND FEATURES SPACE OF IMBALANCED CLASSES

Adaptive systems in a changing environment set its parameters in the direction of the optimal response to external influences in order to meet the defined criteria. By interacting with the environment the system develops a tendency to adapt to the impacts which is often exposed. Extreme ambient conditions are less often than normal but their impact on the system is much stronger.

This fact leads to the conclusion that the amplitudes of inputs from the environment are usually appear in a normal distribution, forcing the adaptive system to develop a specific strategy of behaviour in extreme conditions, while its well-established operation is in accordance with the mean values of external influences. Ideal conditions for setting the parameters of adaptive systems include generally speaking uniform distribution of inputs.

To solve the problem of classification based learning models, we usually assume a uniform distribution of data sets, and this leads to large errors. This problem is solved by balancing data learning data sets in the direction of their uniform distribution, both in classes and within each class, such as the distribution of learning sets does not favour a preference model to any class. The measure of uniformity of distribution of samples is defined principle of entropy maximum,(Jaynes, 1957), (Shannon 1949).

2.1 Entropy

For a discrete probability distribution p on a countable set of values $\{x1, x2, ...xn\}$, of variable$X$,with the corresponding distributions $pi = p(xi)$, entropy of p is defined by the following equation:

$$h(p) = -\sum_{i=1}^{n} p(xi) \log_2 p(xi). \quad (7)$$

For a continuous probability density function *p(x)*, its entropy is defined as:

$$h(p) = -\int_{-\infty}^{+\infty} p(x)\log_2 p(x)dx. \tag{8}$$

It's expected for physical systems to evolve into states with higher entropy as they approach equilibrium. In information theory in context of probability, *h (p)* is considered as a measure of the information carried by *p*, where higher entropy corresponds to more uncertainty, or more of a lack of information. Consider a finite set $\{x1, x2,...xn\}$. If *p(xi)= 1*for *i = k* and *p(xi)* = *0* for any *i ≠ k*, according to eq. (7), $h(p) = -1\log_2 1 = 0.$ In this case, probability distribution*p*always produce onlyone possible outcome, *xk*. We have complete knowledge about the future state of the process. In situation when *p* is the uniform density function, where *p (xi) = 1/n*for all *i*, then $h(p) = \log_2 n,$ every probability density function on $\{x1, x2,...xn\}$ hasentropy $h(p) \le \log_2 n,$ and entropy equal to $\log_2 n,$ occurs only for the uniform distribution, (Jaynes, 1957). Actuallythe probability density function on $\{x1, x2,...xn\}$ having maximum entropy corresponds to the least amount of knowledge about variable *X*. In such a situation, learning models will not show a tendency to favour the particular class or individual samples within the class.

2.2 Synthetic Oversampling with Entropy Maximization

Above facts is the basis of our model for synthetic generation of new samples in the feature space in order to change an existing distribution towards a uniform distribution. One should bear in mind that all feature space is not available, but just limited area defined by a certain number of nearest neighbours.The criteria for the interpolation of new samples are a threshold of mean Euclidean distance, $d(x, y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$, between the observed patterns and their neighbours.Middle distance *ds* between the observed patterns (dots) and their *k* nearest neighbours in the immediate environment are a measure of the density of points in that domain of space*: ds = (d1 + d2 + ... + dk) / k*, where *dk* is distance*d (x, yk)*.Each point in space (sample) ds whose value exceeds a predefined threshold θ with k nearest neighbours define the space in which shall be generated a number of new items in proportion to the distance *ds*. The threshold θ is determined by the measure of mean Euclidean distances between all points of space. In this way you can achieve more uniform density of points in all parts of the feature space. In classification of unbalanced class this algorithm is applied independently for each class. This method solves the problem of imbalanced data by generating a sufficient number of points and it enables possibility to select a representative samples for all classes. All previous methods of balancing class ignored the general approach of balancing because they focus only on the boundary space between classes and generate a limited number of points which equals the number of samples in the classes. This method aims to offer the most general solution for imbalanced learning because it is based on the fundamental principles of the intelligent response subject to changing ambient conditions.Points around the selected subsets *Sr* (*) generate a new synthetic examples Ssy (·), interpolation in the space of their nearest neighbours as shown in Figure 2.1 (c). Interpolation in this space causes a change from the original distribution in the direction of uniform distribution. Figure 2.1 (d) shows the final set of *Sf* which contains the initial set *Si* and a set of synthetic *Ssy*, *Sf = Si ∪Ssy*. In Figure 2.1 (d) clearly demonstrates the phenomenon of filling rarefied features space with new patterns balancing the density of the initial set. This algorithm has a choice of different number of nearest neighbours and distances from between samples, which gives the possibility of optimization which will be the subject of further research.

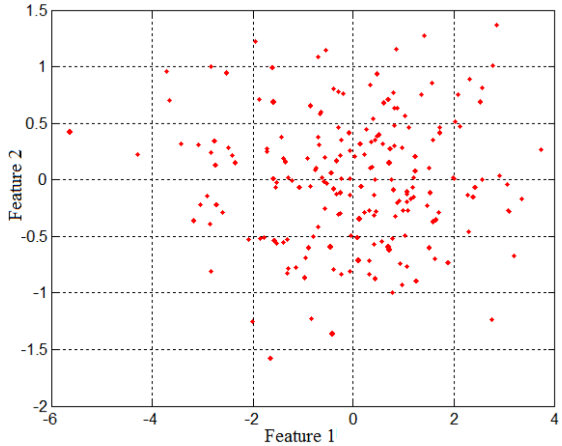


Figure 2.1(a) Initial set of examples.

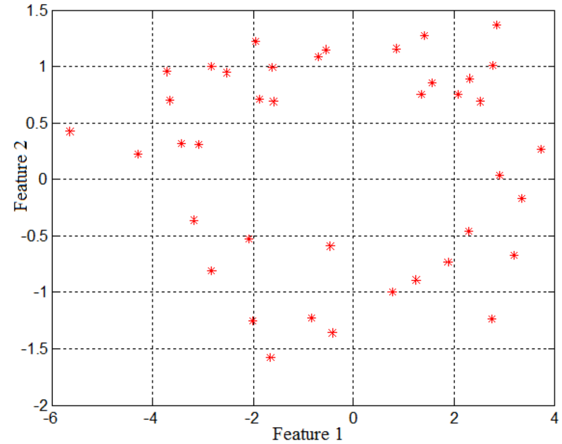
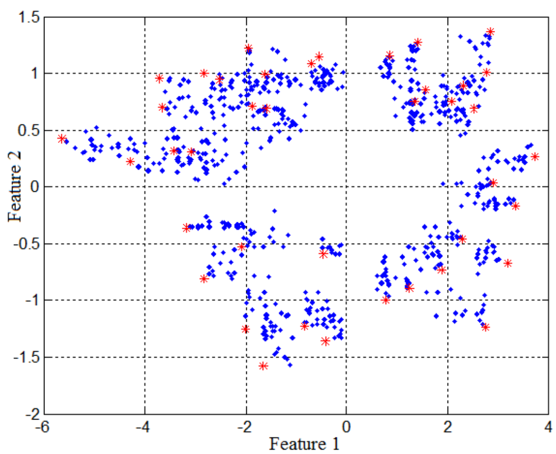


Figure 2.1(b) Examples from sparse space.

This procedure is performed for all classes separately, thereby balancing is done between classes, based on the increased number of samples and their balanced distribution.



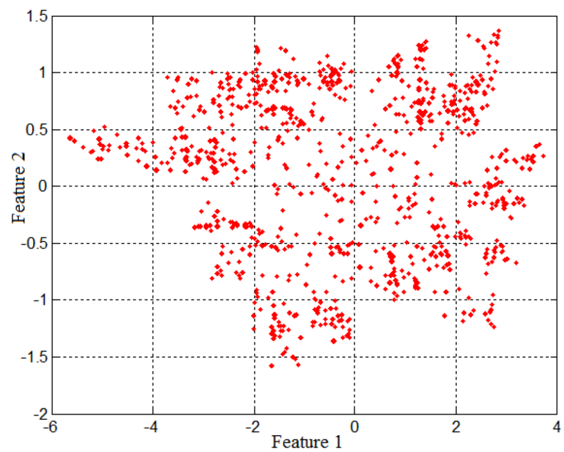


Figure 2.1(c) Synthetic dots in sparse space. Figure 2.1(d) Final (balanced) set.

3. ARTICULATION DISORDER AND ACOUSTIC FEARTURE SPACE

Basis, or rather the holder of a large information potential of speech is a complex morphological functional organization of speech system. Existential role of speech in communication for the survival of the human race, has led to the development of highly sophisticated and efficient speech system in terms of morphological-functional and anatomical-physiological organization. Articulation is generally based on the dynamic activation paradigms of components of the speech system.Due to the inherent complexity of the answering machine and a variety of physical or psychological limitations caused by the properties of its components, such as mass, position, momentum, the shape of the resonator and articulator, neurological or psychological constitution of the subject, there are variations in the quality of articulation.

Diversity of continuous speech signal in three dimensions (time, amplitude and frequency), a huge number of combinations and a large internal variability leads to a high signal complexity and makes it close to a random process, and therefore it is difficult to find in it principles to be derived from to enable high quality of recognition or articulation evaluation.

Distribution of the observed realization of the phonemes in the space features a typically uneven, regardless of the effort to ensure the representativeness of training data samples.

Digitization (sampling, quantization and coding) causes loss of information in speech signal and the goal should be the higher sampling frequency. But the high sampling rate causesthe high dimension of speech signal. The solution is to eliminate redundancy usingvarious methods for compression of the signal by extraction of features: MFCC, LFCC, LPC, PCA and other techniques.

3.2 Data Preparation

We tested aninitial group of 200 children, a hundred boys and girls. The sample was divided into two equal parts, training and test part. Distribution of respondents for quality articulation of phonemes /ʃ/ and/ʒ/, given in Table I, shows that about 88% and 77%of respondents respectively, had acceptable speech quality (3, 4) for which means that the data set is imbalanced. Evaluation was performed using GAT test for actual fricatives (Kostić, et al., 1983).

TABLE I

DISTRIBUTION OF ARTICULATION REGULARITY /ʃ/& /ʒ/ IN %

GAT Test			
rate	/ʃ/	rate	/ʒ/
3	54	3	50
4	34	4	27
5,6	12	5,6	23
4	33.87		50.85
			27.12
			22.03

Errors in the articulation of the fricatives /ʃ/ and /ʒ/ in Serbian language are much more likely than other fricatives, so these phonemes are the main problem to be solved. Rating of articulation performed group of eight speech therapist and final scores are formed by averaging all the individual results. These results are represented in table I. All speech signals were recorded in the software package PRAT.We used our algorithm for synthetic generation of new data to obtain new final set of 200 negative and 200 positive examples. Main objective of this paper is comparison of classifier performance according to data balance, so we madethree experiments, a) training with original imbalanced set and b) training with set balanced by simple random repetition of examples from minority class and c) training with set balanced using our algorithm. Balanced training data for multilayer perceptron (MLP) classifier contains the set of 200 input vectors that represent the features of the speech segment and the set of 200 output binary values {1, 0}, representing two categories: correct "1" and incorrect "0" pronunciation. In the GAT test, the grades 3 and 4 represent the correct pronunciation, while 5 and 6 incorrect. Original imbalanced training data set contains 176 negative examples and 24 positive examples for phoneme /ʃ/, while phoneme /ʒ/ was represented with 154 negative and 46 positive examples. The input data for training are prepared in two stages: speech signal pre-processing and feature extraction.

3.3 Feature Space

Mel Frequency Cepstral Coefficients (MFCC)

MFCC parameters are defined over the set of frames referring to the actual fricatives, /ʃ/ phoneme for example, in a following way:

$$MFCC = real(IFFT(\log(abs(FFT(X))))), \tag{9}$$

Where *X* represents one phoneme frame, *FFT* and *IFFT* are fast Fourier transform and inverse transform respectively. The firs twelve samples of *MFCC* values are taken from each frame. The number of frames varies for each examinee from 7 to 32 in the case of /ʃ/ phoneme. Hence, *MFCC* feature of every phoneme is actually matrix of *Z* rows and *12* columns, where *Z* represents number of frames in the actual phoneme and for each frame there are 12 coefficient values.The *LFCC* coefficients calculation assumes the same procedure, (9), except the use of linear, instead of Mel filter bank.

Real values for the signal length:

This group of features contains next quantities:

Number of samples of the wave signal referring to relevant word *(nw)*,

Number of samples of the wave signal referring to actual phoneme *(np)*, and

The quotient: $nq = np/nw$.

Statistical values:

These are the real valued numbers representing the standard deviation and the mean values of sound energy (*E)* for each phoneme. We remind that each phoneme contains several frames. Continuous acoustic signal energy is defined by the equation (10). A discrete version, used in this work, is presented in (11).

Another feature extracted was relation between sound energies contained in initial consonant /ʃ/ (*Ec*) and following vocal*u*(*Ev*) extracted from actual Serbian word (Shuma), (*Ec/Ev*). (Freyman et al., 1989).

$$E = \int_{t1}^{t2} x^2(t)dt \quad , \tag{10}$$

$$E = \sum_{i=1}^{n} x_i^2 \Delta t \quad , \tag{11}$$

3.4 Results and Discussion

Results of comparison of the performance of the classifier under various conditions of balancing for phonemes / ʃ / and / ʒ / are presented in Fig. 3.1. Grey line represents the random performance of the classifier. The green line represents the performance of the classifier developed on the original set. The blue line represents a classifier trained on a set that is balanced by random repetition of patterns from minor class, while the red line indicator of performance of the classifier, trained on a set balanced with our algorithm. It is obvious that in all three cases, training classifiers perform better than random classifier but also shows that well-balanced set gives almost perfect results approaching very close to the ideal point. The basic idea of balancing the data set proved to be useful. Although the assumption of maximization of entropy learning data set seems logical and simple, it requires a lot of practical steps to be proven and a lot of effort to reduce a heuristic approach to the solution.

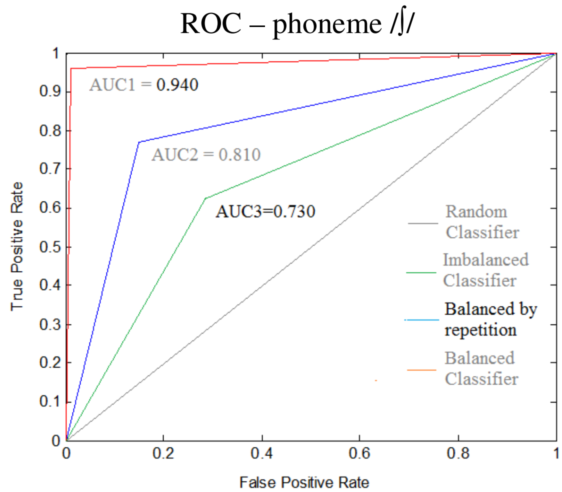


Figure 3.1 (a)

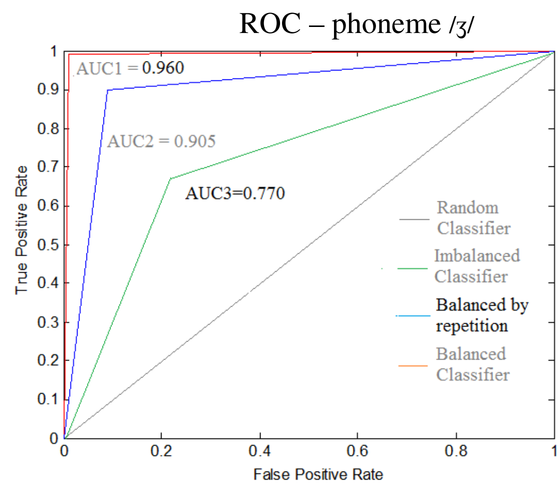


Figure 3.1 (b)

4. CONCLUSION

This paper presents a new method to solve a general common problem of the classification of samples in terms of unbalanced classes. The method is based on the principle of entropy maximization of learning sets in order to eliminate preferences of classifier to favor the dominant class. This balancing of data increases the representativeness of the samples within the class and thus increases their discriminatory potential. Synthetic generation of new examples in the space of the nearest neighbors in low-density parts of the feture space increases the uniformity of the distribution of the whole feture space.The ideal goal of our algorithm is to achive uniform distribution of a final set, obtained by summation of the initial and synthesized set. In real terms this is not easily achieved due to the restrictions required due to the similarity of synthesized and initial samples, but you can achieve much more suitable distribution compared to the initial. Representativeness of new synthetic data is much larger than in the case of data balancing by simple repeating patterns from the minority class.Figure 3.1 shows the effect of a new method of balancing data sets and it can be concluded that it is always shuld be applied even when the initial classes seem well balanced.

REFERENCES

Chawla, N. V., Bowyer, K. W., Hall, L. O., and Kegelmeyer, W. P. (2002). SMOTE: Synthetic Minority Oversampling TEchnique. *Journal of Artijcial Intelligence Research,* 16: 321-357.

Chawla, *N.* V., Japkowicz, N., and Kokz, A., editors (2004a). *SIGKDD Special Issue on Learning from Imbalanced Datasets.*

Chawla, N. V., Japkowicz, N., and Kolcz, A., editors (2003a). *Proceedings ofthe ICML'2003 Workshop on Learningfrom Imbalanced Data Sets 11.*

Dietterich, T., Margineantu, D., Provost, F., and Turney, P., editors (2003). *Proceedings of the ICML'2000 Workshop on COST-SENSITIVE LEARNING.*

Ezawa, K., J., Singh, M., and Norton, S., W. (1996). Learning Goal Oriented Bayesian Networks for Telecommunications Risk Management. In *Proceedingsof the International Conference on Machine Learning, ICML-96,* pages 139-147, Bari, Italy. Morgan Kauffman.

Fawcett, T., "An Introduction to ROC Analysis," Pattern Recognition Letters, vol. 27, no. 8, pp. 861-874, 2006

Ferri, C., Flach, P., Orallo, J., and Lachice, N., editors (2004). *ECAI' 2004First Workshop on ROC Analysis in AI.* ECAI.

Freyman, R.L., Nerbonne, G.P. (1989). The importance of consonant-vowel intensity ratio in the intelligibility of voiceless consonants, *in J. Speech Hear.* Res., 32(3), 524-535.

Han, H., Wang, W.Y., and Mao,B.H.,"Borderline-SMOTE: A New Over-Sampling Method in Imbalanced Data Sets Learning," Proc. Int'l Conf. Intelligent Computing, pp. 878-887, 2005.

Japkowicz, N. (2000b). Learning from Imbalanced Data sets: A Comparison ofVarious Strategies. In *Proceedings of the AAA1'2000 Workshop on Learningfrom Imbalanced Data Sets,* Austin, TX.

Japkowicz, N. (2000). The Class Imbalance Problem: Significance and Strategies. In *Proceedings of the 2000 International Conference on Artificial Intelligence (IC-AI'2000): Special Track on Inductive Learning* Las Vegas, Nevada.

Jaynes, E. T. (1957). "Information Theory and Statistical Mechanics". Physical Review. Series II 106 (4): 620–630.

Kostić, Đ., Vladisavljević, S., Popović, M. (1983). *Tests for assessment of speech and language*. Zavod za udžbenike i nastavna sredstva, Beograd (in Serbian).

Marbán, O., Mariscal, G., and Segovia, J., (2009); *A Data Mining & Knowledge Discovery Process Model.* In Data Mining and Knowledge Discovery in Real Life Applications, Book edited by: Julio Ponce and Adem Karahoca, pp. 438–453, February 2009, I-Tech, Vienna, Austria.

Radivojac, P., Chawla, N. V., Dunker, K., and Obradovic, Z. (2004).Classification and Knowledge Discovery in Protein Databases. *Journal of BiomedicalInformatics,* 37(4):224-239.

Shannon, C, E., Weaver, W. (1949). The Mathematical Theory of Communication," Univ. of IllinoisPress, Urbana, IL.

Solberg, A., & Solberg, R. (1996). A Large-Scale Evaluation of Features for AutomaticDetection of Oil Spills in ERS SAR Images. In *International Geoscience and RemoteSensing Symposium*, pp. 1484–1486 Lincoln, NE.

Torralba, A., Efros, A.: Unbiased look at dataset bias. In: CVPR. (2011) 1521–1528

Weiss, G. and Provost, F. (2003).Learning when Training Data are Costly: The Effect of Class Distribution on Tree Induction. *Journal of ArtiJicial IntelligenceResearch,* 19:3 15-354.

CHARACTERISTICS OF PERCEPTIVE IDENTIFICATION OF LEVEL OF DURATION DEVIATION FOR FRIVCATIVE /Š/ IN TRAINED AND UNTRAINED LISTENERS

SILVANA PUNIŠIĆ[1,2] , ZORKA KAŠIĆ[3], SLAVICA GOLUBOVIĆ[3], SLOBODAN JOVIČIĆ[1,4]
[1]Centar za unapređenje životnih aktivnosti, Beograd, silvanapunisic@hotmail.com
[2] Institut za eksperimentalnu fonetiku i patologiju govora, Beograd
[3] FASPER-Fakultet za specijalnu edukaciju i rehabilitaciju, Univerzitet u Beogradu
[4]Elektrotehnički fakultet, Univerzitet u Beogradu, stjovicic@yahoo.com

Abstract: In the experiment fricative /š/ in initial position in the word /šuma/, was segmented and modified in duration in shortening and prolongation from the speech base of typical stimuli of speakers aged 10 and 11.Two groups were chosen for the experiment: a) trained and untrained listeners. Both groups had two sessions of 160 stimuli to identify based on auditory perception and to grade stimuli in four levels: typical, mild and severe. Results of the technique of trained (expert, experienced) listening and the listening of untrained participants in identification of the grade of distortion of acoustic characteristic of /š/, has shown that in trained listeners there is a correlation between identification function of the perception of distortion and global grade of atypical expression of speech while in untrained listeners there is none. This is the first study for Serbian, with a note that for other languages, no similar studies were found.

Keywords: perceptive identification, duration, fricative /š/, trained and untrained listeners

1. INTRODUCTION

The process of reception and decoding of speech based on listening is called auditory perception, by which recognition of basic meanings is identified. The process of auditory perception lasts for a period of time with two key phases: (i) detection of acoustic characteristics in the speech signal (ii) acumulation and integration in perceptive unit as a minimal segment of speech (acoustic) signal recognized as linguistic information. Speech is made up of sequences of perceptive units that ar at higher perceptive levels integrated and transformed into a linguistic message. (Jovičić, 1999). The listener must use its knowledge on phonological lexical syntaxic and semantic rules of the language. The interpretation of speech perception needs to be considered from perception of isolated segments (sounds and syllables or organized messages. Although the second type is the basis of understanding, both during the process of language development and later, the effect of the principles perception of isolated segments is common (Kašić, 2003b) also needing linguistic experience. The basis of the mechanism of perception and reception of sounds is the perception of auditory stimuli. The oldest method in the analysis of articulation and acoustic characteristics of sound (typical and atypical)still used is assessment based on perceptual identification by speech, or hearing assessment (auditory perception) by speech therapist. This technique is known as an expert or trained listening and it is the method of perceptual (auditory) identification of sound deviations. Expert hearing results in a decision about the quality of the voice, placing a discrimination line between typical and atypical pronunciation of sounds and analyzes of the detected atypical. Among other known procedures, articulation disorders are diagnosed using tests based on the perceptual evaluation of speech therapists in this country (Kostic, Vladisavljević, Popovic, 1983; Vasic, 1971; Vuletic, 1990) and worldwide (Lippke et al., 1987, Smith and Hand, 1997, Gruber 1999; Fristoe and Goldman, 2000; Asa et al., 2000). In the perception experiment conducted by Horga (1988) the level of recognition of the spoken voice was examined in certain frequency bands. The type of speech signal (isolated voic , isolated word, sentence, discourse) and the method of production (repetition of the stimulus to the examiner, independent reading, description of the image content, etc.) is defined by test requirements in relation to the age of respondents and the purpose of evaluating pronunciation.

Speech therapist uses his audio-perceptual system as a "computer" for speech processing, based on experience in the field of standard articulatory and acoustic characteristics of language sounds, by which he diagnoses deviations in pronunciation and models the therapy process and evaluates the treatment of people with articulation disorders. The speech therapist, in addition to being based on a trained listening detect atypical sounds, is able to characterize and classify certain features in adequate pathological group. The two most frequently used tests for articulation in Serbian, are global articulation test (GAT) and Test for analytical evaluation of articulation (AT) (Kostic, Vladisavljević, Popović, 1983), and both are based on the perceived detection and identification of differences in the pronunciation of sounds.

For evaluation of sounds using the AT the listener uses at least three characteristics: for example: typical - shortened - prolonged; typical - voiced – voiceless etc. In the next stage of perceptual processing, if atypical features are detected , the type and degree of atypicality are estimated. AT offers the examiner (in the test form), a set of features for each sound within a group, which he identifies in the sound based on the acoustic sound presentation. For evaluation of sounds using GAT, a scale is used to scale the values (scores) from 1 to 7, where each value is assigned a set of possible characteristics for each of the 30 votes. Grades 1,2 and 3 indicate the typical pronunciation, with grade 1 and 2 used in the evaluation of speech of adult speakers – professionals, while the evaluation of pronunciation of children and the average speaker uses grade 3. Grade 7 is an indication of the substitution or omission in speech. Grade 4, 5 and 6 are labels for the levels and types of atypical (distortion) of any sound that is not offered in the form of the test, they are found in the perceptual memory and the examiner converts them in grades in the process of perceptual processing.

The initial assumption, if both tests is the knowledge of the typical (standard) articulation and the acoustic characteristics of all sounds. Systematization of the description, characteristics and terminology for deviations in speech and language pathology data is consistent with the literature in the field of speech pathology for Serbian (Vladisavljević, 1981, 1997; Golubović, 1997) .

However, each of the assigned features in atypical production of certain sounds may be manifested in varying degrees. It is the size of a set of features, their interrelationship, detecting dominant (discriminatory) characteristics and the degree of its manifestation expressed on a scale marks from 4 to 6, where the height of the grade is directly proportional to the degree of deviation. Study results should be added (Kašić, 2003) showing that sounds are not perceived on the basis of the overall acoustic structure but on the basis of acoustic input, or relevant discriminative features that are crucial in the perception of speech segments.

The presentation of facts related to perceptual processing and assessment by the described tests, aims to highlight the high degree of complexity of the assessment based on perceptual identification by examiners. The technique is in the analysis of the acoustic characteristics of speech (typical and atypical) in the diagnostic process and treatment and is still indispensable. Although most frequent in speech and language diagnosis, the method of expert listening carries certain flaws and limitations in speech and language practice. This is primarily due to the fact that discrimination of typical - atypical sound, can be carried out by experienced therapists (several years of experience) with good or "trained" auditory perception of phonemes for their mother tongue and the skill to detect type and degree of their characteristics. It also encourages the question of the validity of exclusive auditory diagnostics in speech and language pathology, particularly because it reflects on the modeling of the therapeutic process and the evaluation of treatment of people with articulation disorders. The additional burden of this method is lack of standardized speech database of atypical sounds for training of therapists and their auditory perception.

Recognition and identification of variations in the production of a phoneme is a complex perceptual process, because the deviation can occur in one or more acoustic feature. The issue of perception of in deviations produced phonemes , based on its acoustic feature has not been systematically investigated. On the one hand, the reasons for that may be found in the complexity of the demands that are "placed" on the mechanism of auditory perception in the recognition and identification of atypical realization of sound production. On the other hand, addressing the issue of the perception of the acoustic characteristics of sound in an atypical production requires: a) the identification and classification of possible types of variations in the pronunciation of each sound, b) discrimination of the level of expression of atypical forms of possible deviations c) auditory discrimination between similar forms of atypical production; d) perceptual correlates in the domain of articulation, e) identification of the relationship between atypical features in atypical manifestation. Results of the expert (trained) listening and untrained listeners in detecting the extent of deviation of the acoustic characteristics of the duration of the voice /š/, are presented in this study.

2. PREVIOUS RESEARCH ON DURATION

In addition to the intensity, duration is the inherent characteristic of the phonetic system and accompanies acoustic manifestants of languages. To be used to communication, the speech expression must have a certain level of intensity for the recipient's hearing, and sounds and their segments must take a certain time to achieve distinctive features. Duration of sounds have a distinctive role and are very important in voice communication - its variability in continuous speech is a suprasegmental linguistic means of expression. Suprasegments accompany sounds or in combination with sounds represent differential signs for construction and discrimination of semantics (Kostić, 1971). In addition to linguistic point, duration is a very important feature of acoustic and paralinguistic and extralinguistic aspects. It belongs to the variable characteristics of sounds caused by a number of factors such as individual characteristics of the speakers, the demands of the communicative situation, phonetic context, the position of the phoneme in the word, the impact of an accented syllable in the word , the position before or after the break, suprasegmental organization , speed of movement and articulation, etc. (Lehiste, Ivić , 1986; Sovilj, 2002).

Frequent manifestations of atypical pronunciation of sound is variation in their duration – these are deviations by type of distortion. This acoustic feature of sounds is studied using perception studies for Serbian and other world languages, with emphasis that this area of perception has not been fully explored. Influence of vowels on the duration of consonants in continuous speech (Whitehead et al., 2000), the effect of reduction in the duration of vowels on consonant duration for the intervocal environment in read speech (Son and Pols, 1996) has been studied. Earlier studies have shown that the duration of fricatives can affect the perception of articulation (Hughes and Halle, 1956). Jongman (Jongman, 1989) shows that the shortest length of friction needed for the listener to accurately identify /s/ and /S/ is 50 ms. Examination of the general acoustic characteristics of sounds showed that the area of the duration of a voice can set upper and lower limits. For the duration of less than 20 ms, the sound cannot be perceived. However, the upper boundary is not strictly defined and is associated with expirium boundary and emphatic stressing (Kostić, in press), but there is a boundary distortion when sounds become unrecognizable (Kašić, 2000).

Studies have shown that the order of the relative duration of sounds from the "longest" to "shortest" in the articulation base of the Serbian language can be seen as follows: long accented vowels, affricates, short accented vowels, fricatives, plosives, nasals, unaccented short vowels, oral sonants (Kašić, Ivanović, 2011). Analysis of variance duration of votes was done for continuous speech (Kašić et al., 1987) and the analysis of the duration of the fricatives /š/ in isolated words was done in the initial, medial and final position and the effect of the duration of the word accent syllable duration and coarticulation in fricatives (Jovičić, Kašić, Punišić, 2008). The mentioned study found that fricative /š/ is the shortest in the medial position and the longest and most stable in the final position. It also showed that the duration is longer with shorter words, dependent on the number of phonemes and syllables in the word with a short accent. Perceptive analysis of the duration of phonemic and subphonemic segments for different sounds in typical children, with average age of 10 years and 6 months, was carried out in the Croatian language(Heđever, 1996). Research duration of phonemes take a very long time in the linguistic domain (Lehiste, 1970; Crystal et al., 1988, Whitehead et al., 1995). With the development of modern speech technologies, they are gaining in importance in areas such as speech recognition and speech synthesis as well as natural language processing (Huang et al., 2001). Research on these parameters are specific for each language, such as, for example, American English (Umeda, 1977) , Dutch (Heuvel et al., 1994, Spanish (Mendoza et al., 2003), German (Braunschweiler, 1997) French (O'Shaughnessy, 1981), etc. comparative studies included (Delattre, 1965; Laeufer, 1992). Other studies have looked at the length of fricatives during simultaneous communication (Whitehead et al., 1999). Research on of duration fricatives in phonetic context showed that voiceless fricatives in the initial and final position of the sound last longer than voiced fricatives (Baum and Blumstein 1987, Crystal and House, 1988).

Despite the large number of studies on the duration of fricatives, there are no studies that systematically investigate the duration of friction in terms of atypical manifestations. This phenomenon is very important especially for the evaluation of sound disorders (Plante and Beeson, 2007), as well as modern technology of speech synthesis (Kato et al., 2002). Duration is a significant mark in the analysis of deviations and pathology in the articulation of sounds. Here we mention sporadic research dealing with phonemes distortion caused by differences in duration. Results of research conducted by our group (Jovičić, Punišić, 2007; Jovičić et al., 2008; Jovičić et al., 2010; Punišić et al., 2011) showed that the acoustic feature of duration can be a very good indicator of variations in the articulation of friction within the time domain (extension / shortening), and that listeners are very consistent in the perception of differences. Also, analysis of duration in the spectral domain is a very convenient way to characterize sounds from this group. We present some more foreign studies dealing with the characteristics of the duration of vowels and fricatives in speech after esophagectomy (Christensen et al., 1976, Christensen et al., 1981), the duration of speech segments in patients after correction of split palate and hypernasality (Leder et al., 1988), the duration of vowels in aphasias (Ryalls, 1986). Research worldwide have confirmed the high prevalence of distortions in the group fricatives and affricates in children during the period of development and at a later ages Boone and Plante, 1993), mainly caused by short or prolonged duration, strong or weak friction or different forms of sigmatism (Gordon - Brannan and Weiss, 2006).

Results of research conducted on Serbian-speaking participants, (Jovičić, Punišić, 2007a) showed that the acoustic feature of duration can be a very good indicator of variations in the articulation of friction in the time domain (extension / shortening), and that listeners are very consistent in the perception of differences. Other results of perceptual studies have shown that the friction in the fricative group, the most common deviation is by type of distortion (Vasić, 1971; Marković, et al., 1996; Vladisavljević 1997; Djordjević, Golubović, 2008) with atypical features of the duration of their friction, either singularly or in association with some other atypical feature, can contribute to the degree of sound distortion in this group.

3. AIM OF THE STUDY

The aim of this study is to determine the characteristics of the perceptual identification of the degree of deviation for the duration of fricative /š/ in trained and untrained listeners. This research is part of an extensive research with the scientific goal of establishing clear articulatory-acoustic indicators of pronunciation deviations of sounds that are to contribute to a more reliable classification, categorization and assessment of pathological pronunciation in speech pathology.

4. METHODOLOGY

In the experiment, we have analyzed fricative /š/ in the initial position in the word /šuma/, extracted from the speech database of typically spoken stimuli, in speakers aged 10 and 11 years. Fricative /š/ was chosen because of its greatest expression in the group fricatives which enabled easier differentiation from other phonemes and easier measurement of its duration. As mentioned in the introduction, the study of atypical manifestations of sounds is possible only in the case of knowing its typical (standard) articulation and acoustic characteristics. The fact that research related to the measurement and analysis of duration in the field of pathology sounds between typical / atypical features was not found in the literature for the Serbian language has imposed the need for conducting preliminary experiments ranging from segmentation through research on acoustical aspects of deviations to auditory aspects of deviations, which will be described in the following text.

4.1 Organization of the acoustic experiment

In this case, because of the role of characteristics of duration in the identification and discrimination of phonemes in the Serbian language, it is important to know the objective criteria that define the boundaries of the typical duration. Given that the previous descriptions of the characteristics of atypical sounds, objectified acoustic approach usually omitted. For the purposes of this study, multidisciplinary and scientific knowledge, methods and techniques of different fields was used: speech pathology, phonetics and acoustics. Although the measurements were carried out for all three acoustic characteristics: sound duration, intensity and frequency, we have chosen the characteristic duration of fricative /š/ and experimental procedures and results will be given for this domain. The results of this experiment are given in the form of quantification of borders of the variational field of duration, beyond which sound production enters into the domain of pathology. The estimation of the typical / atypical was done on the basis of the characteristics of the duration distribution.

The study was conducted on the speech base of 77 spoken word / šuma /, out of which sound /š/ was used 43 times as typical and 34 times as atypical. The first step in preparing the speech stimulus-word segmentation, i.e. the separation of initial votes from the rest of the words in which special attention is paid to the three main borders: the starting point in the pronunciation of the initial position of words, the endpoint in the analyzed words and the boundary between the first and second phoneme (ie point between the initial consonant fricatives and the following sound in the word /šuma/). These limits define the duration of the initial sound and the rest of the word, as well as the whole word. Segmentation was carried out with the Praat program for acoustic analysis of speech. The boundaries of the sounds were determined by using a spectrogram analysis of each word.

The measurement duration was conducted by an objective approach, after initial segmentation in the recorded words. We obtained the range of duration of friction for voice

/š/ approximately 155 to 250 ms (dimension of variation fields for sound /š/ is 95 ms) beyond which the values are related to short or prolonged duration, or atypical production. The essential contribution of this research is a quantitative indicator of the variation field of a typical duration in sound production, including the atypical, which is significant for speech and language practice and speech technology.

4.2 Organization of the perceptive experiment

The aim of this study was to determine the boundaries of a typical / atypical sound duration for /š/ based on identification function of the probability of perceptual recognition of typical / atypical duration. Segmented sound /š/ whose range of the typical duration of friction was measured within the acoustic experiment, was, at this stage, analyzed with focus on the discrepancy of duration using perceptual identification. The results of perceptual evaluation of sound /š/ in the function of variation of the duration in three levels: short, typical and prolonged. Change of the length of the initial fricatives was performed using software package Praat.

The stimulus - word /šuma / was chosen, in which the duration of the analyzed sound corresponds to a mean value of 223 ms (reference word). In a series of 17 stimuli, it was ninth in a row. Duration of the initial sound of the stimulus was modified or shortened to 8 steps or extended for 8 steps up to distinctive shortening/prolonging period.

The experiment involved seven speech therapists-listeners who each had two listening sessions each: I – listening to shortened stimuli including typical, II - listening to prolonged stimuli including typical. Each stimulus within a session was repeated 10 times. We obtained two audio files with the 90 stimuli each and a total of 1260 stimuli. Stimulus presentation was random and the interval between presentation of stimuli was 5 seconds. The stimuli were presented using headphones. Speech therapists-listeners were required to identify and mark the two categories of stimuli: typical and atypical using a prepared questionnaire with a description of atypical stimulus features: extended or shortened in duration.

The analysis of experimental findings resulted in identification function of probability of perceptive recognition of typical/atypical duration for sound /š/ by which boundaries of typical / atypical duration were determined.

The results showed high agreement of experts in determining typicality of friction duration (Jovičić, Kašić, Punišić, 2010). Comparing the range of variation field of the typical duration in the acoustic experiment (155-250, duration range of 95 ms) with a range of perceptual typical duration (164-260 ms, the range of duration 96 ms) almost identical values were obtained. This result can be used to evaluate the perceptual approach. Its validity can be confirmed in assessing atypical articulation by untrained listeners and professional speech therapists.

5. ORGANIZATION OF THE EXPERIMENT FOR PERCEPTION OF DEVIATION

The experiment involved two groups of listeners: 5 experts and 8 untrained listeners. Each of them had two listening sessions with a total of 160 stimuli. The first session consisted of typical and atypical stimuli shortened in duration, a total of 80 stimuli. The second session consisted of typical and atypical stimuli which were prolonged, a total of 80 stimuli. Within each session, listeners graded the stimuli deviations in four levels: *typical* (3) atypical : mild (4) , medium (5) and severe (6) . Listeners of both groups were instructed as to the aim of the experiment. They were demonstrated examples of typical and atypical stimuli (shortened and prolonged into three levels), prior to the experiment. By perceptual identification, they made a decision based on detected deviations expressed by marking one out of four grades, They expressed the quality of duration for sound /š/. Estimates for each stimulus were entered into a prepared form.

6. RESULTS

Figure 1a and 1b show experimental result in the form of mean probability for perceptive identification graded 3 to 6 for sound /š/ in the function of shortening or prolonging of duration as parameters of deviation in articulation.

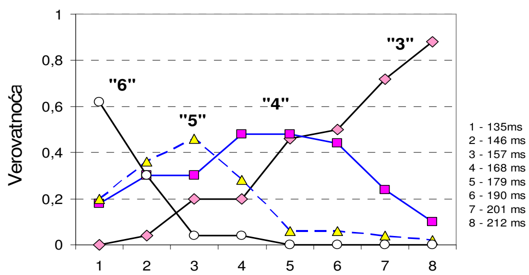


Figure 1a) Probability of perceptual identification of the grade of deviation of fricative /š/ (grade **3**, **4**, **5**, **6**): session *typical/atypical duration* (experts)

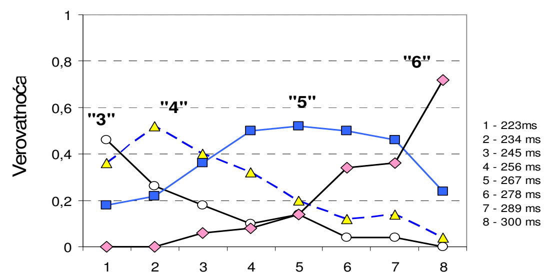


Figure 1b) Probability of perceptual identification of the grade of deviation of fricative /š/ (grade **3**, **4**, **5**, **6**): session *typical/atypical duration* (experts)

Figures 1a and 1b show the expected order of the occurrence probability of the maximum rate in function of the duration which is correlated with the change in duration for typical sound from reduced to prolonged. Going from the typical to the shortened / prolonged stimuli, experts consistently detect, first the mild area (grade 4), to medium (grade 5) to severe distortion (grade 6). In Figure 1a, going from grade 6 to Grade 3, the probability of grade 3 is dominant in the range of 190 to 212 ms, stimuli 6 to 8, which is the field of typical duration. In this range, the probability of grade 3 increases, while probability of grade 4 drops symmetrically. The field between stimuli 5 and 6 (179 and 190 ms) may be accepted as an area of confusion (uncertainty) of experts for grades 3 and 4. On the other hand, the probability of grade 6 is dominant only for the shortest stimulus (135 ms), while listener were indecisive for stimulus 2 (146 ms) between grades 5 and 6. Grade 5 was dominant for stimuli 3 (157 ms), while grade 4 was dominant for stimulus 4 (168 ms).

Somewhat different distribution of the probability of perception for grades was seen for the typical and prolonged, figure 1b. Grade 3 and 4 are close, as well as a broad area that covers grade 5. Also, the greatest confusion of grade 3, 4 and 5 is seen for stimulus 1 to 4 (223 to 256 ms). The results of untrained listeners are shown in Figures 2a and 2b.

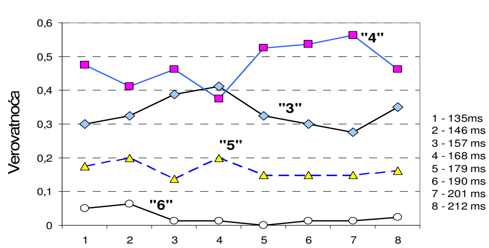


Figure 2a) Probability of perceptual identification of deviation for fricative /š/ (grades **3**, **4**, **5**, **6**): session *typical/shortened duration* (untrained listeners)

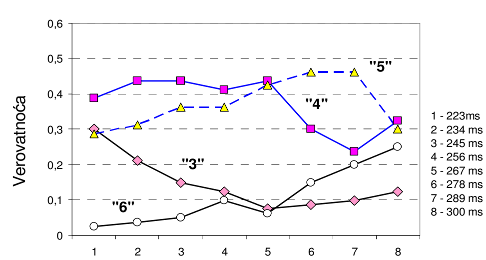


Figure 2b) Probability of perceptual identification of deviation for fricative /š/ (grades 3, 4, 5, 6): session typical/shortened duration (untrained listeners)

Regularities observed and described for experts (Figure 1a and 1b) in terms of the maximum of probability of grade as a function of duration, cannot be seen in results of untrained listeners. In a typical / short duration session, figure 2a, the probability of perception of all marks are evenly distributed along the stimulus. The same can be said for the typical / prolonged duration session, figure 2b , where the expected ratio of grade 3 and 6 can be seen, but their probabilities are much lower than grade 4 and 5. Based on perceptual identification of distortion grades in untrained listeners, we can say that they do not have minimum of perceptual capabilities to grade deviation. In effort to make a smaller errors they have resorted to grades 4 and 5 in order to avoid radical decision in terms of typical or heavy distortion. Higher probability of grade 3 in a typical / shortened duration, compared to a typical / prolonged session, could confirm greater differentiation of perception for the shortening of the stimulus, where they made more certain decisions based on typical / atypical.

Additional analysis of the results of experts can be done, but not for the results of untrained listeners. For each session, experts, and even untrained listeners said that they were more difficult to give grades in a typical / prolonged session. Explanation of their estimates is the fact that the shortening of friction, severe distortion - grade 6 for fricative /š/ very quickly turns into substitution with the affricate /č/ and the possibility of discrimination typical / atypical significantly higher. Conversely, with extension of duration of friction, there is no substitiution effect, making the typical / atypical difficult. These results for both sessions are in accordance with the results obtained in the pilot perceptual experiment.

7. CONCLUSIONS

It is shown that in trained listeners – experts, there is a correlation between the identification function of perception duration distortion and global assessment of atypical pronunciation. Experiments determining the perceptual identification function for recognition of typical / atypical duration of analyzed sounds and experiments analyzing the impact of the duration of articulatory voice to the evaluation of atypical pronunciations shown that there is an asymmetry of the duration axis. It is observed that the shortening of the critical sound below a certain limit value leads to loss of its distinctive characteristics, ie. substitution with another voice (sound /š / substituted with /č /) while extending the duration of friction does not lead to significant phonetic transformation.

The introduction of identification features enables quantitative indicators of typicality and atypicality for duration of the analyzed sounds during production, which is significant in speech practice, opening possibilities for future research on this topic. This and similar studies in the field of sound distortion, could facilitate the development of modern systems for automatic detection of sound distortion in order to improve diagnosis and treatment of speech and language in terms of faster and more objective assessment in speech therapy.

On the other hand, knowledge of the parameters that create limits in the typical sound pronunciation would allow training of speech therapists for faster and more reliable identification of the perceptive type and degree of manifestation of atypical characteristics that contribute to sound expression.

REFERENCES

Ase, D., Hovre, C., Krause, K., Schelfhout, S., Smith, J., Carpenter, L.J. (2000). *Contextual Test of Articulation.* Eau Claire, WI: Thinking Publications.

Baum, S.R., Blumstein, S.E. (1987). Preliminary observations on the use of duration as a cue to syllable-initial fricative consonant voicing in English. *Journal of the Acoustical Society of America*, 82, 1073–1077.

Boersma P., Weenink D. (2010). Praat*: doing phonetics by computer [Computer program]*, Version 5.1.34, retrieved 31 May 2010. from http://www.praat.org/

Boone, D. R., Plante, E. (1993). *Human communication and its disorder*. New Jersey: Prentice-Hall.

Braunschweiler, N. (1997). Integrated cues of voicing and vowel length in german: a production study. *Language and Speech* 40, 353–376.

Christensen, J.M., Weinberg, B. (1976). Vowel duration characteristics of esophageal speech. *J. Speech Hear.* Res., 19(4), 678-689.

Christensen, J.M., Weinberg, B. (1981). Fricative duration in esophageal speech. *J. Commun. Desord*., 14(2), 678-689.

Crystal, Th.M., House, A.S. (1988). Segmental durations in connected-speech signal. *Journal of the Acoustical Society of America* 85, 1553–1573.

Delattre, P. (1965). *Comparing the Phonetic Features of English ,German, Spanish and French*. Julius Groos Verlag, Heidelberg.

Đorđević, V., Golubović, S. (2008). Ispitivanje artikulacije suglasničkih skupova kod razvojne verbalne apraksije i razvojne disfazije. *Govor i jezik, interdisciplinarna istraživanja II.* S. Jovičić i M. Sovilj (ur.) IEFPG; CUŽA, Beograd, 36-62.

Goldman, R., Fristoe, M. (2000). *Goldman-Fristoe Test of Articulation—2*. Circle Pines, MN: American Guidance Service.

Golubović, S. (1997). *Klinička logopedija I.* Defektološki fakultet, Beograd.

Gordon-Brannan, M. E., Weiss, C. E. (2006). *Clinical management of articulatory and phonologic disorders.* Lippincott Williams & Wilkins.

Gruber, F. A. (1999). Probability estimates and paths to consonant normalization in children with speech delay. *Journal of Speech, Language, and Hearing Research,* 42, 448–459.

Heđever, M. (1996). *Akustička analiza vremenskih segmenata normalnog I poremećenog govora*. Doktorska disertacija. Fakultet za defektologiju, Sveučilište u Zagrebu.

Heuvel van den H., Rietveld, T., Cranen, B. (1994). Methodological aspects of segment and speaker-related variability. A study of segmental durations in Dutch. *Journal of Phonetics,* 22, 389–406.

Horga, D. (1988). Perceptivni spektar glasova. *Defektologija,* vol. 24, 1, Zagreb, 17 - 41.

Huang, X., Acero, A., Hon, H.W. (2001). *Spoken Language Processing: A Guide to Theory, Algorithm, and System Development*. Prentice Hall.

Hughes, G. W., Halle, M. (1956). Spectral properties of fricative consonants. *Journal of the Acoustical Society of America,* 28, 303–310.

Jovičić, S.T. (1999). *Govorna komunikacija: fiziologija, psihoakustika i percepcija*, Nauka, Beograd.

Jovičić, S. T., Punišić, S. (2007a). Perceptivno prepoznavanje akustičkih obeležja koja karakterišu odstupanja u izgovoru frikativa /š/, *Zbornik radova LI Konferencija ETRAN*, Herceg Novi, AK5.1.

Jovičić, S.T., Kašić, Z., Punišić, S. (2008). Trajanje frikativa /š/: analiza u izolovanim rečima, *Zbornik radova*, *XVI TELFOR,* Belgrade, 715-718.

Jovičić, S. Punišić, S., Šarić, Z. (2008). Time frequency detection of stridence in fricatives and affricates, *Int. Conf. Acoustics 08,* Paris, 5137-5141.

Jovičić S., Kašić Z., Punišić S. (2010). Production and perception of distortion in word-initial friction duration. *Journal of Communication Disorders* 43/5., DOI:10.1016/j. jcomdis.2010.04.007.

Kašić, Z., Peter, S., Urošević, Z., Filipović, M. (1987). Varijantnost trajanja glasova u reči. U: *Zbornik radova ETAN*, Bled, 229-233.

Kašić, Z. (2000a). Funkcija suprasegmenata u govornom izrazu. *Beogradska defektološka škola, br.2-3,* 113-124.

Kašić, Z. (2003a). *Fonetika.* Beograd: Defektološki fakultet.

Kašić. Z. (2003b)**.** Percepcija distinktivnih obeležja u izolovanim jednosložnim rečima kod dece mlađeg školskog uzrasta**.** *Istraživanja u defektologiji - Smetnje u razvoju*. Beograd: Defektološki fakultet - CIDD, 217-240.

Kašić Z., Ivanović M. (2011). Stabilnost/nestabilnost trajanja glasova u promeni tempa govora. *Jezici i kulture u vremenu i prostoru Zbornik radova.* Novi sad: Filozofske fakultet.

Kato, H., Tsuzaki, M., Sagisaka, Y. (2002). Effects of phonetic quality and duration on perceptual acceptability of temporal changes in speech. *Journal of the Acoustical Society of America*, 111(1 Pt 1), 387–400.

Kostić, Đ. (1971). *Metodika izgradnje govora u dece oštećenog sluha.* Savez društva defektologa Jugoslavije, IEFPG, Beograd.

Kostić, Đ. Uvod u fonetiku, knjiga u štampi

Kostić, Đ., Vladisavljević, S., Popović, M. (1983): *Testovi za ispitivanje govora i jezika.* Zavod za udžbenike i nastavna sredstva, Beograd.

Laeufer, Ch. (1992). Patterns of voicing-conditioned vowel duration in French and English. *Journal of Phonetics* 20, 411–440.

Leder, S.B., Lerman, J.W., Alfonso, P.J. (1988). Speech segment duration measurements in adult speakers with repaired cleft palate and hypernasality, *Laryngoscope*, 98(8 Pt 1), 884-887.

Lehiste, I., (1970). *Suprasegmentals*. MIT Press, Princeton.

Lehiste, I., Ivić, P. (1986). *Word and Sentence Prosody in Serbocroatian*. MIT.

Lippke, B. A., Dickey, S. E., Selmar, J. W., Soder, A. L. (1987). *Photo Articulation Test—Third Edition*. Los Angeles, CA: Western Psychological Services.

Marković, M., Golubović, S., Brakus, R. (1996). Frekvencija artikulacionih poremećaja kod dece predškolskog uzrasta*. Beogradska defektološka škola br. 2*, 65-75.

Mendoza, E., Carballo, G., Cruz, A., Fresneda, M.D., Munoz, J., Marrero, V. (2003). Temporal variability in speech segments of Spanish: context and speaker related differences. *Speech Communication* 40, 431–447.

O'Shaughnessy, D. (1981). A study of French vowel and consonant durations. *Journal of Phonetics* 9, 385–406.

Plante, E. M., Beeson, P. M. (2007). *Communication and communication disorders: A clinical introduction*. Allyn & Bacon.

Punišić S., Subotić M., Jovičić S. (2011a). Analysis of duration and intensity of voiceless affricatives and fricatives in typical and atypical pronunciation. *Third European Congress on Early Prevention, Detection and Diagnostics of Verbal Communication Disorders.* Sovilj M, Skanavis, M i Bojanova V. (Eds.), Proc., Belgrade, 72-79.

Ryalls, J.H. (1986). An acoustic study of vowel production in aphasia. *Brain Lang.,* 29(1), 48-67.

Smit, A., Hand, L. (1997). *Smit-Hand Articulation and Phonology Evaluation*. Los Angeles, CA: Western Psychological Services.

Son, van R.J.J.H., Pols, L.C.W. (1996). *An acoustic profile of consonant reduction*, in Proceedings ICSLP 96, vol.3, 1529 – 1532.

Sovilj, M. (2002). *Dečji govor-kvantitativni pratioci govora.* Zadužbina Andrejević, Beograd.

Umeda, N. (1977). Consonant duration in American English. In *J. Acoust. Soc. Amer*., 61(3), 846-858.

Vasić, S. (1971). *Razvitak artikulacije kod dece na uzrastu od tri do devet godina.* Naučna knjiga, Beograd

Vladisavljević, S., (1977) *Nepravilan izgovor srpskohrvatskih afrikata.* Jugoslovenska knjiga, Beograd.

Vladisavljević, S. (1981). *Poremećaji izgovora.* Privredni pregled, Beograd.

Vladisavljević, S. (1997). Govor i jezik jezik i govor, Zavod za udžbenike i nastavna sredstva, Beograd.

Vuletić, D. (1990). *Test artikulacije.* Fakultet za defektologiju Sveučilišta u Zagrebu, Zagreb.

Whitehead, R., Weglarski, A., Sewall, A., Schiavetti, N., Metz, D. (2000). Effect of vowel environment on consonant duration: An extension of normative data to adult contextual speech. In *Journal of Communication Disorders*, 33, 1-10.

Whitehead, R.L., Schiavetti, N., Whitehead, B.H., Metz, D.E. (1995). Temporal characteristics of speech in simultaneous communication. *J. Speech Hear.* Res., 38(5), 1014-1024.

Whitehead, R.L., Whitehead, B.H., Schiavetti, N., Metz, D.E., Farinella, K. (1999). Effect of vowel environment on fricative consonant duration in speech produced during simultaneous communication. *Journal of Communication Disorders*, 32, 423–434.

CHANGES IN EEG THETA RHYTHM PEAK FREQUENCY AND AMPLITUDE IN FRONTAL MIDLINE CORTICAL REGION DURING SHORT-TERM AUDITORY MEMORY FORMATION FOR WORDS AND NON-WORDS

MIODRAG STOKIĆ[1,2], ZORANA RADIVOJEVIĆ[1,2], VANJA NENADOVIĆ[1,2], SLAVICA MAKSIMOVIĆ[1,2]
Institute for experimental phonetics and speech pathology, Belgrade, Serbia[1]
Life activities advancement center, Belgrade, Serbia[2]
iefpg@iefpg.org.rs[1]
ifp2@ikomline.net[2]

Abstract: Past decade is dedicated to brain research with special emphasis on memory processes. The role of Theta rhythm in short-term memory processes is well documented in recent literature. In this research, we wanted to examine cortical distribution of maximal amplitude of EEG theta rhythm and peak frequency during resting state and formation of short-term memory for words and non-words. Sample comprised 10 adult participants. Participant's task was listening one stimulus (word or non-word) and to memorize it. The interval between listening and repeating was 5 seconds. We wanted to analyze only time interval between listening and repeating. EEG was recorded using Nihod Kohden apparatus, 19 electrodes in longitudinal monopolar montage. Additional EOG electrodes were used in order to register horizontal and vertical eye movements. One hundred five-second artifact free periods were analyzed offline using spectral analysis (FFT algorithm). Results showed increase in theta rhythm amplitude in frontal midline cortical region with alterations in peak frequency in frontal and temporal regions during both words and non-words. Differences in anterior and posterior brain regions between words and non-words are discussed in this paper.

Keywords: theta rhythm, peak frequency, amplitude, short-term memory, words, non-words

1. INTRODUCTION

"We are what we are not only because we think ("cogito ergo sum") but also because we can remember what we have thought about. Every thought we have, every word we speak, every action we engage in –indeed, our very sense of self and our sense of connectedness to others- we owe to our memory, to the ability of our brains to record and to store our experiences. Memory is the glue that binds our mental life, the scaffolding that holds our personal history and that makes it possible to grow and change throughout life."

Larry R. Squire and Eric R. Kandel
(Memory: from Mind to Molecules, 1999)

How we learn and remember are questions that have been central to three scientific disciplines: philosophy, psychology and biology. Until the nineteenth century, the study of learning and memory was restricted largely to the domain of philosophy. Later, this theoretical approach was replaced by more experimental studies, initially in psychology and finally in biology. Today psychologists and biologists have joined forces to open up the "black box" to study how the brain and behavior allows us to learn and have memories. The neurobiology of memory can now be studied at two different but complementary levels, one aimed at brain structure, circuitry and behavior, and the other aimed at individual nerve cells and the molecules within nerve cells. The first is concerned with neural systems of the brain important for memory - *where are memories stored*?. The second is concerned with the cellular and molecular mechanisms of memory storage - *how are memories stored*?

Concerning the question of where memories are stored, the modern view is that there is no single locus in the brain where all memories reside. Many parts of the brain appear to participate in the internal representation of memory by encoding different aspects of the whole. Specific brain regions have specialized functions (language, vision, and motor control, for example) and each contributes in a different way to the storage of whole memory. One of the more striking and perhaps most surprising findings in the biology of memory is that learning alters the physical structure of the brain. This remarkable plasticity exhibited by the brain is fundamental to our individuality. The different environments to which each of us is exposed and the different amount of information each of us has acquired modify our brain in unique and sometimes permanent ways. Of course, each of us shares the same basic brain anatomy which results from common blueprint of our species. However, this blueprint is plastic, or changeable, and therefore its specific details will vary from person to person according to our individual experiences. But not all of the experiences we encounter in our daily life leave a lasting trace in our brain. Our interests, preferences, motivations and personality play an important role in determining the quality, quantity and persistence of the information we store in our brain.

1.1. Words and non-words from the brain perspective: What is the word?

From the brain's perspective, language is mapping between physical inputs/outputs, in the form of written, spoken, or signed signals, and experiences, memories, and knowledge stored in long-term memory. One of the critical units for such mapping is the word. Neurophysiological methods have been aimed at better specifying the features of a word, the organization of different kinds of information associated with a word, and the various influences on word processing. One proposal is that information about words is represented in a mental "lexicon" containing both lower-level phonological and orthographic information, as well as higher-level information about the meaning of a word and its various syntactic properties (when applicable), such as grammatical gender and subcategorization On the standard model, recognizing a word activates this information in the lexicon, in a process known as "lexical access." This information, in turn, is used to combine the meanings of words into phrases and the meanings of phrases into sentences and discourses (Stokic et al., 2011).

Initially, a linguistic stimulus is just another sensory signal – a pattern of light hitting the retina or a constellation of sound pressure waves reaching the cochlea. It is not surprising, therefore, that the earliest brain responses to language are indistinguishable from those to other types of visual and auditory inputs. Eventually, however, the brain begins to categorize (and thus respond differentially to) the input, for example, as a visual string rather than a single object, as a familiar event rather than a novel one, as belonging to the class of stimuli that may be associated with meaning. When and how these classifications unfold are critical questions that have been partially answered.

Lexical items are divided into different word classes, such as nouns and verbs, because they play different semantic and syntactic roles in language and, in behavioral tasks, are responded to differentially by language users. For example, whereas nouns are pointers to objects (people, places and things), verbs generally refer to actions and states. Verbs have been described as more `relational' in their semantics than nouns (Gentner, 1981; Langacker, 1987). In any given language, nouns and verbs typically receive different types of inflectional (grammatical) markings and/or appear in different canonical places in the sentence structure. Perhaps because of these semantic and syntactic differences, nouns are acquired earlier during language development (Nelson, 1973) and are remembered more easily than verbs (Thios, 1975; Reynolds and Flagg, 1976); nouns are also less likely than verbs to be altered during within-language paraphrasing or across-language translation (Gentner, 1981).

1.2. Electrophysiology of lexical processing

Reaction time and neurophysiologic measures indicate that the processing of a single word is facilitated by the prior occurrence of a semantically related word. This facilitation is known as semantic priming and it reflects how word representations are organized in our mental lexicon. Electrophysiological signs of semantic relations between words have been investigated primarily using the lexical decision task (Bentin, McCarthy, & Wood, 1985) and the category membership verification task (Boddy & Weinberg, 1981). In both tasks, ERPs to semantically primed words are more positive between 200 and 500 ms than are those to unprimed words, with the difference presumed to be a member of the N400 family. While the N400 effects in different modalities as well as cross-modally (Holcomb & Anderson, 1993) are similar in comprising a monophasic negative wave between 200 and 600 ms, they differ in amplitude, onset latency, and/or scalp distribution (Holcomb & Neville, 1990). Distributional differences and the reliability with which N400 amplitude is modulated by semantic relations has made it a useful metric for testing various hypotheses about language processing. A central characteristic of language comprehension is that very different sources of information, including information about form, syntax, and meaning of words and sentences, have to be accessed and combined very rapidly. Brain imaging studies have shown that a large number of brain areas are involved in processing each of these relevant types of information. Since different bits of information processed in different parts of the brain must be integrated to obtain a unified concept of the language input at a given moment, the different brain areas involved have to communicate with each other. A fundamental issue in research on the neurocognition of language comprehension is therefore how the dynamic binding of the distributed nodes of the language network takes place, transforming form onto meaning. A good candidate mechanism for such dynamic network formation is that of synchronization and desynchronization of oscillatory neuronal activity.

The spectral composition of EEG data can be obtained with a comparably high temporal resolution using short-time spectral analyses. Depending on the required frequency band and its bandwidth, the time resolution of this technique is better than hundreds of milliseconds allowing for a successful evaluation of dynamical patterns of brain activity. Moreover, this approach warrants that the brain signals of time- but not phase-looked processes are preserved after averaging across repeated events, thus, revealing aspects of brain activity that are not visible with time-domain analysis. Due to the low spatial resolution of EEG, it is difficult to compute source locations of various oscillatory activities. The question of whether oscillations in neuronal networks, as reflected in brain waves, are merely epiphenomena or reflect general functions is still under debate. It has been suggested that higher-frequency oscillations - 20 Hz may mediate the formation of assemblies of neurons that represent a given stimulus pattern. The activity of such an assembly of neurons or cell assembly is characterized by the coherent firing of large groups of neurons. If these coherently activated neurons represent some part of a cortical cell assembly, then cell assemblies can be assumed to be the units by which elementary cortical functions are realized. Thus, one way of exploring these distinct cognitive processes in the human brain could be to measure coherent oscillations with non-invasive techniques, such as EEG or MEG.

Eulitz et al. (1997) showed in an experimental situation where simple lexical processing took place, that normalized spectral power was predominantly enhanced over temporo-occipital brain regions of the language-dominant left hemisphere. In contrast, during the perception of non-verbal stimuli, the enhancement of the normalized spectral power was largest over centro-parietal areas of the right hemisphere. This result might be taken as evidence for the activation of those cortical cell assemblies responsible for language processing located for the most part in the left hemisphere. On the other hand, it might be taken as evidence for the activation of other cortical cell assemblies situated for the most part in the right hemisphere, thus, accounting for the processing of non-verbal information.

These conclusions are somehow different from ours (Djokovic et all. 2010; Stokic et al., 2010) where we showed opposite situation emphasizing that during non-word perception in Beta 1 rhythm only temporal regions were creating functional systems, both in left and right hemisfphere connecting mid temporal and posterior temporal regions with recurent connections in right hemisphere without any other regions. It might be explained by the simplicity of real words perception. They already exist in knowledge and have to be „simply“ pulled out from storage while non-words have to be analysed and without cue kept in auditory regions for repeated computations. Aslo we found in Low Alpha rhythm during real word perception connection between frontal midline region and mid temporal region in right hemisphere but not during non-word perception. During real words perception attention might be directed to meaning while during non-words perception attention might be directed towards its phonological composition becouse meaning can not be used in auditory processing.

Theta activity refers to EEG activity within the 4–8 Hz range, prominently seen during sleep. During wakefulness, two different types of theta activity have been described in adults. The first shows a widespread scalp distribution and has been linked to decreased alertness (drowsiness) and impaired information processing. The second, the so-called frontal midline theta activity, is characterized by a frontal midline distribution and has been associated with focused attention, mental effort, and effective stimulus processing. In light of the observation that these oscillations facilitate transmission between different limbic structures, it has been speculated that theta activity may have a gating function on the information processing and memory retrieval (Djokovic et al., 2010).

2. AIM AND METHOD

2.1. Aim

In this research, we wanted to examine cortical distribution of maximal amplitude of EEG theta rhythm and peak frequency during formation of short-term memory for words and non-words.

2.2. Sample

Ten undergraduate students, 4 male and 6 female, aged 21-23 years, participated in this experiment. All participants were native speakers of Serbian language with no history of hearing and speech-language disorders. All participants were not using any medication that may influence EEG signal. They passed standard hearing screening before experiment –

tonal liminar audiometry, tympanometry, impendancmetry and Otoacoustic Emission (TEOAE and DPOAE). The study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki. All participants gave their written consent.

2.3. Materials

Two sets of stimuli were used in the experiment. The first set consisted of bisyllabic words and the second set consisted of bisyllabic non-words. Each set consisted of ten stimuli. Every stimulus in the word set was balanced by its phonological counterpart in the non-word set. Also stimuli were balanced in length. List of words was created using frequent nouns in Serbian language.

2.4. Procedure

During the experiment the participants were placed in a comfortable sitting position in a sound isolated room. The first part of the experiment consisted of the recording period without auditory stimulation for 5 min during which they had a task to visualy fixate a black square on a white background. Participant were asked to minimize their movements (eye blink, head and limbs movement) as possible in order to eliminate artifacts in row EEG trace. Resting state was used to determine if there are neurological disorders that may influence achievemnt on short-term memory task. During the second part of the experiment participants had a duty to listen a list of bisyllabic words. The period of auditory perception lasted 0.5 second followed by the retention period of 5 seconds and after that was a reproduction of previously heard word. The same procedure was applied using bisyllabic non-words. In this paper we analyzed the retention period of the bisyllabic words and non-words. Stimuli were recorded previously by proffesional speaker, who read the stimuli one by one with the same intensity and without any variation in melody, rhythm and emotional expression.

2.5. EEG recording

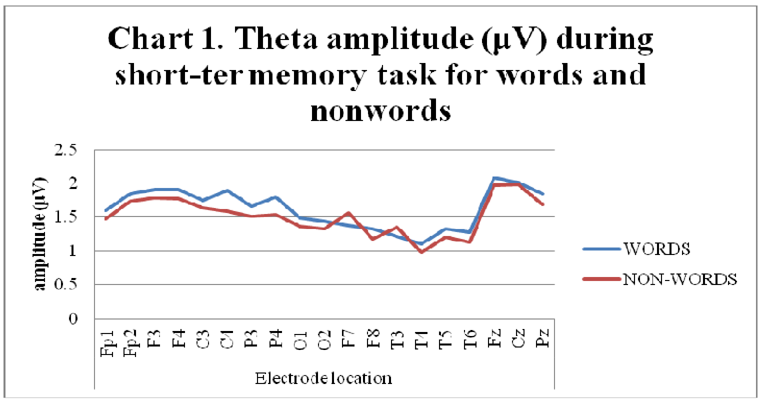
EEG was acquired using the Nixon Kohden Corporation, EEG 1200K Neurofax apparatus with Electrocap (model number 16 755) International, Inc., Ag/AgCl ring electrodes filled with electro-conductive gel, providing 16 EEG channels. Electrodes were positioned according to the 10/20 system in longitudinal, monopolar montage. The reference electrode was set offline to A1 and A2 (ear lobes). Resistance was kept below 5kΩ, lower filter was set on 0.53Hz and upper filter on 35Hz in order to select frequency band of interest as well as to cut off higher frequencies that might be artifacts. Sampling rate was 500 Hz. According to International 10/20 system of electrode positioning following cortical regions are covered: Fp1-Fp2 (frontopolar), F3-F4 (mid frontal), F7-F8 (inferior frontal, anterior temporal, frontal-temporal), T3-T4 (mid temporal) , T5-T6 (posterior temporal), C3-C4 (central), P3-P4 (parietal), O1-O2 (occipital), Fz (frontal midline central), Cz (vertex) and Pz (parietal midline). Odd numbers represent left hemisphere and even numbers right hemisphere.

2.6. Signal analysis procedure

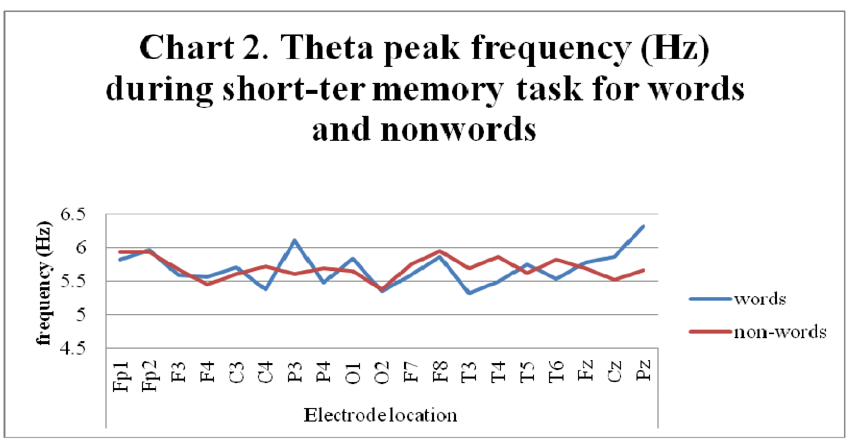
In our study we have used FFT in order to separate Theta rhythm from the row EEG trace where all of rhythms occur simultaneously. First task in signal analysis was to choose artifact free epochs in duration of 5 seconds. Before computing FFT each epoch was multiplied by an appropriate windowing function (Hanning window was used) in order to avoid border problems (leakage). Then FFT was computed in order to get spectrograms and amplitude maps of selected 5-second-epoch.

3. RESULTS

Chart 1 presents results of EEG Theta rhythm amplitude during short-term memory task for words and nonwords for 19 electrodes according to International system for electrode positioning. From the Chart 1 we can see increase of amplitude for memory task for words when compared to nonwords for C4 (words-1.89μV, nonwords-1.59μV) and P4 (words-1.79μV, nonwords-1.54μV) region (central and parietal cortex of the right hemisphere). Also there is an increase in amplitude in frontal midline region Fz (words-2.08μV, nonwords-1.97μV) as well as central midline Cz (words-2.0μV, nonwords-1.98μV) with slightly lower amplitude in parietal midline region Pz (words-1.84μV, nonwords-1.68μV. During memory task for nonwords when compared to words there is higher amplitude in F7 and T3 region (lateral frontal i temporal region – covering approximately primary auditory region (T3) and dorsal-lateral prefrontal cortex (F7) of the left hemisphere.



ANOVA analysis of variance obtained statistically significant difference between words and nonwords for C4 region (MS 3.55, F12.63, *p=0.001*).



ANOVA analysis of variance obtained statistically significant difference between words and nonwords for P3 region (MS 11.13, F8.08, *p=0.01*).

Chart 2 presents EEG Theta rhythm's peak frequency during short-term memory task for words and nonwords. From the Chart 2 we can see higher peak frequency in P3 (parietal region of the left hemisphere) for words when compared to nonwords, as well as in the midline central and parietal regions (Cz and Pz). There is no difference in EEG Theta rhythm peak frequency in frontal-midline region (Fz). For nonwords there is higher EEG Theta rhythm peak frequency in T4 and T6 (temporal cortex of the right hemisphere).

4. DISCUSSION AND CONCLUSIONS

In adult memory research, new methods for studying cortical correlates of successful encoding have been developed in recent years. Functional magnetic resonance imaging (fMRI) and diffusion tensor imaging (DTI) permit the identification of functional brain circuitry and structural connectivity among brain regions that contribute to effective memory formation. Available evidence suggests that successful memory encoding operations involve distributed neural networks across multiple brain regions (Varela et al., 2001; Paller and Wagner, 2002). In fMRI-based research, some consensus has been reached about the functional neuroanatomical correlates of memory encoding. However, the nature and time course of dynamic interactions among brain regions that contribute to encoding efficacy remain largely unknown. Methods with higher temporal resolution than current fMRI, such as electroencephalographic (EEG) recordings, are needed to shed light on the time course of encoding-relevant brain dynamics (Dixon et al., 2004; Summerfield and Mangels, 2005).

Successful encoding apparently relies on close interactions between sensory-specific and multimodal posterior association areas as well as flexible executive regions within the frontal lobes (Fletcher and Henson, 2001; Simons and Spiers, 2003). A more process-oriented understanding of cortical correlates of successful memory encoding thus requires evidence on the dynamical interplay among memory-relevant brain regions. To this end, functionally relevant interaction patterns among brain areas during encoding (Varela et al., 2001) need to be assessed with methods that yield high temporal resolution such as EEG recordings.

The theta power exhibits a tendency to increase with stimulation shifts, consistent with the notion that this rhythm probably signals level of attention. The similarity of results in both the auditory and visual sensory systems (Pedemonte et al., 2005) implies that the theta rhythm behavior is a general attentional mechanism, rather than one specific to the specific system. Furthermore, this rhythm can modulate the firing rate and spike timing of a single neuron (Lee et al., 2005) as well as the gamma power of the intracortical local field potential (Canolty et al., 2006).

Conclusions:

1. increase of EEG Theta rhythm in Fz, for both, words and nonwords, reflects possible role of frontal midline region in short-term memory process in global, without specialization for specific stimulus type (semantic vs. non-semantic),

2. parietal midline region involved in storage of semantic cues has lower EEG Theta rhythm amplitude for nonwords when compared to words,

3. primary auditory (T3) and dorsal-frontal regions (F7) of the left hemisphere have higher EEG Theta rhythm amplitude during memory task for nonwords reflecting possible articulatory-phonological analysis of auditory presented stimuli without semantic cues,

4. central (C4, $p=0.001$) and parietal (P4) regions in the right hemisphere have higher EEG Theta rhythm amplitude during short-term memory task for words when compared to nonwords reflecting role of posterior regions of the right hemisphere in semantic processes (assignment of the meaning to perceived stimulus),

5. higher EEG Theta rhythm peak frequency in the right temporal cortex during memory task for nonwords when compared to words might reflect phonological search mechanism,

6. higher EEG Theta rhythm peak frequency in the central and parietal cortex (P3 – *p=0.01*, Cz and Pz) during memory task for words when compared to nonwords might reflect direct semantic processing without need for phonological processing because meaningful frequent words are already part of the long term memory.

ACKNOWLEDGMENT: This paper is supported within project 178027 "Interdisciplinary research of the verbal communication quality" which is financed by the Ministry of Science and Technological Development of Serbia.

REFERENCES

Bentin, S., McCarthy, G., & Wood, C. C. (1985). Event-related potentials, lexical decision and semantic priming. *Electroencephalography and Clinical Neurophysiology*, *60* (4), 343–355.

Boddy, J., & Weinberg, H. (1981). Brain potentials, perceptual mechanism and semantic categorization. *Biological Psychology*, 12(1), 43–61.

Canolty, R.T., Edwards, E., Dalal, S.S., Soltani, M, Nagarajan, S.S., Kirsch, H.E., Berger, M.S., Barbaro, N.M., Knight, R.T. (2006). High gamma power is phase-locked to theta oscillations in human neocortex. Science 313, 1626–1628.

Dixon, R.A., Wahlin, A., Maitland, S.P.etal.,(2004). Episodic memory changes in late adulthood: generalizability across samples and performance indices. Memory and Cognition 32, 768–778.

Djokovic S., Stokic M., Nenadovic V., Milosavljevic Z., Maksimovic S. (2010). Spectral analysis of EEG signal in verbal information processing task. *Disabilities and Disorders: Phenomenology, Prevention and Treatment part II*, Editors: Prof Jasmina Kovacevic, Prof Vesna Vucinic, ISBN 978-86-80113-99-9, pp. 63-82.

Eulitz C., Maess B., Pantev C., Friederici A., Feige B., Elbert T. (1996). Oscillatory neuromagnetic activity induced by language and non-language stimuli. *Cognitive Brain Research*, 4: 121-132.

Fletcher, P.C., Henson, R.N.A., 2001. Frontal lobes and human memory: Insights from functional neuroimaging. Brain 124, 849–881.

*Gentner D. (*1981). *Some interesting differences between nouns and verbs. Cogn Brain Theory;* 4*:* 161*–78.*

Holcomb, P.J., Neville, H.J. (1990). "Auditory and visual semantic priming in lexical decision: A comparison using event-related brain potentials". *Language and Cognitive Processes* 5: 281-312.

Holcomb, P. J., & Anderson, J. E. (1993). Cross-modal semantic priming: A time-course analysis of event-related brain potentials. *Language & Cognitive Processes*, 8(4), 379–411.

*Langacker RW. (*1987). *Nouns and verbs. Language.* 63*:* 53*–94.*

Lee, H., Simpson, G.V., Logothetis, N.K., Rainer, G., (2005). Phase locking of single neuron activity to theta oscillations during working memory in monkey extrastriate visual cortex. Neuron 45, 147–156.

*Nelson K. (*1973). *Structure and strategy in learning to talk. Monogr Soc Res Child Dev; 38: 136.*

Paller, K.A., Wagner, A.D. (2002). Observing the transformation of experience into memory. Trends in Cognitive Science 6, 93–102.

Pedemonte, M., Gambini, J.P., Velluti, R.A., 2005. Novelty-induced correlation between visual neurons and the hippocampal theta rhythm in sleep and wakefulness. Brain Res. 1062, 9–15.

*Reynolds AG, Flagg PW. (*1976). *Recognition memory for elements of sentences. Mem Cogn;* 4*:* 422*–32.*

Simons, J.S., Spiers, H.J., (2003). Prefrontal and medial temporal lobe interactions in long-term memory. Nature Reviews Neuroscience 4, 637–648.

Stokic M., Milosavljevic Z., Markovic D. (2010). Quantitative EEG correlates of verbal information processing at four-years-old child with severe auditory phoneme addiscrimination. *Third European Congress on Early Prevention, Detection and Diagnostics of Verbal Communication Disorders, Book of Abstracts* (Editors): M. Skanavis, M. Sovilj, Olimpia, Greece,pp.48

Stokić, M., Milosavljević, Z., & Maksimović, S. (2011). Oscilatorna moždana dinamika tokom procesiranja reči. *Specijalna edukacija i rehabilitacija*, 10(1), 141-152.

Summerfield, C., Mangels, J.A. (2005). Coherent theta-band activity predicts item-context binding during encoding. NeuroImage 24, 692–703.

Thios SJ. (*1975). Memory for general and specific sentences. Mem Cogn;* 3*:* 75*–7.*

Varela, F., Lachaux, J.P., Rodriguez, E., Martinerie, J. (2001). The brainweb: Phase synchronization and large-scale integration. Nature Reviews Neuroscience 2, 229–239.

THE SPEECH ACT OF APOLOGY IN SPOKEN VERBAL COMMUNICATION

DEYANA PENEVA
Shumen University, Bulgaria
deyanavvv@abv.bg

Abstract: The paper dwells on the structure of apology speech act in English and Bulgarian with regard to spoken verbal communication and also comments on the felicity conditions which contribute to the successful performance of the apology speech utterances. The paper further focuses on spoken discourse and the analysis is based on a corpus of data taken from recorded and transcribed oral monologue and dialogue interactions from BNC and a Learner corpus which comprises a variety of apologetic structures used in different context-dependent situations. With regard to spoken discourse certain issues are discussed in the paper: the difference between verbal and spoken communication; the opening and closing of the exact speech act; the specific characteristics of performative utterances.With regard to the second problem the paper focuses on the felicity conditions which are considered to be the conventions that the interlocutors in a speech event (the speaker and the hearer) use as a code to produce and recognize actions.

Key words: apology, felicity conditions, performative utterances, speech act, speech situation,

Apology, as one of the speech acts, and its realization patterns have been the subject of extensive research in the fields of psycho-linguistics and pragmatics and is a significant challenge in interlanguage research on pragmatics as an intercultural communication issue. In order to communicate effectively and efficiently in any language foreign language speakers not only need to acquire grammatical competence to master their linguistic knowledge but they also need to be adequately familiar with the sociolinguistic rules so that they can be able to use appropriately the linguistic forms. Thus, for non-native speakers, adopting and learning these rules is of crucial importance if they want to use correct linguistic patterns and know in what situations they can apply them.

Non-native speakers find themselves in embarrassing situations when talking to native speakers. In some cases it is difficult for them to decide what actually stands behind their words; sometimes they find it even more difficult to understand what the meaning of the speech act that is performed actually refers to. Native speakers of a language use it intuitively; they also exercise the speech acts in their own language socially. However, non-native speakers must be taught speech principles and strategies to be able to express a certain attitude and the type of speech act being performed corresponds to the type of attitude being expressed. For example, a statement expresses a belief, a request expresses a desire, and an apology expresses a regret (Bach 1994). A speech act is considered successful, as an act of communication, if the hearer is able to identify the attitude being expressed. Cross-cultural studies of speech acts in a variety of cultures and languages have been carried out by many researchers (Holmes 1990; Blum-Kulka, Olshtain 1984a, 1984b; Searle 1965). However, little attention has been paid to the speech act behaviour of the native Bulgarian speakers of English.

Since the present paper is a short extract of my PhD thesis it dwells, in particular on how language is used in context and in that respect the paper focuses on units larger than sentences and it can be assumed that the study of the speech act of apology is in general a study of discourse with regard to the use of language in texts, context and the main functions of language with respect to speech situation.

The paper focuses on the structure of the apologetic utterances with regard to spoken verbal communication and also dwells on the felicity conditions which contribute to the successful performance of the apologetic speech act.

Spoken discourse

The two primary channels for verbal communication are speech and writing. A written message is likely to have a different form from an equivalent spoken one. Here the contemporary study focuses mainly on spoken discourse and the corpus is taken from recorded and transcribed oral monologue and dialogue interactions from British national corpus; the experiment data are collected and then analyzed on the basis of students' oral answers and presentations. And it is essential here to differentiate the two notions: verbal versus spoken communication. Actually these two terms do not stand for one and the same notion. Verbal communication comprises the linguistic items which we use when talking and namely the words we choose to use, whereas spoken communication as a broader term, is a combination of verbal communication and non-verbal communication skills. Spoken communication does not only include the linguistic side of communication, the particular delivery of words in the particular language in a meaningful way, but it goes beyond the verbal communication since it includes the speaker's articulation, the tone and prosodic manifestation of the speech as well as the speaker's mannerism. In that respect the spoken discourse when exploring the apology speech acts comprises not only the linguistic side of the acts but also their non-linguistic manifestation – prosodic cues, participants and setting of the speech situation (Tannen 1982).

But since we dwell on spoken not written communication we must point out here that when processing speech the hearer cannot stop the flow of words, phrases and sentences, and search for records to "check on some interpretations" and since the participants have no record of conversations that inextricably leads to the assumption that the speakers have to monitor hearer's understanding during the discourse and that the hearer has to provide evidence not just that they have heard but that they have properly understood the speaker's message (Owen, 1983). In that respect in the case of apology the speaker (apologizer) can be wrongly understood by the hearer (apologize) and may need to rephrase his utterance or provide the addressee with additional explanatory material. Speaker's communicative production may result in hesitations or "filled pauses" (ums and ers) or she/he may need to use gestures to help the better understanding of their message (Tannen, 1982).

For example:

A boy wants to show his friend his new digital camera and his friend unintentionally drops it on the ground.

Student 1:	"*Ooops! I am (keeping silent, a pause) …. really …. so….. sorry!"*
Student 2:	"*What have you done? It's brand new!"*
Student 1:	*(a silent pause). "Oh, God, I am such an idiot!"*
Student 2:	"*Needless to say it's worth a fortune!"*
Student 1:	"*I have to do something about this. Anyhow, it's my fault. Is it still under guarantee?"*
Student 2:	"*Indeed it is. But…"*
Student 1:	"*You believe I didn't mean it, don't you? We have to go to the shop and see if it can get a quick fix."*
Student 2:	"*We'd better go. Uff! I just got it. I can't believe you broke it"*.

Student 1: "*Oh, I am so sorry. So stupid of me! If it can't get fixed, I will buy you a new one. Don't get upset. We are still friends, right?"*

Student 2: "*I can't get angry with you. Right."*

(from the British serial "Teenage kicks", ep.2, 2011)

It is obvious here that speech relies extensively on the context of utterance for its interpretation. It includes common knowledge shared both by the speaker and hearer. Speakers generally perform their utterances in such a way that the hearer will be able to perceive them in real time; and the speakers know what the demands of hearers are since these demands are hearers' too (Van Dijk 1985). All these are characteristics of spoken discourse.

When people converse they learn things about their co-participant; they may succeed in all or some of their goals and even certain words spoken or heard are forgotten something has been achieved (Sacks, Schegloff, Jefferson 1974).

Openings and closing

Another point to take into consideration in the structure of the spoken apologetic interaction is the opening and closing of the exact speech act; how the apologetic speech act is initiated and how it is closed down. According to James (1980) any conversation has beginning, middle part and end. He suggests that openings and closings are negotiated by 'ritual' exchanges that consist of a limited set of stereotyped phrases or class of verbal formulae and that is called *phatic communion* (Goffman 1981:266; Laver 1975:218). Laver stresses on the double nature of phatic communion that it is *indexical* and *deictic*. 'Indexical' refers to its function to transmit to the hearer information about the speaker's personality and social status. That phatic communion is 'deictic' means that it refers to factors specific to the time and place of the utterance. Phatic communion is also used to end conversations and in the case of speech acts the function of polite closing is to "ensure easy resumption" (Laver, 1975). A crucial question in contrastive analysis is therefore what serves as the subject matter for phatic communion in apology speech acts in different linguistic communities?

With regard to apologies there is not a strict organization of apologetic utterances, though "*I'm sorry*", "*Sorry*", "*I really regret*" tend to be frequently used to initiate the act. Offering a straightforward apology ("*I apologize for …*") or using language that acknowledges the speaker's perspective is typical for initiating the speech act ("*I understand how frustrating it must have been to…*).

In order to be successful (to be properly understood, accepted and adequately responded) the statement of apology or empathy must be followed by other apologetic strategies: explanation of the problem's cause ("*I actually overslept and didn't hear the clock ringing*"); proposed solution to the problem ("*I will call your parents and explain the matter*").

A goodwill closing may include expressions of concern for the other's person's welfare *("You didn't hurt, did you?")*, promising of non-recurrence*("I promise I will never speak to you that way. It was so rude of me.")* or offer of repair*("I broke it, I know. I will find a mechanic and you will have it fixed in no time.")* (Deutschmann 2003).

Regarding the explanation of the problem's cause the apologizer must explain what went wrong but she/he has to do it in short as if it goes too long, the explanation or account may begin to sound like an insufficient, incomplete excuse. In view of the proposed solution to the problem the apologizer should be clear and specific about what actions she/he has taken or will take to correct the problem. A goodwill closing may include a repetition of the straight apology asking for forgiveness or a promise of non-recurrence.

Though there is not a strictly-organized order of the apologetic strategies there are routine structures which are most frequently used.

Undoubtedly here the channel, the way an apologetic interaction takes place and is organized is dependent on the "propositional content" and "illocutionary force" of the utterance (Searle 1969), that is according to Grice (1975) "what is said" and "what is meant" respectively.

Since most of the apologetic situations are conducted through speech and in particular monologue and dialogue discourse, the attention in the present study is focused on everyday interaction and especially ordinary everyday conversation presented by performative utterances.

Now I should concentrate more precisely on the structure and specificity of performative utterances which are in the core of the study.

Performative utterances

When linguistically expressed apologies become explicit in the form of speech acts, but what exact kind of speech act they are is rather problematic and the issue deserves to be discussed.

It is generally known that the speech act is an utterance which serves some function in communication which becomes explicit in real-life interactions in speech situations and it possesses a certain illocutionary force (expressing the speaker's intention when uttering the sentence). Consequently apologies as speech acts are utterances with certain illocutionary force which are also declarative sentences which have a subject followed by a verb. They can state a fact or an idea without requiring an answer or action from the hearer (reader) and they do not give a command or request and do not ask a question. So we could assume that apologies are declarative utterances. But since they possess a certain illocutionary force they can be considered statements. But according to Bach (2004) a statement is one type of utterance whereas an apology is a different type. The difference comes from the fact that a **statement** is an assertive illocutionary act (Bach 2004; Doerge 2006) which represents a state of affairs saying that some state of affairs is true and it is usually represented by a performative verb such: *state, claim, describe, tell, assert.* For example:

He claims that the President of Bulgaria is Plevneliev.

Actually a statement is a kind of performative utterance but it possesses a certain true or false value. On the other hand an apology is also presented by certain performatives such as: the performative verbs *apologize, regret, excuse* and the performative adjective *sorry*. But an apology differs from a statement in that it is not an assertive illocutionary act but an expressive illocutionary act which tends to express the mental state of the speaker about an event **presumed** to be true. Consequently both statements and apologies are performative utterances in that they possess a performative verb expressed by a certain illocutionary force. They differ in that that **statements** are **assertive performative utterances** which are based on truth-value semantics whereas **apologies** are **expressive performative utterances** where it doesn't make sense if we say that they are true or false. Additionally, as apologies cannot be taken to be true or false, they possess two other qualities – to be felicitous or infelicitous. A number of conventions which Austin calls felicity conditions (Austin 1962) determine and regulate the use of performative utterances. For instance, one of the felicity conditions for uttering *I am sorry I didn't see you* is that the speaker has the authority to make an apology. And here comes the tricky moment – it is **presumed** that apologies are true, not asserted to be true. An apology can be considered true or false only if it is viewed in a specific situation in a given context which requires felicity conditions. For example:

Speaker: *I am sorry that I didn't call you beforehand and you were late for the gathering.*

We can presume the apology to be true. But when presented in a given context the truth values can change into non-truth values.

Hearer: *But you did it intentionally.*

Speaker: *No, I didn't.*

It is rather obvious that in performative utterances and in expressive performatives, in particular, the terms *truth – non-truth values* are rather ambiguous and viewed from different sides in different context-dependent situations. So it is better to talk about felicity conditions rather than truth-value conditions as the latter primarily belong to the domain of semantics whereas felicity conditions are characteristics of pragmatics.

Holmes considers that apology as an expressive illocutionary act has certain minimal felicity conditions and namely:

1) an act has occurred;
2) the speaker believes the act has offended the addressee;
3) the speaker takes some responsibility for the act.

Felicity conditions

According to Turnbull felicity conditions are conventions that the interlocutors in a speech event (the speaker and the hearer) use as a code to produce and recognize actions. Speakers use the felicity conditions for actions as a means for encoding their actions into sentences with a specific linguistic structure that they produce via utterances. Hearers, on the other side, use the same set of felicity conditions for actions as a means of decoding the speaker's actions from the linguistic structure of the sentences the speaker produced (Turnbull 2003).

Searle set out a series of conditions which "were designed only to give us the bare bones of modes of meaning in actual discourse" (Searle 1969). Bennett, Hamermas and Apel (1991) objected that Searle only describes the semantics of speech act verbs but does not focus on the subtleties of a speech act.

Regarding the speech act of apologizing the following set of rules are allocated here (these rules are modeled closely on Searle's rules for other speech acts) (1969:67) which actually are expected and needed and establish appropriate circumstances for a speech act to be recognized as intended (http://ifla.uni-stuttgart.de):

1) *Propositional act*: the speaker expresses regret for a past act she/he has done.

For example: *"I really regret I didn't call you on time."*

2) *Preparatory condition*: the speaker believes that the act he has done was not in hearer's best interest that is in fact the pre-existing conditions about the event.

3) *Sincerity condition*: the speaker regrets the offensive act; that is the attitude of the speaker towards the act.

4) *Essential condition*: the communicative act counts as an apology for the offensive act; that is the change of state of the speaker.

(The examples are taken from the Learner corpus).

All these rules known as felicity conditions are a main factor in the theory of speech acts (Turnbull, 2003).

Let us see how this might work with a specific example.

Dannie says to his brother: *"Sazhalyavam, che ti schupih kamerata"*.
(From the Bulgaria serial 'Glasshome', ep.12, 2011)
("I am sorry I broke your digital camera")

Propositional act: the speaker (Dannie) expresses regret for a past act (breaking Kamen's digital camera) which the speaker himself performed.

Preparatory condition: Dannie believes that breaking Kamen's camera was not in Kamen's best interest.

Sincerity condition: Dannie is sorry he broke Kamen's camera.

Essential condition: In uttering the words *"Sazhalyavam, che ti schupih kamerata"* Dannie apologizes to Kamen.

Actually Searle's rules could cope well with the proposed example. But the example is rather simple, a paradigm case and it is not necessary for us to look very far to find perfectly ordinary examples of apologies which do not fit these rules (e.g. *"Izvinyavam se, che vi preredih, no ne mozheh da dopusna Vie da ste prav na reditsata" - "I am sorry I jumped the queue but I couldn't bear seeing you in the lead).* The speaker actually apologizes that she/he has done something inappropriate, but he neither feels sorry nor regrets as the act is not in his/her interest. The speaker in fact breaks the preparatory and sincerity conditions.

It is essential here to take the conditions and see how they apply to instances of apologizing which we come upon everyday life.

Propositional act: In many cultures it is possible to apologize on behalf of someone or something else: of someone close to you or of whom you have responsibility (children, the family car, family members); of an institution with which you are associated (the company or firm you for which you work). Consequently, a question arises here: does the act have to be performed by the speaker? It is not unusual to hear people in English apologizing for things over which they have no control such as saying *sorry* when someone bumps into them or apologizing to overseas visitors for the weather. In Bulgaria people follow similar trends: they apologize for train delays or bureaucracy misunderstandings, something they are not responsible for (Thomas 1996).

Going further into the discussion of apology conditions a second question arises: Does the act have to be a past one? Can one apologize for a future act?

For example: *"I am sorry but I shall have to report you."*

Can one describe as an apology the action of a thief who asks for your forgiveness before breaking into one's house? And more: Does the speaker have to express regret formally/explicitly? (Thomas 1996).

There are circumstances (when an employee arrives late at work) when simply saying *"I was struck in a traffic jam"*. This could count as an apology if the employer has chosen to accept it as such, though here the role of the hearer has insufficiently been taken into account.

The following example illustrates some of these points:

The episode from which this extract was taken was set in an accounting department office in Boston. One of the main characters, Sean, had recently understood that he had an illegitimate daughter by a Swedish woman. Sean's wife got very upset and had decided to leave him and return to her parents. Though eventually, she changed her mind and went back to her husband. Later, Sean understands that he is sterile and not able to have children. The suggested communicative interaction comes as follow:

Sean: *"I'm not Nikita's father, Julia."*
Julia: *"Is that sorry?"*
Sean: *(Sean keeps silent nodding his head shamefully).*
(taken from the American TVserial "the Office", ep.11, 2011).

An important assumption can arise from this example: Sean's words have the potential to act as an apology but his words are accepted as an apology only when Julia makes up her mind to take them as such.

Preporatory condition. The question here is whether the speaker has to believe that the act was/is/will be to the hearer's disadvantage (Holmes 1990). One could apologize rather sincerely for unintentionally knocking down his/her friend junk food hamburger while personally thinking that his/her friend had better not eat it at all. In Bulgaria it is common practice (in other cultures as well) when visiting neighbours, friends or relatives to bring a bottle of alcohol or something sweet and we routinely apologize for our gift though we know that the host shall be delighted with it. For example:

"Kogato i da doydem, vse nosim edno i sashto. Shte izvinyavate, ama kakvo drugo da e."

(from the Bulgarian sitcom "Local residents in more", ep.13)

"Whenever we come along we are always bringing one and the same. You should excuse us, but what else could we bring?"

Sincerity condition. People often say they are sorry when they are actually not. Does it mean that they have not apologized? (Holmes 1990).

During the miners' strike in Bulgaria (Novemeber, 2011) in front of the parliament in Sofia, the miner's leader was ordered to apologize to the legal authorities for misinterpreting their regulations. In a later TV interview he was asked if he had regretted his actions and respectively his words. He simply replied:

"Kazah, che naistina se izvinyavam, no ne sam kazal, che sazhalyavam."

"I said that I did apologize but I didn't say I was sorry.'

In both English and Bulgarian-speaking cultures, most native speakers agree that the performative structure *I apologize* (in Bulgarian *Izvinyavam se*) often sounds like something routine, a formalized apologetic structure just "for the form's sake", which is less sincere than *I am sorry (Sazhalyavam*).

Essential condition. When saying or writing that you are sorry this actually seems to be the essential element or condition when apologizing. But here, in fact, is raised a question if it is absolutely essential to utter certain words (or any words at all) in order to apologize. Thomas (1996) cites Searle in that the propositional act and the preparatory condition are rather essential in the speech act of apologizing which operates in everyday life, that is: the speaker expresses or implies or in some other way indicates regret for a past, present or future act performed by the speaker, or someone or something for which the speaker has responsibility or could be seen to have responsibility for (but perhaps has no responsibility whatsoever) and he may or may not believe that the act was, is or will be against the hearer’s best interests.

When we try to expand Searle’s rules to reflect the way in which the apology speech acts function in daily life, the conditions become rather complex, vague and useless. The formal rules of the speech acts operate only in very restricted circumstances and when discussing the apologetic speech acts I have taken this into account with regard to the relevant data and results in both English and Bulgarian corpus and examples.

REFERENCES

Austin, J.L. (1962) *How to Do Things with Words*. Oxford: Oxford University Press.1962.

Bach, J. (1994). “*Conversational Impliciture*” Mind and Language, 9: 124–162. (Influential paper on the explicit and the implicit, distinguishing ‘implicIture’ (with an ‘i’) from implicatures.), 1994.

Blum-Kulka,S.; Olshtain, E. (1984a). Blum-Kulka S., Olshtain, E. Requests and apologies: *A cross-cultural study of speech act realization patterns*. Applied Linguistics, 5, 196-213.

Blum-Kulka, S.; Olshtain, E. (1984b).. Requests and apologies: *A cross-cultural study of speech act performance of learners of Hebrew as a second language.* Applied Linguistics, 3,

Deutschmann, M. (2003). Apologizing in British English. Umea: Institutionen for moderna sprak, 2003.

Doerge, F. C. (2006). *Illocutionary Acts - Austin's Account and What Searle Made Out of It*. . Tuebingen .

Grice, H. P. (1975). Grice H.P. Logic and conversation. In A. Jaworski, & N. Coupland (Eds.), *The discourse reader.* New York: Routledge, 76-87.

Goffman, E. (1981). Forms of Talk, Philadelphia: University of Pennsylvania Press. ISBN 978-0-8122-7790-6.

Holmes, J. (1990). Apologies in New Zealand English, Language in Society 19, 155-186.

James, C. (1980). *Contrastive Analysis*, Longman House, 136-154

Bennet, J. 1991. How do gestures succeed? In Lepore E, van Gulick R (eds.) John Searle and his critics. Basil Blackwell, Oxford,. 12-15.

Laver, J. (1975). Communicative functions of phatic communion. In A. Kendon, R.M. Harris & M.R. Key (Eds). Organization of behavior in face-to-face interaction: Mouton, 215-238.

Owen, M. (1983). Apologies and Remedial Interchanges: A Study of Language use in Social Interaction. Berlin & New York: Mouton Publishers.

Searle, J. (1965). *What is a speech act?* In P. P. Giglioli (Ed.), Language and social context. Harmondsworth, England: Penguin Books.. 136-154.

Searle, J. (1969). Speech Acts: An Essay in the Philosophy of Language. Cambridge: Cambridge University Press.

Sacks, H.; Schegloff, E.; Jefferson,P. (1974) in "A Simplest Systematics for the Organization of Turn-Taking for Conversation*, Language of Pragmatics*, December.

Tannen, D. (1982). Tannen D. Spoken and written language: Exploring orality and Literacy, Albex, Norwood, NJ.

Thomas, J. (1996). Thomas J. Meaning in interaction: an Introduction to pragmatics. Longman, London and New York, 99-102.

Turnbull, W. (2003). Turnbull W. Language in Action: Psychological Models of Conversation. *Psychology Press*.

Van Dijk, T. (1985). (ed.). Handbook of discourse analysis, (four volumes), Academic Press, New York.

http://ifla.unistuttgart.de/institut/mitarbeiter/jilka/teaching/Pragmatics/

MOUTH ACTIONS IN SIGN LANGUAGES: THE ROLE OF MOUTHING IN HZJ

ANET MARCAŠ, MARINA MILKOVIĆ
Universitiy of Zagreb, Faculty of Education and Rehabilitation Sciences
anet.marcas0@gmail.com ; milmarzg@gmail.com

Abstract. The purpose of this paper is to attempt to dispute one of numerous popular misconceptions about sign languages, that is, the hands are the most important articulator of signed utterances. Surely, the hands are the primary articulator, but the articulators of sign language are not just manual. Non-manual markers are just as linguistically important. This paper focuses on mouth actions, more specifically on *mouthing* in Croatian Sign Language (HZJ).
The research show that *mouthing* (full or partial articulation of spoken word) has special function in the formation of linguistic message, which includes the following features: a) the extension of meaning, or semantic modification of the sign, b) the distinction of manual homonyms, c) non-manual connecting parts of a sentence, and d) emphasizing certain manual information. Given the above functions, *mouthing* shows the effects on phonological, morphological, syntactic and semantic level in HZJ.
Key words: mouthing, mouth actions, non-manuals, Croatian Sign Language (HZJ)

1. INTRODUCTION

Linguistic studies of sign languages began in 1960s, by William Stokoe's influential work on American Sign Language (ASL) phonology structure. Nowadays, he is recognized as the founder of the linguistic study of sign languages. His and later studies of sign languages were primary focused on determining the identity of sign languages as natural human languages which are not related to the surrounding spoken languages or based on pantomime and gesture. Therefore, fifty years of linguistic studies of sign languages so far have proved that the sign languages are natural human languages with a complex organization of their phonology, morphology, syntax and prosody. Thus, sign languages contain all the linguistic features found in spoken languages (Emmorey, 2002; Sandler & Lillo-Martin, 2001). Despite the fact that sign and spoken languages share basic linguistic properties on above mentioned levels, they are produced and perceived in different ways (Perniss et al., 2007). The grammatical structures of sign languages donot match or resemble those of neighboring spoken languages.

Although it has been proved that sign languages do not depend on surrounding spoken language, there are still many misconceptions about sign languages. One of them is that sign languages include both signing and speaking in the same time. In that case it should be noted that that represents simultaneous communication where the lexical units of sign language follow the syntactic structure of spoken language at the same time. This form of communication is deprived from full-blown grammar and constitutes an incomplete linguistic system. On the other hand, we find misleading that linguistic structure in sign languages are fully marked manually, that is, articulated by hands only. Although the principal phonological parameters for sign languages include hand configuration, hand location and movement (Brentari, 1998), the hands are not the only articulator in sign languages.

Furthermore, one of the most obvious differences between sign and spoken language is that spoken languages have a single articulatory system, while sign language production involves simultaneous use of multiple articulators beyond the two hands (Vinson et al., 2010). It is not disputable that the hands are very important articulator while signing, but other articulators like the upper body, the head and the face are equally important. All these elements that are not expressed by the hands are referred to as non-manual markers or just non-manuals (Pfau & Quer, 2010). The role of these articulators is very complex and rich. Sign utterances consists of both manual and non-manual components which are intertwined in a very complex harmony while signing. Some signs require the use of non-manual parametres as well as hand actions. Even though the manual parameters like the handshape, location, palm orientation and movement have the same function on a phonological and morphological level, non-manual characteristics are equally important in the sense that they show the specificity of sign language visual modality.

1.1. Non-manual markers

As mentioned above, non-manual markers are very important component in sign languages. Both hand and non-manual features complement each other in a way they allow signers to convey complete and well formed linguistic message. This statement corroborates the fact that signers, while communicating, do not focus their attention on each other's hands but rather on the face, where essential grammatical information is encoded non-manually (Pfau & Quer, 2010).

Non-manual markers consist of various facial expressions, head tilting, shoulder raising, mouth actions, and similar signals which are added to manual signs to create and convey meaning. In HZJ, there are eight basic groups of non-manual markers: mouths shape, eyegaze, position of eyebrows, blink, head movement, head nod/shake, body shift and body lean (Šarac-Kuhn et al., 2006). As in other sign languages, the research of HZJ so far has shown that the signals from upper body and face have a significant role in lexical distinctions, prosodic cues, morphological modifications and syntactic structures in communication.

In this research, our aim was to investigate different mouth actions which accompany signs, specifically their function and frequency distribution. Furthermore, it should be noted that in the literature, various terminologies and definitions have been used to address mouth actions and lack of standardized terminology is still present. Terminology regarding mouth actions which is widely adopted and currently in use is shown and described in Figure 1.

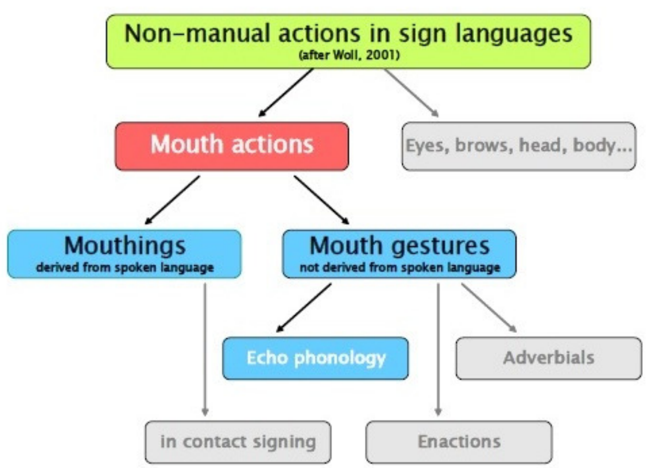


Figure 1. Hierarchy of non-manual actions in sign languages (Woll et al., 2008:663)

1.2. Mouth actions

Although consensus on terminology in describing different types of mouth actions within the researchers still isn't reached, in general, there is a general distinction between two main types of mouth actions: *mouthing* and *mouth gestures*. The main difference between these two types of mouth actions is in the relationship with the spoken language.

Mouth gestures are not derived from spoken words and have no relationship to spoken language. This type of mouth actions has also been labeled mouth arrangements, oral components, or oral adverbials. Furthermore, these mouth actions are inherent features of every sign language, thus they reflect uniqueness of sign language grammar (Crasborn et al., 2008).

On the other hand, mouthing is referred to as full or partial voiceless approximation of a spoken word on the lips, which usually has a semantic correspondence with a sign produced at the same time (Mckee, 2007). Furthermore, mouthing is sometimes referred to as spoken components, word pictures or oral components. Besides terminology, the precise status of mouthing in sign language provokes much debate in the literature. Some researchers consider mouthing as borrowings from a spoken language, thus coincidental to sign languages. From this perspective, mouthing is considered to be a result of code mixing and thus not as an integral part of any sign language (Crasborn et al., 2008; Ebbinghaus & Heiβmann, 2001; Hohenberger & Happ, 2001). Furthermore, this view is justified by the fact that there are mouthing which can be considered redundant in a way they don't add meaning of a manual sign with a more general meaning (Pfau & Quer, 2010).

It must be noted that rejection of mouthing as an integral part of sign languages is not universal. From other perspective, regarding features and frequency distribution among a large number of sign languages, mouthing is considered to be an integral part of many sign languages. Studies of mouthing in ASL have shown that mouthing contributes significantly to formal and semantic aspects of ASL (Nadolske & Rosenstock, 2007). Similar significance of mouthing was also found in other sign languages as in British Sign Language (BSL), Norwegian Sign Language (NSL), Nederlandse Gebarentaal (NGT), and New Zealand Sign Language (NZLS) (Mckee, 2007; Pfau & Quer, 2010; Schermer, 2001; Woll, 2009).

Regarding the features of mouthing in various sign languages, it has been noted that mouthing: a) tends to be seen most often with nouns an uninflected verb forms, b) is used more for open than closed class items, and c) occurs with signs which may be described as morphologically simple (Pfau & Quer, 2010; Nadolske & Rosenstein, 2007). Furthermore, the similarity and overlapping in some functions between mouthing and mouth gestures also confirms the attitude that mouthing has been integrated in morpho-syntactic structure of sign languages. Also, studies of mouthing have shown similar distribution of types of mouthing across different sign languages (Pfau & Quer, 2010). However, we can't talk about universality of non-manual features among sign languages. The frequency of mouthing while signing depends on sociolinguistic variations, variations in discourse settings (informal/formal), exposure to the surrounding spoken language and other socio-cultural and contextual factors: age, gender, age ot the onset of signing etc. (Monschein, 2009).

Likewise, studies of mouthing indicated that mouthing may have three different functions: a) to disambiguate minimal pairs, b) to disambiguate signs with identical manual parameters (manual homonyms), and c) to specify or complement the meaning of the sign. For example, the manual sign ETEN ('*to eat*') in NGT can be accompanied by the mouthed word *BROOD* ('*bread'*), thus forming the complex meaning *'to eat bread'*. As well, it was recognized that mouthing can be sole carrier of the meaning when there is no manual component (Woll, 2009). In that case, the sign has no manual component, thus mouthing conveys the whole linguistic message.

2. MOUTHING IN HZJ

Since 1970s, there has been great interest for mouth actions in sign language, which are not related to the surrounding spoken language and therefore this type of mouth actions has been investigated extensively for European sign languages in the past few decades. One of the reasons is the fact that mouthing does occur in the majority of sign languages, such as those in Norway, Germany, Italy, Switzerland and the Nethererlands (Schermer, 2001).

Studies of mouth actions in HZJ have confirmed that there are two types of mouth actions in HZJ: mouthing and mouth gestures (Šarac-Kuhn et al, 2006; Dukić, 2011; Marcaš, 2013). In the current study, we present results found in previous studies regarding categories of mouthing, their frequency distribution as well as their relation to the word class. Regarding the frequency distribution of mouthing, Marcaš (2013) reported that mouthing is the largest category of mouth action which occurs while signing (57%). This result is consistent with those of other sign languages, such as BSL, NZSL and German Sign Language (DGS) where very high frequency of mouthing are reported, with 51% to 80% of all manual signs involving mouthing (Crasborn et al., 2008; Mckee, 2007; Monschein, 2009). It must be noted that studies of mouth actions are relatively new, thus resemblance and overlapping in the data across different sign languages can be due to the influence of spoken language, similar sociolinguistic factors in Deaf communities as well as similar educational systems.

Furthermore, the same study reported existence of four types of mouthed words :

- full mouthing: articulation of complete Croatian lexical items
  (e.g. *KUĆA*; '*house'*)
- first syllable: articulation of the first syllable of Croatian word
  (e.g. *SJE* as in SJEDITI; '*sit'*)
- first phoneme: articulation of the first phoneme of Croatian word
  (e.g. *O* as in OKOLO; '*around'*)
- reduced mouthing: articulation of two syllables at least
  (e.g. *PONO* as in PONOVO; '*again'*)

Also, investigating frequency of different types of mouthing mentioned above, results showed that the largest category of mouthing in HZJ is full mouthing where complete Croatian word is articulated. Furthermore, when reduced, the first syllable of the Croatian word is usually retained (Marcaš, 2013).

2.1. Word classes and mouthing

Although in the past few decades sign language researchers have been studying numerous structural characteristics of a number of different sign languages, the distinction between word classes in sign languages is still underrepresented due to many theoretical and methodological problems (Schwager & Zeshan, 2008). There is no universal classification on word classes, thus researchers who deal with this topic have to find their own criteria to identify different word classes in target sign languages. Also, it must be noted that word classes are language specific, since different sign languages have different word classes. Due to the lack of standardized classification of word classes in sign language, researchers often must rely on word classes of the surrounding spoken language, which is neither methodologically nor theoretically viable.

Since the categorization of word classes in HZJ has still not been investigated nor identified in any detail yet, in previous study regarding correlation between mouthing and word classes, Marcaš (2013) identified the word classes on the basis of semantic value of the sign, its position and function in sentence. According to these criteria, she found a high frequency of mouthing with nouns, adjectives, pronouns, adverbs, conjunctions, quantifiers, prepositions and modals. On the other hand, as expected, verbs had a much lower rate of mouthing due to their morphologically complexity. According to these results, the conclusion that HZJ depends on Croatian language would not be valid because mouthing has its function on different levels of HZJ grammar.

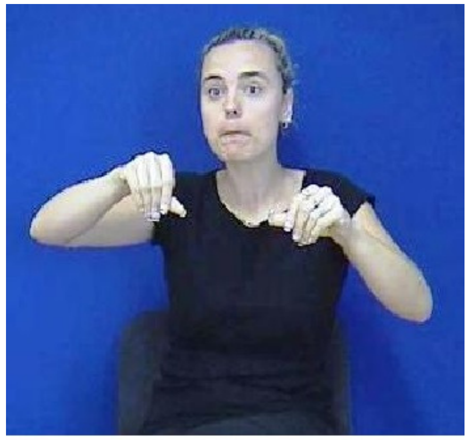
2.2. Functions of mouthing

In addition to having a very high frequency distribution in HZJ, mouthing has a special function in the formation of linguistic message as well, which includes the following features: a) the semantic modification of the sign, b) the distinction of manual homonyms, c) connecting parts of a sentence, and d) emphasizing certain manual information (Marcaš, 2013).

The first and the most frequent function of mouthing in HZJ is semantic modification of the sign by which we mean that mouthing specifies or complements the meaning of the sign (Figure 2). This feature of mouthing tends to be seen with nouns, adjectives and verbs, as well.

[SLOBODAN]
Figure 2. VAGON
slobodan vagon...
'an open wagon'

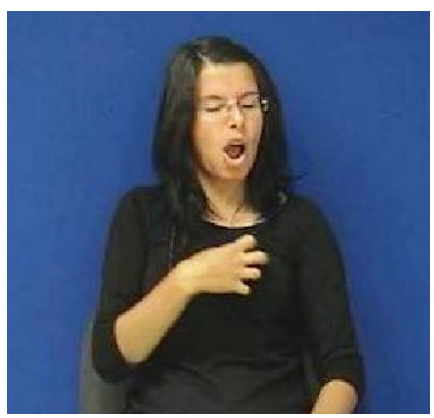
An example of mouthing that complements the manual sign is the sign for VAGON (*'wagon'*) accompanied by the mouthed word *SLOBODAN* (*'free, open'*), thus forming the complex meaning *'slobodan vagon'* (*'an open wagon')*. In this case, mouthings usually have the form of a complete Croatian lexical item. For NSL (Norwegian Sign Language), Vogt-Svendsen (2001) points out that mouthings occasionally function as non-manual adjectives in combination with a noun, in particular, colour adjectives. In most cases, manual part of sign is accompanied with one mouthed word, but there are cases when manual sign can be accompanied with two mouthed words which serve the same function of complementing the meaning of manual sign (Figure 3)



[NEMA-ZEMLJE]
Figure 3. ZEMLJA
nema zemlje
'no ground'

For example, the manual sign ZEMLJA (*'ground')* can be paired with two mouthed words *NEMA-ZEMLJE* (*'no ground'*) where the first word *NEMA* (*'no')* is semantically incongruent with manual part, while second word semantically coincides with the sign. In this case, signer also uses mouthing to create a complex sign with a semantically composite meaning.

Simultaneous articulation of two mouthed word with the manual part of a sign can also function as an intensifier when combined with manual adjectives. That is, two mouthed words might as well be combined with manual adjectives, modifying the meaning of the manual sign (Figure 4)



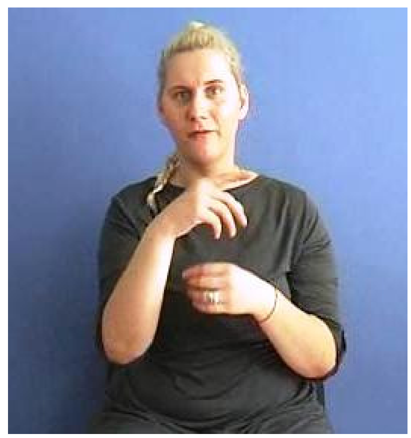
[JAKO LJUT]
Figure 4. LJUT
jako ljut.
'very angry'

As presented in Figure 4, manual sign LJUT (*'angry'*) is accompanied with the two mouthed words *JAKO LJUT* (*'very angry'*), thus modifying the meaning of manual adjective and yielding the meaning *'jako ljut'* (*'very angry'*). In this case we talk about intensification of manual adjectives because mouthing specifies adjectival information additional to that specified by a manual sign.

In all of the presented examples, mouthing serve a morphological function because they productively modify the meaning of the accompanying manual signs, thus they can usually be analyzed as morphemes. Boyes Braem (2001) points out that mouthings are a device for the derivation of related, new lexical items.

HZJ signers also use mouthing to disambiguate manual homonyms, signs which have formally identical manual components. In HZJ, this function of mouthing is found only when mouthed words are accompanying pronouns, more accurately personal and demonstrative pronouns. In HZJ, examples of signs that differ minimally by accompanying mouthings are the signs for *ON/A* (*'s/he'*) (Figure 5), and *OVAJ* (*'this/this one'*) (Figure 6).

[ON]
Figure 5. IX-on
's/he'



[OVAJ]
Figure 6. IX-ovaj
'this/this one'

Both of this pronouns (Figure 5 and 6) are expressed by indexing or pointing (extended index finger), thus they are manually marked identically, but they differ minimally by their mouthing. In this case, when disambiguating manual homonyms, mouthings illustrate phonemic function.

Another function of mouthing manifests on the syntactic level, by which we mean that mouthing connects parts of sentence. Furthermore, in this case, we talk about compound sentences which have at least two clauses. For example, compound sentence *'Auto je došao i onda je eksplodirao'* (*'The car came and then exploded'*) has two clauses: a) *'auto je došao'* (*'the car came'*), and b) *'eksplodirao je'* (*'car exploded'*). As for HZJ, Marcaš (2013), reports that these types of sentences have a high frequency of mouthings accompanying nouns and pronouns. Also, it must be noted that in these cases mouthed words are not lexically congruent with the manual noun or pronoun, but rather function as conjunctions.

Furthermore, it was noted that mouthed conjunctions are frequently marked before marking the manual noun or pronoun, thus during the preparation of the hand shape for target signs (Figure 7).

[A SIN]
Figure 7. (TATA ZAGLAVITI) SIN (cl: autobus-skočiti)
tata je zaglavio, a sin je skočio u autobus
'dad was stuck, but his son jumped on the bus'

In this example, the signer connected two clauses: a) *'tata je zaglavio'* (*'dad was stuck'*), and b) *'sin je skočio u autobus'* (*'son jumped in the bus')* with a mouthed conjunction *A* (*'and, but'*). Furthermore, this conjunction is articulated during the preparation of the handshape for the manual noun SIN (*'son'*), thus mouthed word functions as the sole carrier of meaning, since is not specifically manually marked. For NSL (Norwegian Sign Language), Schermer (2001) points out that 60% of the mouthings without a manual part represent Dutch prepositions, function words and adverbs which can be considered as direct influence from spoken Dutch.

The last function of mouthings recognized in HZJ is adding emphasis or stress to certain manual information. This feature is most often seen in simultaneous constructions which are defined as linguistic representations produced in more than one articulatory channel, whereby each channel bears distinct and independent meaning units, which stand in some relationship to each other (Miller, 1994; Leeson & Saeed, 2002). Therefore, dominant and non dominant hands are in productive linguistic relation, thus conveying complex meaning and, most often, carrying the locative information (in the depiction of the spatial relationship between two referents). Simultaneous constructions are expressed by classifier constructions which are generally consider to be morphemes with a non-specific meaning, which are expressed by particular configuration of the manual articulator and which represent different entities (Zwitserlood, 2012).

As for HZJ, it is pointed out that mouthing is most often seen in simultaneous constructions which are made by *Whole entity clasifiers* (represent a specific kind of object; e.g. person, vehicle etc.; Ujević, 2011) and signs which represent an action (verbs), location and path of specific entity (adverbs, prepositions) (Marcaš, 2013). Simultaneous construction presented in Figure 8, is made by two whole entity classifiers, whereby movement of the dominant hand conveys information about the path of the entity expressed by dominant hand.

[AUTOBUS]
Figure 8. d: cl:autobus-udariti
n.d. cl:auto
autobus je udario auto
'the bus hit a car'

Therefore, signer expressed two different linguistic information with classifier constructions yielding a meaning *'autobus je udario auto'* (*'the bus hit a car'*). Non-dominant hand represent just entity, while dominant hand, except information about entity, contains a movement, thus it carries verbal information. Furthermore, during the articulation of this linguistic compound message, signer used mouthing to emphasise certain information which he considered to be more relevant. Thus, with mouthed word *AUTOBUS* (*'bus'*) signer added stress on information *who hit whom*.

3. CONCLUSSION

Sign languages are natural human languages, that is, contain all the fundamental linguistic features. Studies of European and other national sign language repeatedly indicate that sign language are completely distinct and separate from surrounding spoken languages, although they contain all the linguistic features found in spoken language. The main difference between sign and spoken languages manifest in the unique possibility of sign language to use multiple articulators whereas in spoken languages simultaneity is limited by the fact that people have only one vocal tract with which they produce speech. Thus, besides manual articulator (hands), sign languages involve the simultaneous use of numerous non-manual signals which show significant role in communication.

Beside manual actions, sign languages include several types of mouth actions. In this paper, we provided an insight on mouthings and their relation to the word class. Similar to studies in other sign languages, there is a high frequency of signs accompanied by mouthings in HZJ, as well. However, this results does not imply that HZJ depends on Croatian spoken language because mouthing has a special function in forming the linguistic message. Furthermore, results indicated that mouthings carry equally important and as linguistically significant informations as manual parameters. Regarding functions of mouthing in HZJ, it shows a significant role on a phonological, morphological and syntactic level. Although the precise status of mouthing in HZJ needs to be yet determined and further studies need to be conducted, our dana support the claim that mouthings are incorporated in the structure of HZJ grammar.

Along with fighting prejudice that hands are the only and most important articulator, results presented in his paper contribute to addressing the misconceptions about HZJ and developing awareness and understanding of its grammar. Furthermore, the results could be applied in education of deaf children and adults, as well as in education of HZJ interpreters because mouthing is potentially an important tool in clarifying and expressing meaning where established sign equivalents are lacking.

REFERENCES

1. Boyes Braem, P. (2001). Functions of Mouthing in the Signing of Deaf Early and Late Learners of Swiss German Sign Language (DSGS). In: *The hands are the head of the mouth: The mouth as articulator in sign languages* (P. Boyes Braem &,R. Sutton-Spence, eds.). Hamburg: Signum Press, 99-132.
2. Brentari, D. (1988). *A prosodic model of sign language phonology*. Cambridge: MIT Press.
3. Crasborn, O., van der Kooij, E., Waters, D., Woll, B. & Mesch, J. (2008). Frequency distribution and spreading behavior of different types of mouth actions in three sign languages. *Sign Language & Linguistics*. 11, 45-67.
4. Dukić, L. (2011). *Nemanualna obilježja u hrvatskom znakovnom jeziku – specifični pokreti usta kod svršenih i nesvršenih glagola*. Zagreb: Odsjek za logopediju Edukacijsko-rehabilitacijskog fakulteta u Zagrebu.
5. Ebbinghaus, H. & Heßmann, J. (2001). Sign language as multidimensional communication: why manual signs, mouthings, and mouth gestures are three different things. In: *The hands are the head of the mouth: The mouth as articulator in sign languages* (P. Boyes Braem &, R. Sutton-Spence, eds.). Hamburg: Signum-Verlag, 133–151.
6. Emmorey, K. (2002). *Language, cognition, and the brain: Insights from sign language research*. New York, Mahwah: Lawrence Erlbaum Associates.
7. Hohenberger, A. & Happ, D. (2001). The linguistic primacy of signs and mouth gestures over mouthings: evidence from language production in German Sign Language (DGS). In: *The hands are the head of the mouth: The mouth as articulator in sign languages* (P. Boyes Braem, & R. Sutton-Spence, eds.). Hamburg: Signum-Verlag, 153–189.
8. Leeson, L. & Saeed, J. (2002). *Windowing of attention in simultaneous constructions in Irish Sign Language (ISL)*. Paper presented at HDSL 5. University of New Mexico, Albuquerque, November, 2002.
9. Marcaš, A. (2013). *Nemanualna obilježja u hrvatskom znakovnom jeziku – specifični oblici i pokreti usta.* Zagreb: Odsjek za logopediju Edukacijsko-rehabilitacijskog fakulteta u Zagrebu.
10. McKee, L. R. (2007). *Hand to mouth: Findings on the role of mouthing in NZ Sign Language*. Australian Sign Language Interpreters Association National Conference. Sydney: Macquarie University.
11. Miller, C. (1994). Simultaneous constructions in Quebec Sign Language. In: *Word-order issues in sign language*: *Working papers presented at a workshop held in Durham* (M. Brennan, G. H. Turner, eds). Isla, Durham, pp. 89-112.
12. Monschein, L. (2009). *Empirical research of mouth patterns considering sociolinguistic factors: A comparison between the use of mouth patterns of deaf L1- and hearing L2-users of German Sign Language (DGS).* Poster presentation: Sign Language Corpora, Linguistic Issues Workshop. London: University College London.
13. Nadolske, M. A. & Rosenstock, R. (2007). Occurrence of word pictures in American Sign Language: A preliminary study. In: *Comparative studies on sign language structure* (P. Perniss, R. Pfau & M. Steibach, eds.). Berlin: Mouton de Gruyter, 35-61.
14. Perniss, P.**,** Pfau, R. & Steinbach, M. (2007). Can't you see the difference? Sources of variation in sign language structure. In: *Visible variation: Cross-linguistic studies in sign language structure* (P. Perniss, R. Pfau & M. Steinbach, eds.). Berlin: Mouton, 1-34.
15. Pfau, R. & Quer, J. (2010). Nonmanuals: their prosodic and grammatical roles. In: *Sign languages* (D. Brentari, ed.). Cambridge: Cambridge University Press, 381-402.
16. Sandler, W. & Lillo-Martin, D. (2006). *Sign language and linguistic universals*. Cambridge: Cambridge University Press.
17. Šarac Kuhn, N., Alibašić Ciciliani, T. & Wilbur, R.B. (2006). Phonological parameters in Croatian Sign Language. *Sign Language & Linguistics*, Vol. 9,1-2: 33-70.
18. Schermer, T. (2001). The role of mouthings in Sign Language of the Nederlands: Some implications for the production of sign language dictionares. In: *The hands are the head of the mouth: The Mouth As Articulator in Sign Languages* (P. Boyes Braem, R. Sutton-Spence, eds.). Hamburg: Signum Press, 273-284.
19. Schwager, W. & Zeshan, U. (2008). Word classes in Sign Languages: Criteria and Classifications. *Studies in Language*, 32(3): 509-545.

20. Ujević, E. (2011): *Vrste klasifikatora u hrvatskom znakovnom jeziku*. Diplomski rad, Edukacijsko-rehabilitacijski fakultet, Zagreb.

21. Vinson, D. P., Thompson, R. L., Skinner, R., Fox, N. & Vigliocco, G. (2010). The Hands and Mouth Do Not Always Slip Together in British Sign Language: Dissociating Articulatory Channels in the Lexicon. *Psychological Science*, 1-10.

22. Vogt-Svendsen, M. (2001). A comparison of mouth gestures and mouthings in Norwegian Sign Language (NSL) In: *The hands are the head of the mouth: The mouth as articulator in sign languages* (P. Boyes Braem & R. Sutton-Spence, eds.). Hamburg: Signum-Verlag; 9–40.

23. Wool B., Capek C., Waters D., Campbell R., McSweeney M., Brammer M. & David T. (2008). Do hands sign? Do mouths speak? Sign languages: spinning and unraveling the past, present and future. TISLR9, Florianapolis, Brazil, 2006, str. 663.

24. Woll, B. (2009). Do Mouths Sign? Do Hands Speak? Echo phonology as a window on language genesis. In: *Language Evolution: The View from Restricted Linguistic Systems* (R. Botha & H. de Swart, eds.). Utrecht: LOT, 203-224.

25. Zwitserlood, I. (2012). Classifiers. In: *Sign Language, An International Handbook* (R. Pfau, M. Steinbach & B. Woll, eds.) Berlin/Boston: Walter de Gruyter, 158-186.

MAXIMAL VOWEL SPACE

MILAN VOJNOVIĆ
Life Activities Advancement Center
vojnovicmilan@yahoo.com

Abstract: In the analysis of the vowel formant frequencies spoken by children under the age of one year, it is difficult to define exactly which vowel is pronounced. Therefore, it is better to do the analysis of the MVS. This global analysis of changes in vowel formant frequencies can later be used for more accurate discrimination of spoken vocals. Primary information for determining the MVS is a shape of VT and the freedom degree of its individual parts, or restriction of the articulator organs movement. In the case where the acoustic model of the VT is detailed (approximation of a VT with large number of cylindrical segments) estimation MVS can not be done by calculating the formant frequencies for all possible cases, because there are too many. The number of possible VT shapes should be reduced as much as possible to obtain the correct (real) field vowel formant frequencies changes. At the same time, computational time for MVS estimation have to be in "reasonable" limits. MVS estimation procedure is analyzed on the example of Russian vowels where the VT is modeled with thirty cylindrical segments The length of cylindrical segments are 5 mm. Changes in cross-sectional area of the VT are statistically dependence (there are no sudden changes in the shape of the VT), which was used to reduce the degrees of freedom of changing the shape of the VT.

Keywords : maximal vowel space, vocal tract model, vowel formant frequencies

1. INTRODUCTION

Speech is a non-deterministic process, so the statistical estimation of different parameters has to be used. Even in the analysis of narrow group of phonemes (e.g. vowels), there is still non-deterministic and need for statistical tools and methods. No matter that, the spoken vowel sounds and means the same in every repeated pronunciation, from the analytical side, there are differences.

The speech studies used different presentation and analysis methods to show range of changes of the analyzed parameters. For vowel formant frequencies analysis the F_1-F_2 and F_2-F_3 diagrams or maximal vowel space (MVS) are using. It is common to define MVS for the first, second and third formant frequencies. MVS shows the space of spreading the three formant frequencies of a speaker's vowel pronunciation. For example, in a human speech there is no vowel with first formant frequency of 800 Hz and the second formant frequency of 1000 Hz at the same time. However, it is possible combination: first formant 400 Hz and 1000 Hz second formant.

At the earliest age (up to one year) of children, the MVS is extremely important in analysis of vowel formant frequencies. At this early age, the child have not yet developed speech nor accepted pronunciation of some phonemes. Pronunciation of vowels are emphasized is centralized so it is difficult to distinguish which vowel is spoken. Therefore, it is better and more effective to analyze the variational space (the range of changes) of formant frequencies. In the analysis of vowels spoken by an adult are, essentially, two phases: the perception of vowels and estimation of formant frequencies.

Well, as a first we determine which vowel is spoken by audio perception, i.e. we perform the discrimination of spoken vowels, and after that, the formant frequencies is estimating. Estimated formant frequencies are grouping with discriminated vowels. It is normal that discrimination of spoken vowel is routine that performs with no errors. The discrimination of vowel pronunciation by a child under the age of one year is problematic due to poor articulation and enhanced centralization. Therefore, it is more appropriate to analyze formant frequencies space changes without trying to recognise the spoken vowels. Only when the estimation and analysis of MVS is completed the analysis of formant frequencies can be repeated together with recognizing the spoken vowels. Estimated MVS provides a roughly range of vowel formant frequencies changes. Simply, estimated MVS shall serve for a simpler and more accurate discrimination of spoken vowels.

Global changes of MVS, during the growing child, may be an indication of the typical and normal speech development. The advantage of this early screening method is not in speech control and correction (for this age speech is not developed), but the control of speech organs: vocal fold oscillations and movement of articulation organs.

2. ESTIMATION OF MAXIMAL VOWEL SPACE

The MVS is an important parameter in the analysis of vowel pronunciation, especially in situations where it is not possible accurate discrimination of spoken vowels. This is just the case with the analysis of vowel pronunciation of children under the age of one year.

It should distinguish two main type of MVS estimation:

- estimation based on the analysis of real speech (pronunciation of vowels) and
- estimation based on simulation of vowel pronunciation.

The MVS estimation based on simulation of vowel pronunciation is the first step, because we have to define the borders of vowel formant frequencies in real speech. In addition, the expected space of vowel formant frequencies should help in defining the parameters for program extraction.

To define MVS based on simulation and modelling vowel pronunciation it is necessary to know the shape of the vocal tract (VT) and its acoustic model. Estimation of one-year-old child VT is a particular problem [Vojnovic, 2013] and has not been finally resolved. Although the [Vojnovic, 2013] proposed a VT configurations for one-year-old child, the first part of the paper will be pointed to the problem of estimating the MVS for an adult male who pronunciation Russian vowels. Data on the VT shape in this case [Fant, 1970] have long been known, in some way, represent the standard VT configuration in the vowel analysis. The research in this paper is divided into two major parts:

- estimation of MVS for an adult male (used configurations of VT from [Fant, 1970]) and
- estimation of MVS for one-year-old child (using the configuration from VT [Vojnovic, 2013]).

In the first case, it should develop and verify the procedure and method of MVS estimation. After that will be estimated the MVS of one-year-old child based on data presented in [Vojnovic, 2013a]. Estimation of MVS for an adult male has to confirm the correctness of the procedures, and to find efficient and fast algorithms for its implementation.

To estimate MVS, it is necessary to know the acoustic model of VT and its dimensions: length, range of cross-sectional area changes and number of cylindrical segments for VT modelling. In the acoustic domain, VT is modelled by a short cylindrical tube (cylindrical segments), defined cross-sectional area. The accuracy of the sound propagation simulation through such acoustic structure depends on the length of cylindrical segments. If the segments are shorter the accuracy is greater. The accuracy of the simulation, in fact, means the upper cut-off frequency at which is acoustic model is valid, i.e. upper cut-off frequency at which the plane waves still spread through the tube. In the analysis of speech, it is sufficient that these cylindrical segments are less than 5 mm. If we assume that the average length of an adult male VT is 17.5 cm, this means that his VT can be modelled with 35 cylindrical tubes with cross-sectional area in the range from 0.16 to 16 cm^2. According to [Fant, 1970], taking the discrete logarithm distribution of cross-sectional area, so that this range has 16 different values of the cross-sectional areas. If we want to estimate the MVS, it is necessary to calculate the formant frequencies (resonance frequencies) in all possible cases. This means that we should analyze about $16^{35} \approx 1.4 \times 10^{42}$ different acoustic configurations, which is, of course, impossible. Finding an efficient algorithm means the strategy of VT configuration choice that will be analyzed. From this huge number of possible VT configurations we should choose a small part, while at the same it remains representative of the entire set. This is the main problem in estimating the MVS.

3. ADULT MALE MVS ESTIMATION

Before we get into the problems of MVS estimating for accurate VT models, a four-tuber VT model [Fant, 1970] [Flanagan, 1972] will be considered. In this model (Figure 1), the first tube simulates mouth opening, second tube mouth cavity, third tube represents narrowing the "tongue-palate" and the fourth tube simulates pharyngeal cavity.

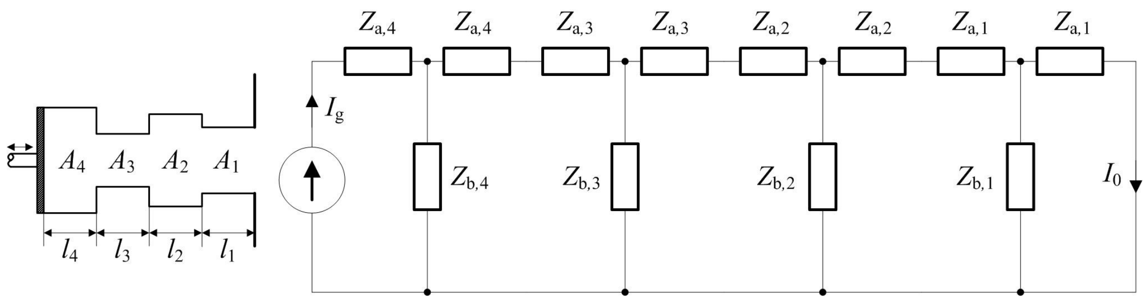


Figure 1. Acoustic and electric four-tube VT model.

If we assume that, the total length of VT is 17.5 cm and the length of four cylindrical segments are equal length, and then each tube shall have length of 4.375 cm. For 16 different values of the cross-sectional areas, the total number of possible combinations is $16^4 = 65536$.

Figure 2 shows all formant (resonant) frequencies for this VT model VT. Formant frequencies of Russian vowels (with a more accurate modelling of VT - cylindrical segments of 5 mm length) are marked whit white squares. There is relatively good agreement with the results in [Boë *et al.*, 1989].

We use VT model with distributed parameters, including losses, infinitely large VT wall impedance and VT subglottal system [Vojnovic, 2008]. The impedance of mouth radiation was zero. The parameter values used in the VT modelling process VT were:

- density of air: 1.14×10^{-3} g/cm^3,
- velocity of sound at temperatures 37°C: 35300 cm/s,
- viscosity of air: 1.84×10^{-4} g/cm s,
- coefficient of heat conduction of air: 5.5×10^{-5} cal/cm s °C ,
- specifična toplota vazduha pri konstantnom pritisku: 0.24 cal/g °C i
- adiabatic gas constant: 1.4.

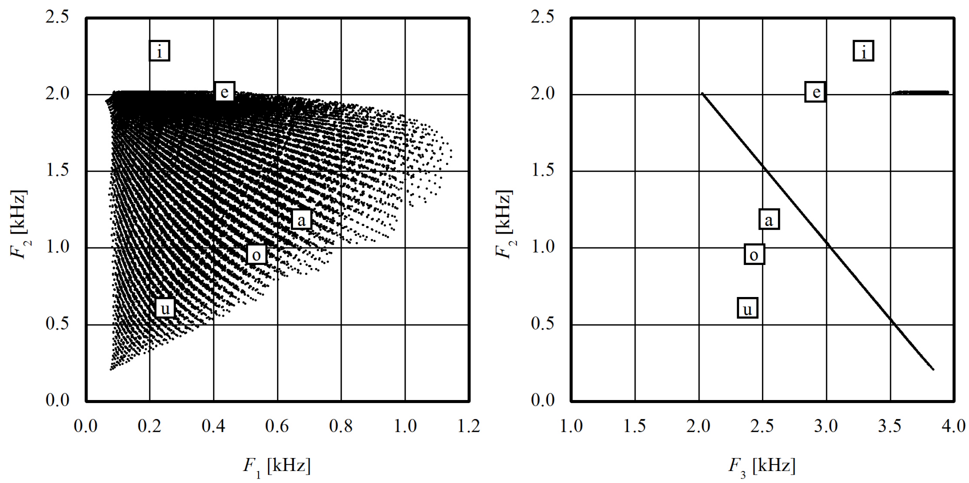


Figure 2. VT resonant frequencies modelled with four cylindrical tube 4.375 cm length and 16 different values of the cross-sectional area. The impedance radiation of mouth opening is zero

Note that the vowel /*i*/ is not within estimated space. Similarly, F_2-F_3 diagram does not correspond to the real situation. Obviously, the simulated and the real value of the third formant are not aligned. The reason for this may be a small number of cylindrical segments (rough VT modelling), and the use of zero-impedance of mouth radiation. Figure 3 shows the results of repeated MVS estimation, except that here the total VT length was 15 cm, i.e. VT is modelled with four cylindrical tube length 3.75 cm and 16 different values of the cross-sectional area. The radiation impedance of the mouth opening is approximated by radiation circular piston set in a spherical baffle.

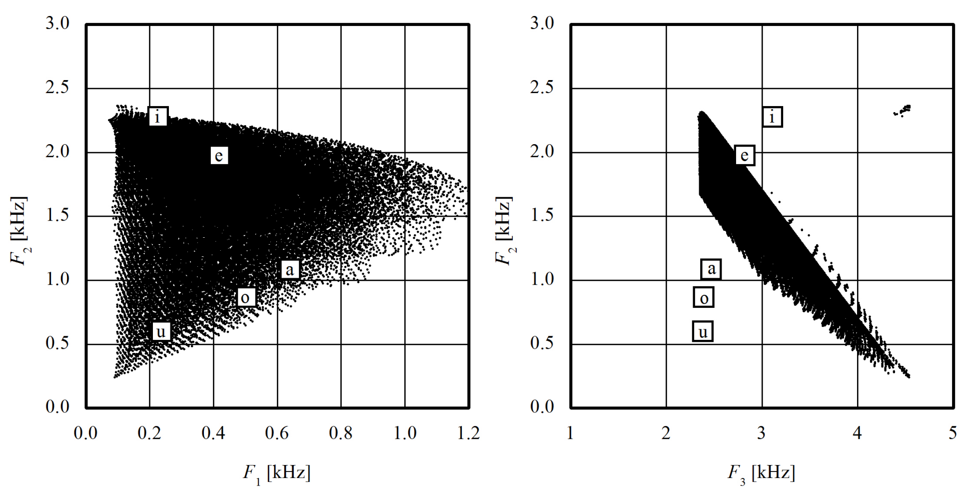


Figure 3. VT resonant frequencies modelled with four cylindrical tube 3.75 cm length and 16 different values of the cross-sectional area. The mouth opening radiation impedance is approximated by radiation circular piston set in a spherical baffle.

According to Figure 3, the vowel /*i*/ is covered by estimated MVS. The values of third formant are slightly different from in the previous case, but still not in the range of real values. Simple, four-tube VT model is not suitable for the simulation of higher formant frequencies. The example in Figure 3 shows that one has to take care about the VT length in the process of MVS estimation. In other words, the estimation should be done for different length of VT, which corresponds to the particular vowels. Certainly, it should be done for vowels /*u*/, /*a*/ and /*i*/ because their formant frequencies frame MVS.

As mentioned earlier, the cross-sectional area in the two previous examples had a logarithmic distribution. The MVS estimation from Figure 2 is repeated except that the cross-sectional area changed linearly in the range of 0.3 to 15 cm^2 (11 values: 0.3, 1.5, 3, 4.5, 6, 7.5, 9, 10.5, 12, 13.5, and 15). Estimated space of resonant frequencies four-tube VT model, in which the cross-sectional area changes linearly, is shown in Figure 4.

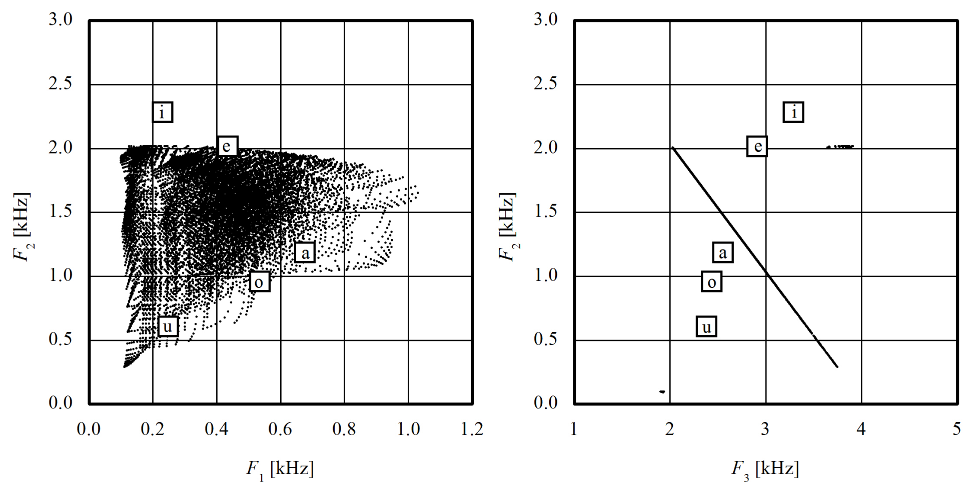


Figure 4. VT resonant frequencies modelled with four cylindrical tube 4.375 cm length and linear change of the cross-sectional area. The impedance radiation of mouth opening is zero.

The space of resonant frequencies is much more compact in case of logarithmic changes of the cross-sectional area (Figure 2) than in the case of linear change (Figure 4). This is the reason why, in this paper, we always used VT model with logarithmic distribution of cross-sectional area.

These few examples of the four-tube VT model show that:

- the VT model should include a realistic radiation impedance of mouth opening,
- MVS estimation should be performed on at least 3 different VT length corresponding to the vowels /*u*/, /*a*/ and /*i*/,
- have to use more precise VT modelling (more cylindrical segments, length of less than 5 mm) and
- values of cross-sectional area should be chosen by a logarithmic law.

4. MVS ESTIMATION FOR MORE ACCURATE VT MODEL

A more accurate VT model implies shorter cylindrical segments, length not exceeding 5 mm. Cross-sectional areas should be chosen in accordance with the logarithmic distribution. As said before, the number of configurations for this VT model is huge so the some kind of random sampling method has to be used (Monte Carlo method).

Results of the first examples of MVS estimation for more accurate VT model are shown in Figure 5. VT shapes were chosen randomly and there are 3×50,000 in total. We use VT model with losses and with distributed parameters [Vojnovic, 2008]. The VT wall impedance and impedance of subglottal system are infinite. The mouth opening radiation impedance is approximated by radiation circular piston set in a spherical baffle.

The three groups (3×50000 points) of estimated resonant frequencies are presented that correspond to three VT lengths: 16.5, 19.5 and 17 cm. These lengths corresponding to the pronunciation of Russian vowels: /*i*/, /*a*/ and /*u*/, respectively. Three spaces of resonance frequencies are marked with different shades of grey:

- light grey - VT length of 16.5 cm (vowel /*i*/),
- dark grey - VT length of 17 cm (vowel /*a*/) and
- black - VT length of 19.5 cm (vowel /*u*/).

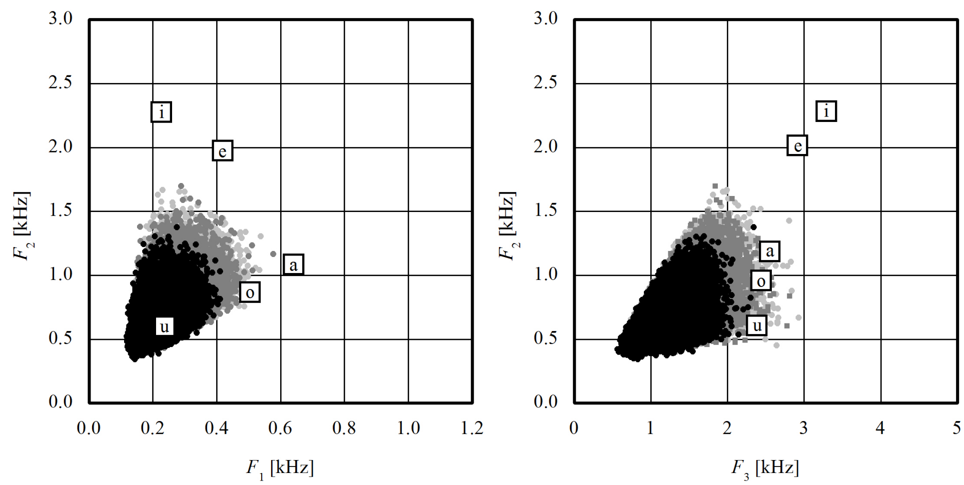


Figure 5. VT resonant frequencies modelled with four cylindrical tube 5 mm length and 16 different values of the cross-sectional area. Three VT length: 16.5 cm (vowel /*e*/), 17 cm (vowel /*a*/) and 19.5 cm (vowel /*u*/).

There is a clear distinction between the spaces of the resonant frequencies for VT length of 19.5 cm (marked with black dots) and a length of 17 cm (dark grey marked points). Space of resonant frequencies for 16.5 cm VT length (light grey marked points) and 17 cm are very similar so you cannot see a clear boundary between them. What is more important is to say, vowels /*e*/ and /*i*/ are not covered with estimated spaces. Vowels /*a*/ and /*o*/ are on the very border.

Due to the huge number of possible VT configurations and their random sampling, the analysis does not include the real (or close to them) VT configuration that correspond to the pronunciation of the back and middle vowels. It just shows that estimation should be adapted to the real situation, i.e. allow sampling only those configurations that are possible in real speech.

The first step in reduction of VT configuration is to use 15 values of cross-sectional area instead of the 16. Area value of 0.16 cm^2 does not occur in the pronunciation of the Russian vowels and can be eject. Next restriction is to introduce fix values of the cross-sectional areas for larynx modelling. Shape of the larynx is almost unchanged (enough small to be tolerated) in pronunciation of five Russian vowels. Larynx is modelled with the first four cylindrical segments, starting from the glottis, and in this example their areas would be fixed to the following values: 2.6, 1.6, 1.3 and 1 cm^2. Larynx modelled on such way corresponds to pronunciation of vowel /*a*/. Therefore, in the following examples, where it was mentioned that the shape of the larynx is fixed, these cross-sectional areas will be involve. With this restriction of VT shape changes, the total number of possible combinations is reduced to about 0.0002%. Estimated space of resonant frequencies are shown in Figure 6.

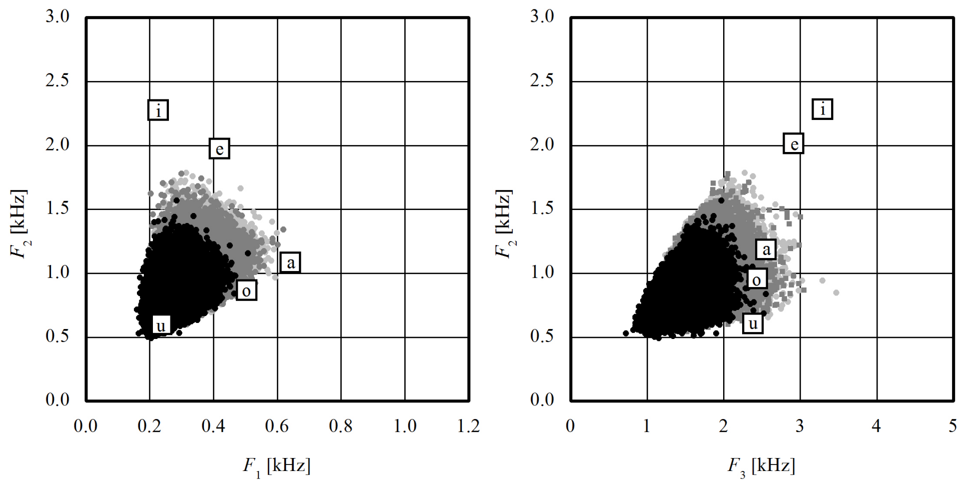


Figure 6. VT resonant frequencies modelled with four cylindrical tube 5 mm length and 15 different values of the cross-sectional area. Larynx was modelled with 4 cylindrical tube lengths of 5 mm and a fixed cross-sectional area.

Achieved results are slightly better than those in Figure 5, but remains remark that the back vowels, and somewhat middle, are outside of estimated space. Therefore, it is necessary to introduce additional restrictions in the change of VT shape.

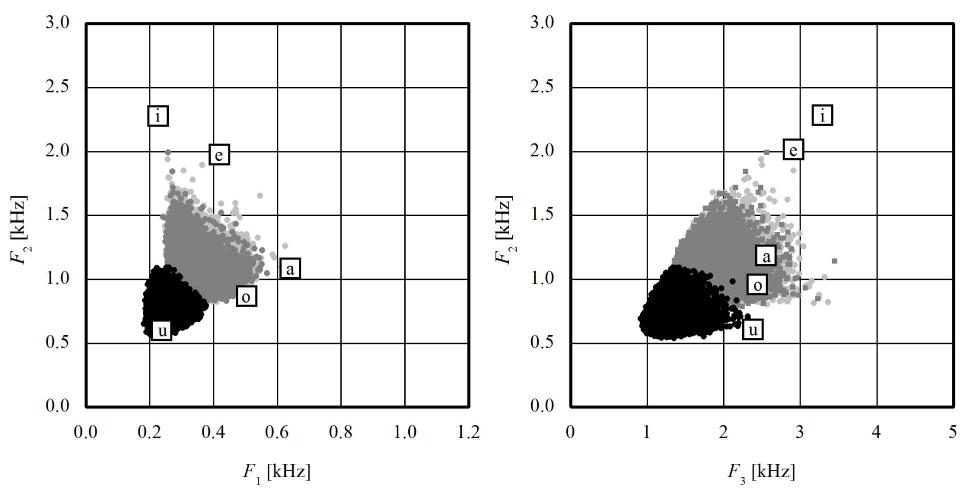


Figure 7. Rezonantne resonant frequencies modelled with four cylindrical tube 5 mm length having two (limit) value of cross-sectional area.

It is clear that some regions of VT have different degrees of freedom and the change of the cross-sectional area in the range of 0.32 d 16 cm^2 cannot be allowed for all VT regions. One of the limitations of this kind is fixing the larynx shape, as it is done in the previous example. The remaining cylindrical segments could take any value in the range of 0.32 to 16 cm^2. The first step in limiting the choice of the cross-sectional area value is to take only limit (maximal or minimal) value. According to [Fant, 1970], cylindrical segments above larynx have cross-sectional area in the range of 4 to 10.5 cm^2. The next segments have cross-sectional area changes from 2.6 to 10.5 cm^2, and so on. If only the minimal and maximal values of area are taken, the number of all possible VT configurations is 2^{31}, which is an extremely small number of configurations in comparison with the previous example (15^{31}). Estimated space of resonant frequencies for that case is shown in Figure 7.

This simple limitation cross-sectional area values did not provide significant improvement in the estimation of the resonant frequencies space. Certainly, it is required deeper analysis of cross-sectional area changes to reduce number of VT configurations in order to get real situation.

One important fact, related to the of VT shape, is that there is no sharp (rapid) change in its form. For example, a VT shape in which two adjacent cylindrical surface segments are 0.32 and 16 cm^2 is not realistic. Guided by this example, it would be preferable to reject all these and similar VT shapes from the process of resonant frequencies estimation, because they really do not exist. Detailed statistical analysis of cross-sectional area changes (area change of adjacent cylindrical segments) shows normal, the Gaussian, distribution. As mentioned earlier, VT cross-sectional areas are elected according to logarithmic law. The jumps between adjacent cylindrical segments have normal distribution with zero mean value and standard deviation of 1.5. The range of change is ± 3 steps. In practice, this means that if we know the cross section of a cylindrical segment, then the adjacent segment have cross-sectional area ranging from twice less to twice more. With such a defined strategy of VT shapes area distribution, estimation process of resonant frequencies is much closer to the real situation, because they rejected all VT configurations with too sharp change of cross-sectional area. Figure 8 shows the estimated space of the resonant frequencies for this case of VT shapes sampling.

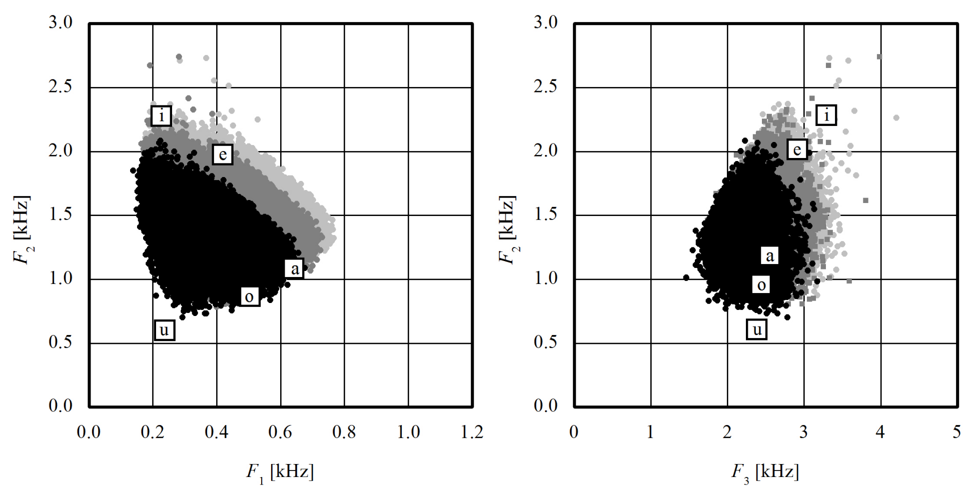


Figure 8. Rezonantne resonant frequencies modelled with four cylindrical tube 5 mm length where disabled rapid change in the values of the cross-sectional areas.

Estimated resonant frequencies space covers all Russian vowels except vowel /*u*/. This problem can be solved with performing double estimation:

- estimation of the resonant frequencies space for the case of the limit cross-sectional area (the results presented in Figure 7) and

- estimation of the resonant frequencies space for the case with no sharp cross-sectional area change (the results presented in Figure 8).

If we combine these two estimations, we will get the results shown in Figure 9. Now all five Russian vowels are within estimated space. The third formants of vowel /u/ and /i/ are not "deep" in estimated space. The other Russian vowel formant frequencies are completely covered with estimated space.

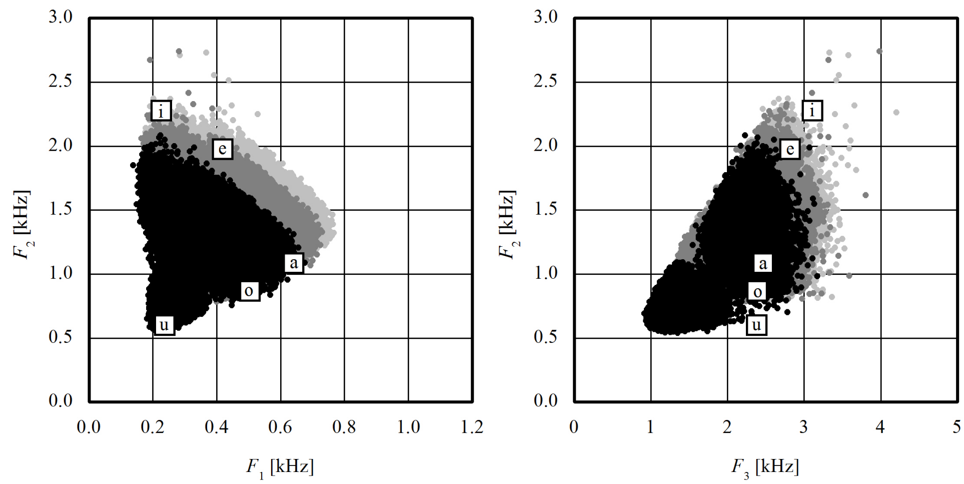


Figure 9. Rezonantne resonant frequencies modelled with four cylindrical tube 5 mm length obtained by combining sampling of VT configuration:
a) cross-sectional area has one of the limit values;
b) cross-sectional area without rapid changes; greater than 100% or less than 50%.

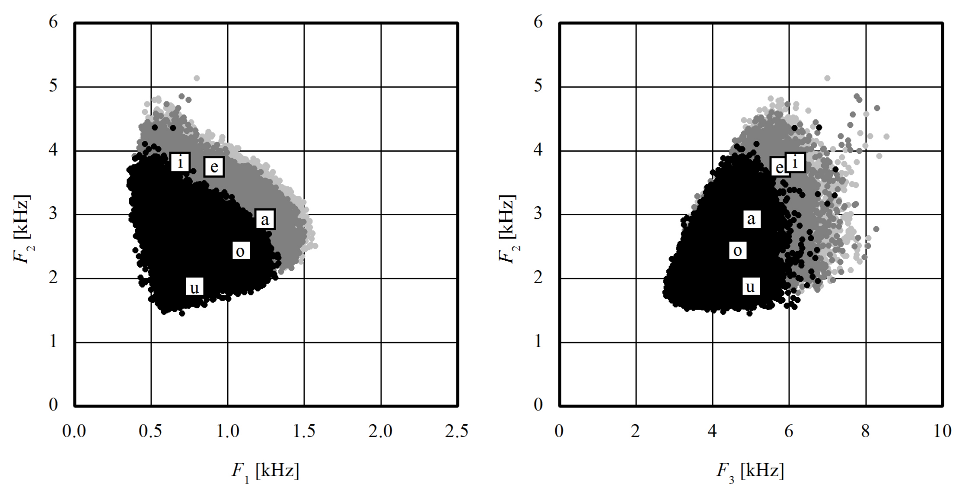


Figure 10. Estimated MVS for one-year-old child.

Presented procedure of estimation VT resonant frequencies shows that one must take care about VT length, the range of cross-sectional area changes as well as their statistical distribution. It is enough to do analyse for three VT lengths that correspond to the pronunciation of vowels: /u/, /a/ and /i/.

A series of papers [Vojnovic, 2013] [Vojnovic et al., 2013b] was realised within the research of vowels pronunciation in children at an early stage of development, from birth through the first year of life. As a first step, we defined the VT shapes of the one-year-old child during the pronunciation of vowels [Vojnovic, 2013]. With these VT configurations, it is possible to estimate MVS using the procedure shown above (Figure 9).

Estimated MVS for one-year-old child is shown in Figure 10. As it can be seen, the formant frequencies are within estimated space, which means that there is good agreement between the proposed VT shape of the one-year-old child [Vojnovic, 2013] and estimated MVS.

5. DISCUSSION

According to Figure 10, there is a good agreement of hypothetical VT shapes of one-year-old child and estimated MVS. That still does not confirm that the proposed VT shapes are good and match the real situation. The research presented in [Goldstein, 1980] gives a somewhat different VT configuration during pronunciation of three vowels: /*u*/, /*a*/ and /*i*/. The VT configurations are related to the infant VT. The biggest difference between these two sets of VT configurations refers to cross-sectional area. In some regions of VT, the cross-sectional area is about two to three times higher in [Goldstein, 1980], although they relate to the infant. Larger changes in newborn VT cross-sectional area caused a significantly higher MVS (Figure 11).

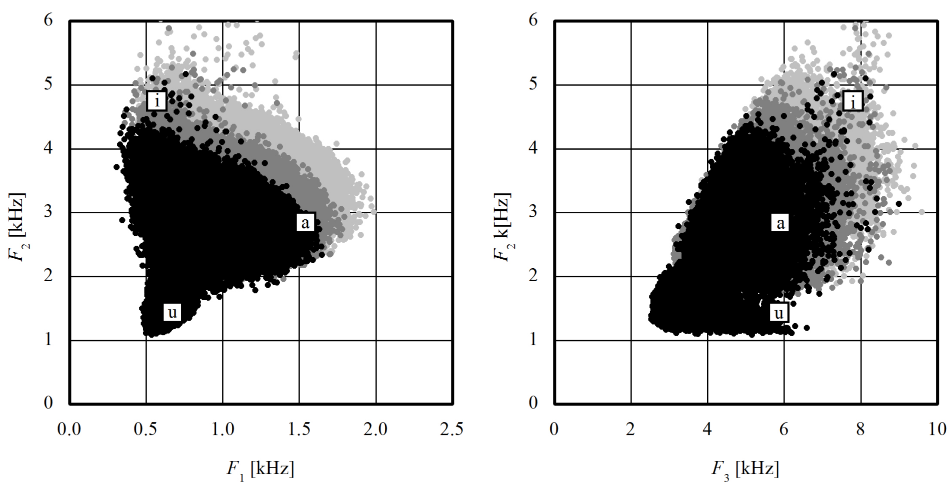


Figure 11. Estimated MVS for newborn according to the data of the VT shape [Goldstein, 1980].

Real confirmation of the validity of hypothetical VT models can be verified by analyzing the voice of one-year-old child and the MVS estimation based on these data. This was done for one child whose voice is recorded in the period from the second to the twelfth month of life [Vojnovic *et al.*, 2013b]. The results were very good for vowels /*u*/, /*o*/ and /*a*/. Vowels /*e*/ and /*i*/ are not within the estimated MVS and the reason for that can be wrong VT shapes or a child of that age are difficult and/or rarely pronunciation front vowels /*e*/ and /*i*/.

6. CONCLUSION

This paper presents a method for generating MVS based on geometric shapes of VT during the pronunciation of vowels. The relevant parameters that influence the accuracy and speed of MVS estimation were considered. Due to the huge number of possible VT configurations, we proposed to reduce their number by rejecting all unrealistic configurations. Therefore, the algorithm of VT configuration choice includes statistical distribution of cross-sectional area. It is sufficient to prevent sudden changes in VT shape and to obtain a valid MVS.

ACKNOWLEDGMENTS

The work was partly funded by the Ministry of Science and Technological Development of Serbia through the project "E-Speech therapist" number TR32032.

REFERENCES

Boë, L.-J., Perrier, P., Guérin, B. and Schwartz, J.L. (1989). *Maximal vowel space*, Eurospeech 89, 281-284.

Fant, G. (1970). *Acoustic theory of speech productionitle*, Mouton, The Hague.

Flanagan, J. (1972). *Speech analysis, synthesis and perception*, Springer-Verlag, New York, 1972.

Goldstein, U. G. (1980). *An articulatory model for the vocal tract of the growing children*, Thesis of Doctor of Science, MIT, Cambridge, Massachusett.

Vojnović, M., Mijić, M. (2005). *An improved model for the acoustic radiation impedance of the mouth based on an equivalent electrical network*, Applied Acoustics 66, 481-499.

Vojnović, M. (2008). *Uticaj maske na akustičke i artikulacione karakteristike govora*, Ph.D. dissertation, Elektrotehnički fakultet, Beograd.

Vojnović, M. (2013a). *Vocal tract shapes estimatio for children ages to one year*, 4th International Conference on Fundamental and Applied Aspects on Speech and Language, Belgrade.

Vojnović, M., Bogavac, I., Dobrijević, Lj. (2013b). *Vowel formant frequencies estimation for newborn children*, 4th International Conference on Fundamental and Applied Aspects on Speech and Language, Belgrade.

MAKSIMALNA OBLAST VOKALA

APSTRAKT

Kod analize formantnih frekvencija vokala koje izgovaraju deca starosti do jedne godine, teško je definisati tačno koji je vokal izgovoren. Zbog toga je bolje raditi analizu maksimalne oblasti vokala (MOV). Ova globalna analiza promena formantnih frekvencija vokala može kasnije da posluži za precizniju dikriminaciju izgovorenih vokala. Polazna informacija za određivanje MOV je oblik vokalnog trakta (VT) i stepen slobode promene njegovih pojedinih delova, odnosno ograničenja u kretanju artikulacionih organa. U slučaju kada je akustički model VT detaljan (aproksimacija većim brojem cilindričnih segmenata) estimacija MOV se ne može uraditi izračunavanjem formantnih frekvencija za sve moguće slučajeve, jer ih ima suviše mnogo. Broj mogućih oblika VT treba što više redukovati a da se pri tome dobije korektna (realna) oblast promena formantnih frekvencija vokala i da potrebno vreme estimacije bude u "razumnim" granicama. Procedura estimacije MOV je analizirana na primeru ruskih vokala pri čemu je VT modelovan sa tridesetak cilindričnih segmenata dužine 5 mm. Promene površine poprečnog preseka VT imaju određenu statističku raspodelu (ne postoje nagle promene u obliku VT) što je iskorišćeno za smanjenje stepena slobode promene oblika VT.

Milan Vojnović, Centar za unapređenje životnih aktivnosti

INTUITION SPEECH

VESNICA KLJAJEVIĆ[1], DRAGANA PORTIĆ[2]
[1]Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia
[2]Life Activities Advancement Center, Belgrade, Serbia

Abstract. Every man has the intuitive ability, so called intuition, which constantly subconsciously use. Although we do not notice its presence and activities, that abilitie greatly influence the decision-making in everyday life. If a person learns to listen and follow that inner voice ,that clearly occurs, he will have an increasing amount of opportunities to create new ideas, develop optimal strategies for making the best decisions in addressing the challenges and problems. Although human perception is reduced to the five senses, it is not the question whether intuitive skills exist or not, but how to make more effective link between the mind and the ability (intuition), how to hear it and how to establish a confidential relationship and turn it into an action .The goal is consciously making the best decisions that rely on intuition or emotionally knowledge and rational thinking or logical knowledge. So, the question is how to establish a visible, perceptible relationship with our own intuition. A precondition for establishing the right connection is the achievement of inner peace. The messages that come through intuitive abilities are always sent in a very simple form: words, simple sentences, clear picture, clear sound, quietly. Often, the overlooking of such messages, because they are considered too simple, zu reaction "...it cannot be that simple," or" ... it cannot be intuition ... "Usually great sensations, miracles are expected, But this is precisely the great strength and power of intuition. It occurs without emotion, of course, from a deep inner peace. In the event of inner speech which carries a negative emotion, anxiety, agitation, anger, it may have something with the fear, but not with intuition.
Very Often a person makes decisions based on rational thought, although the intuitive part had "said "otherwise. This is called defensive decision-making that does not contain its own responsibility, but the responsibility is transferred to the environment. By developing the intuition, one comes to the core of his spiritual being and to the knowledge of the existence and functioning of the living creatures.
Key words: intuitive abilities, inner voice, speech, an emotional knowledge, defensive decisions making.

1. INTRODUCTION

1.1. What is intuition?

Intuition is the reestablishement of the forgotten relation between a man and the Universal energy, the Universe. Each man posses *intuitive abilities*, ie. intuition which is an aspect of good communication with the Universe. Although its presence is not noticeable and we cannot tell where it comes from, its existence and origin cannot be determined (1), intuition affects our everyday decision making. If a person learns to listen to and follow that inner voice that occurs so clearly, he will have many possibilities for creating ideas for the development of his own optimal strategies for making good decisions while dealing with chalenges and problems.

1.2. Where has intuition disappeared?

In the old principles, a man \`has been deprived of the right\` to use those fantastic abilities and possibilities in order to become detached from other beings with the Ratio as the logical part of his mind. In order to adequately fit into the social norms, a man \`has forgotten\` this inexhaustible source of his inner self. A person acting on the intellectual level is useful, but it has somehow become the master of the entire human being. The intellect has no experience on the same level as the intuition and thus it gives the same old answers to the raised questions. It tries to dominate and so it has the logic by its side –

reason, argument, proof that it can rule, and when there is a conscious mind, it presents a problem, but is not always able to adequately respond to them (5). Therefore, the goal of the modern man is the establishment of the fantastic link and good communication between his intellect, Ratio and his intuitive abilities, i.e. his own self and the Universe.

1.3. How to make a connection with the inner intuitive abilities?

In order to make a connection with his inner intuitive abilities, it is necessary for a man to:

- Have the ability of *empathy*. The fastest and the safest way to meet your intuitive abilities is made through emotions. By knowing well emotional conditions, a man is able to understand, comprehend and sympathize with other people. In the presence of his emotions, a man does not try to understand other peoples` emotions, because he *knows* what the other person feels. Empathy is the first step to making connection with intuitive abilities within oneself. By developing emotional intelligence, the door is opened to the intuitive abilities that offer a completely different life quality, the ones that harmonize all three aspects: body, mind and spirit. The emotional intelligence is at the same time connected to the ego. If a man with his own ego detaches from his environment, other people, time and space, he will only have the lead of his inner needs and aspirations and his goal is then only to satisfy his needs. The door to his intuitive abilities is closed. However, if a man comes above his ego and accepts the fact that he is a being able to expand, learn and make a fantastic connection with the Universe, he can then allow himself to act with empathy and his *I* becomes *we*.

- Have the ability to reach inner, spiritual peace. It can be accomplished first through loving oneself, deep respect of oneself as a very important, unique being. By respecting and loving oneself there is a fantastic relation of gratitude between God and a man as a stable being. The biggest gift God has ever given to the man is *prayer*. It is a perfect way of making connection with one's own inner being, and establishing inner spiritual peace. Prayer is the creation of peace within a man, the balance since it establishes the unity of man with the higher energy of the Universe. Prayer is creation (2). Although there is a consciousness about the state of the real, outer world, through prayer a man is given the possibility of reaching silence. The elimination of the noisy environment that keeps the man within the material world, through prayer we reach silence which is a path that leads to God. Mahatma Gandhi once said: ` I often think about how somebody who is looking for the truth needs to be in silence`. When the inner silence is reached, then we can ask our intuition (ex `Tell me what I need to know regarding this situation? ` or `What do I need to do?`).

1.4. How does intuition appear?

When there is an answer form the intuition, inner voice, it is then necessary to make a relationship based on *trust*. The messages that come through intuitive abilities are always sent in a very simple form:words, simple sentences, clear images, clear sound, quietly. Often, there is the overlooking of such messages, because they are considered too simple ("...it cannot be that simple!") Usually great sensations, miracles are expected. However, this is precisely the great strength and power of intuition. It occurs without emotion, of course, from a deep inner peace. In the event of inner speech which carries a negative emotion, anxiety, agitation, anger,... it may have something with the fear, but not with intuition. Intuition always gives the feeling thet evrything is all right and that a man is on the right path, that he is safe. It is shown with its perfect simplicity

2. METHOD

2.1. Decission making

In life, every decision making, to a certain degree, changes and forms the future and in all its complexity has the goal of a more successful life, bliss. The process of decision making has its cause nad consequence: at the level of Ratio, intelectual level and at the intuitive level, the level of emotional knowledge. There is also a relation between a man and the Universe and this does not involve only numerous number of demands and wishes. The Universe perceives and listens to which level is responsible for decision making , how a man feels in the process, what is the form of the change regarding the environment, which consequences does it have to the future,... and allows man the freedom of decision making. The results, or the consequences come to the man as the perfect results of his work.

2.2. The difference between rational and intuitive decision

Sometimes a man is given too little or too much information when he needs to make a (quick) decission regarding his future. On the rational level decision making is a much longer process and demands a lot of thinking because there are available information from the level of logical knowledge. The intelect needs more time. It analizes, synthetizes... During this process the logical mind relies on the limited number of information. They can be from the personal experience, but they can also be transfered ` from age to ages` as information or strategies for reaching the goals, or for the success in the lives of the previous generations.

However, on the other side, decision making on the level of emotional knowledge is much faster and there are no excuses or explanations for them. With this impact of the forces of the Universe a man has an infinite number of information and possibilities. It is important to emphasize here that this kind of decision making does not always result in satisfaction and success. There are situations which have pain or suffering as the outcomes. Regarding the consequence this way, a man realizes that life is an endless process of learning on many levels and that it demands experiencing all emotional states.

There is sometimes a problem when intuitive and logical possibility of decision making do not match, when there is a disorder between intuitive feeling and the Ratio. A man then usually makes a *defensive decision*, a decision from the rational level since that kind of the decision is more generally accepted than the other, made from the level of emotional nowledge (4). It is then important to realize that decision making does not liberate the man of his own personal responsibility and that it is in accordance with social norms, and thus neglects intuitive feeling. Realizing the existence of these two possibilities of decision making the man is given the freedom of choice which creates a compromise between the intuitive and the rational.

Decision making on the level of intuition is often a better solution because such a solution has just `come` from the level of the Universe and the man tends to make a connection with it based on the belief that the Universe already knows what is best to the man. Intuition is more subtle than reason. The estimate of the consequence is often emotional, and not rational in its nature. A man should ask himself how he *feels* after decision making.

3.THE GOAL

3.1. `Living in the light`

Developing intuition, emotional knowledge, a man reaches the core of his spiritual being and the knowledge of functioning and the existence of the being. Listening to the speech of his own intuition, there are new possibilities of good communication with the Universe. In the world as we know it today, in the world of computers and programmed life, where most decisions are made at the level of Ratio, it is not socially acceptable for a man to rely on his intuition. Contemporary man today relies mostly on his intelect which becomes more and more powerful. The whole educational system is based on intelect sharpening. It is believed that greater intelectual abilities lead to a greater success. However, the intelect is a part of the conscious mind, and it is only a little part of a man`s potentials (5). The conscious mind can be seen, but part of the unconscious mind is bigger and more powerful, and its potentials are not fully used. With the advance of the human conscious, a man is now asked to show his courage which is reflected in decision making on the level of emotional knowledge since everybody has a *responsibility* for them. Such a responsibility implies understanding that every success, fulfillment, discontent,... come from within. And this creates the mutual trust and realation between *I* and its *higher I* (3), and life experience becomes richer and deprived of fear. This inevitably leads to the improvement of social coherence quality, and thus to a global coherence of human consciousness.

4. CONCLUSION

If a man accepts the fact that life is a never-ending process of learning and advancement, that in the moments of discomfort and despair he should be aware that it is time for making changes (1). Although it seems that sometimes nothing happens, in fact, something is happening. Changes demand all three levels: body, mind nad spirit and they contribute to establishing a close relationship with the most sublime energy, the energy of the Universe, with joy, happiness, bliss, creative inspiration and trust. Life with intuition brings sense, splendour, joy, blessing and bliss. Intuition reveals the secrets of existence, brings incredible silence, and calmness which cannot be disturbed and which cannot be taken away from the man (5).

References

(1) Gvejn Š. (2009). *Živeti u svetlosti,* Beograd, Tomić Book.
(2) Aivanhov O. M. (1986). *Moć misli,* Beograd, Edicija Prosveta S.A.
(3) A. de Melo (2004). *Put ljubavi,* Beograd, LOM Edicija.
(4) G. Gigerenzer (2008). *Gute Intuition*, vorlesungen, Max-Planck Institut fuer Bildungsforschung, Berlin, Deutschland.
(5) Osho (2011). *Intuicija, spoznaja izvan logike,* Beograd, Leo commerce

ABILITY OF PHONOLOGICAL ANALYSIS IN FIRST AND SECOND GRADE ELEMENTARY SCHOOL CHILDREN

NINA STANOJEVIĆ[1], MARINA RANĐELOVIĆ[2]
[1, 2] Institute for Experimental Phonetics and Speech Pathology "Djordje Kostic '
Belgrade, Serbia
ninastanojevic88@gmail.com

Abstract. Phonological awareness is the ability of phonemes segmentation and knowledge of the phonemes-graphems retaionship and represents the basis of functioning of a language. According to *Golubovic S.,* (2003, 2005, 2006, 2007, 2011, 2012), this in itself grouping a number of functions that contribute to the understanding and application of precision automated phonetic system of a language. One of these functions is auditory analysis, the ability to in a certain word of recognize phonemes which the given word consists of. Ability od auditory analysis phonems in word represent one of preconditions for the development and acquisition of reading skills.

The aim of this study was to investigate the ability of phonological analysis of the initial and final phoneme in the words of the first and second grade elementary school children.

Sample consisted of N = 60 children, of which N = 30 students of the first grade, while the N = 30 students of the second grade. The percentage of females was 60%, while the percentage of men was 40%. All subjects were students from the elementary school '*Arcibald Rajs'* in Belgrade. For assessment we used group of tasks B-2-4: Phonological analysis of voices from the Diagnostic kit for assessment the ability of speech, language, reading and writing *(Bjelica J. Posokhova, 2001*).

The results show that the maximum number of points maintained 47% of the children first grade and 90% of children of second grade. The values of mean scores for the total number of points in both sets of tasks for children first grade and second grade children show a statistically significant difference (p <0,05).

Keywords: phonological awareness, analytic phonological skill, children of first and second grade

INTRODUCTION

Phoneme is the smallest unit of linguistic expressions, that is the smallest distinctive unit without meaning, it has a distinctive feature, which means that by using different phonemes higher units are made.

Phonology deals with the sound system of a language, but a particular segment phonology analyzes the speech by the partition of the discrete segments such as phonemes.

Phonological decoding is process of detection and discrimination of phonemes of a certain language, and phonological encoding is process of selection and producing of phonemes that form language expression.

Phonological meaning refers to the use of voices to differentiate meaning (Goodluck, 1990, according to Golubovic, 2007).

The acquisition of phonological skills consists of four basic interactive components: auditory, perceptual, cognitive and neuromotor (Stoel-Gammon & Dunn, 1958, by Golubovic, 2007). Frost and Emery (1997, by Golubovic, 2007) identified three main components of the phonological deficit: phonological awareness, decoding speed, packing and finding phonological information in memory.

Kasic (2003) states that for deciphering of the message on a certain language, the knowledge of the specific voice patterns of language expression and understanding of the complete structure of the language are needed.

Phonemic hearing is provided by the functioning of temporal lobe of the left hemisphere, precisely by the Wernicke's area. This zone enables extracting of phonematic acoustic characteristics which are different by the meaning, from the flow of speech, therefore it represents the main brain mechanism of phonemic organisation of speech. The function of upper temporal lobes of hemisphere is provided by the plastic relations of this region with lower lobes of postcentral cortex area and lower lobes of premotor cortex area, therefore it is included in system which is essential for ensurance of phonemic organisation of speech act (according to Golubovic S., 2006).

Phonological awareness is the ability of phonemes segmentation and knowledge of the phonemes-graphems relationship and represents the basis of functioning of a language. According to *Golubovic S.,* (2003, 2005, 2006, 2007, 2011, 2012), this in itself grouping a number of functions that contribute to the understanding and application of precision automated phonetic system of a language such as auditory perception, auditory discrimination, auditory differentiation, auditory analysis, auditory combination, auditory memory, auditory continuous and proper classification, auditory form of auditory word recognition, the formation of rhyme, alliteration, and intonation or accent (Golubovic, 2003, 2005, 2006, 2007, 2011, 2012). According to Golubovic (2003, 2005, 2006, 2007, 2011, 2012) there are eleven elements of phonological awareness which she classified and defined:

Auditory perception is the ability to recognize certain phonemes in a given word.

Auditory differentiation is the ability to distinguish whether two phonemes are the same or different.

The ability to recognize phonemes which the given word consists of.is *auditory analysis,* and the ability to group a separately spoken phomenes in a word is *auditory syntesis.*

Finding new words in case you leave out one or two consonant when a word is pronounced orally, as well as if you leave out one or two vowels is *auditory combining.*

Auditory memory is the ability to get over a short period of time remember and reproduce a number of phonemes, words and numbers that are given orally.

Reproduction of a number of words that are given orally in the correct order is *proper and continuous auditory classification.*

Auditory word recognition involves recognizing words when only one part of the word is given.

Formation of *rhyme* is the ability to distinguish whether the last phonemes in a particular word are equal or not, and the ability to find words that have extensions that rhyme compared to orally given word.

Alliteration include the ability to extract the words wich begins with the same consonant from the long-term memory, and *accent or intonation* are representing distinguishing of accent in a word or sentence.

Tasks that are commonly used when testing the phonological awareness are phonological analysis tasks. Phonological analysis requires a high level of awareness of phonemes and is seen as the ability of high-level hierarchy of phonological awareness skills (Hegal, 1998 Watts, 2002). It requires the child to parse the word into smaller parts and read them in order (by Hsin, YW, 2007). The abilities of phonological analysis and synthesis in children with typical development are usualy developed between 5 and 7 years, however, Lonigan at al. (1998, according to Sutherland, D., 2006) indicate that successful performance on phoneme-level tasks has been reported to appear around age 5 among children from middle-class families, but not children from families with low incomes. Research suggests that develop of the synthesis and analysis provides a good basis for the acquisition of reading skills (Chard and Dickson, 1999). Pullen and Justice (2003) found that when children develop the ability of analysis and synthesis, they improve their reading skills along with other skills of phonological awareness (according to Daniel, MJ, 2006).

Treiman and Zukowski (1991, by Hsin, YW, 2007) suggest a reciprocal relationship between phonological awareness and reading, because state that rhyming ability develops early as the ability of phonological analysis occurs only at the start of the course reading. This indicates that reading training encourages the development of phonological awareness. Analysis and synthesis are therefore two different aspects of phonological processing which indicate two different skills that are related to achievement in reading (Torgesen, Wagner, and Rashotte, 1994, by Conway, TW, 2003).

Phonological analysis to measure tasks that require parsing words to phonemes, in contrast, phonological synthesis involves the preparation of phonemes in a word. Both of these capabilities are essential for reading, however, Conway (2003) stated that the phonological analysis proved to be a better predictor of success in reading than synthesis.

Yet is not clear wheter a greater impact on reading acquisition is awareness of rhyme or awareness of phonemes. Bryant and colleagues (Bradley and Bryant, 1983, 1985, Bryant, MacLean, Bradley, and Crossland, 1990; Goswami and Bryant, 1990, according to Sutherland, D., 2006) hypothesized that pre-reading awareness of rhyme provides the basis for two different paths to acquire reading skills. First, directly affecting the child's acquisition of reading skills (the child understands that can use this knowledge to read words such as 'sight, ligjt, fight ..') (Bryant, 2002, according to Sutherland, D., 2006). Second, by providing the knowledge necessary for the development of phonological awareness, which has a direct impact on reading. A number of studies indicate that the ability of each phonological awareness supports development of the next ability which should develop (Daniel, MJ, 2006).

High technology confirms the positive relationship between the treatment of phonological awareness and reading skills. FMRI reveals that the systematic training based on phonological reading skills improves reading fluency and leads to an increase in activation of the left hemisphere of the brain which is responsible for language. FMRI results suggest that reading training should be applied as early as possible to prevent phonological deficits and the subsequent difficulties in reading. Swanson Hodson and Schommer-Aikins (2005, by Hsin, YW, 2007) has come to the complementary conclusion that in the analysis of treatment outcome of phonological awareness in children of the seventh grade, poor readers, bilingual community, found that poor readers showed improvement after treatment directed to phonological awareness, their results after treatment were higher at the tasks of phonological awareness, 'atack word' word recognition, word comprehension and understanding of the paragraph. ixon, Stuart Masterson (2002, according to Chen, TW, 2009) point to the fact that children who were practiced phonological awareness more quickly acquired new vocabulary than children who were less practiced.

2. SUBJECT AND THE AIMS OF RESEARCH

The subjest of this study is ability of phonological analysis in first and second grade elementary school children**.**

The aim of this study was to investigate the ability of phonological analysis of the initial and final phoneme in the words in first and second grade elementary school children**.**

The second aim was to compare the development of phonological analysis skills in children at the beginning of first grade, that is at the start of the reading training and children's second grade that is one year from beginning of reading training.

3. METHOD

Sample of this study consisted of N = 60 children, of which N = 30 children attending first grade of elementary school (FGES), and N = 30 attending the second grade (SGES). The percentage of females was 60%, while the percentage of men was 40%. All children are 'Archibald Reiss' elementary school students.

Research was conducted in the month of September that is at the beginning of reading training when it comes to first grade and one year since beginning of reading training at the second grade children.

For examination we used *Diagnostic kit for testing the ability of speech, language, reading and writing* (Bjelica J Posokhova 2001). This diagnostic kit determines all the important aspects of speech and language development and cognitive functions necessary for acquiring the skills of reading and writing.

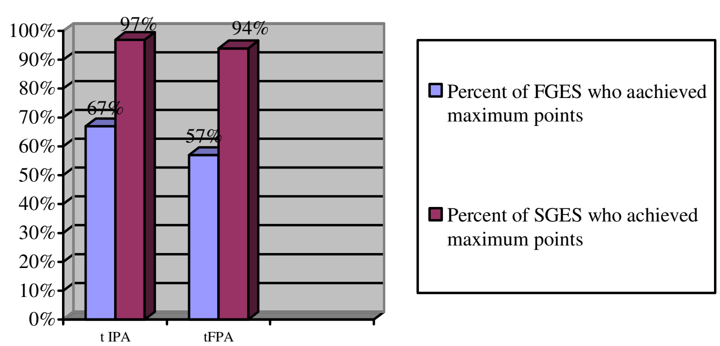
The kit consists of three groups of diagnostic material. For the purposes of this study we used tests from group of diagnostic material for the detection of specific interference in reading and writing of elementary school students, section B: Checking the language system for students with disabilities in reading and writing, sub-section B-2: Phonological processes. We used a group of tasks B-2-4: Phonological analysis of voices (TPA). From TPA we used the first part - the extraction of the initial phoneme in words (tIPA) and the third part - the extraction of the final phoneme (tFPA).

In tIPA and also the tFPA, the examiner read the words and ask respondents to raise the card with the '+' or '-' depending on whether the given phoneme is at the beginning of the word or not, and at the end of the word or not. The maximum number of points is three for tIPA and tFPA.

4. RESULTS

The results will be analyzed on the basis of points and first separately for tIPA and the tFPA.

Figure 1. Percent of children who achieved maximum points in tIPA -and tFPA special.



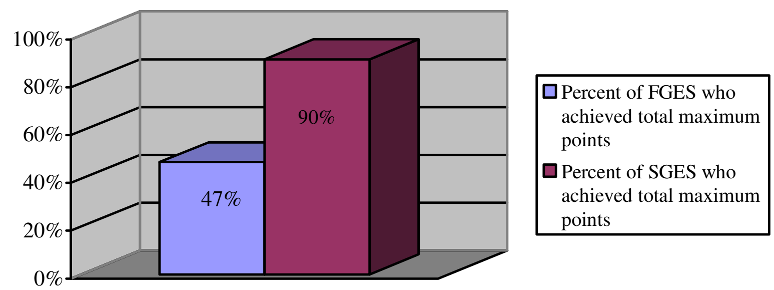
At tIPA a 3 points achieved 67% of FGES and 97% of SGES. The case that child achieve 0 points to be awarded in the event that the child is unable to complete the task, is not registreted. Two points in the FGES achieved 33%, and while in any of FGES or in

SGES none of the respondents made less than two points, the percentage of those who have made two of SGES is 3%.

In tFPA a 1 point achieved 3% FGES, while at the SGES no one has made less than two points. Two points achieved 40% of the FGES and 7% of SGES's. The maximum number of points occured in 57% of FGES and 94% of SGES.

The maximum total number of points was recorded in 47% of FGES and 90% of SGES. None of children had a greater difference than one point between the scores on the two parts.

Figure 2. Percent of children who achieved maximum points in the TPA



The difference in the values of AM results in TPA shows a statistically significant difference (p = 0.0001), its value is at the FGES 5.2, while at the SGES 's is 5.9.

Table 1. The values of the arithmetic means for the tIPA and tFPA

	FGES	SGES	Statistical significance
AM za TPA	5.2	5.9	p=0.0001

5. DISCUSSION AND CONCLUSION

Results of TPA shows that for the children of the first grade the tasks of phonological analysis of the initial phoneme in the words are easier then the final phoneme. We noted that the ability of phonological analysis is not fully developed, which is to be expected given that they are only at the start of the reading training.

In children the second graders we can see that a very small percentage failed to completely resolve the tasks of phonological analysis, suggesting that this ability is developed in children of this age, that is one year of the training of reading.

With the statistical measurement of the results we have shown that there is a statistically significant difference in the development of phonological analysis ability between the children first and the children second grade.

We conclude that the results of the research are in line with our expectations, that is, the ability of phonological analysis highly developed in children second grade, that is children who have one year of systematic reading training .

REFERENCE

Bjelica J, Posokhova I: A diagnostic kit for testing the ability of speech and language in children. *Zagreb 2001, Ostvarenje ,Croatian.*

Chen, T. W. (2009). The Role of Phonological Awareness: Phonological Awareness in Alphabetic and Logographic languages for Taiwanese Students. *Master thesis*. *Kent State University.*

Conway, T. W. (2003). Measuring phonological processing and phonological working memory in adults with development dyslexia: A functional magnetic resonance imaging study. *Doctor dissertation. The University of Florida. Florida*

Daniel, M. J. (2006). Phonological awareness instruction: Opinions and practices of educators and speesh-language pathologists in West Virginia. *Master thesis. Marchal University.*

Golubović, S., (2006). Razvojni jezički poremećaji. *Društvo defektologa Srbije, Merkur, Beograd*.

Golubović, S.(2007). Fonološki poremećaji. *Društvo defektologa Srbije*, *Merkur, Beograd*.

Golubović S. (2011). Disleksija, disgrafija, dispraksija. *Fakultet za specijalnu edukaciju i rehabilitaciju, Univerzitet u Beogradu, Merkur, Beograd*.

Golubović, S. (2012). Fonološki poremećaji-drugo dopunjeno i izmenjeno izdanje. *Društvo defektologa Srbije, Tonplus, Beograd*.

Golubović, S. (2012). Razvojni jezički poremećaji- drugo dopunjeno i izmenjeno izdanje. *Društvo defektologa Srbije, Tonplus, Beograd.*

Hsin, Y.W. (2007). Effects of phonological awareness instruction on pre-reading skills of preschool children at-risk for reading disabilities. *Doctor dissertation. Ohio State University. Ohio.*

Kašić Z. Fonetika. *Autorizovana skripta. Beograd.*

Sutherland, D. (2006). Phonological representations, phonological awareness and print decoding aility in children with moderate to severe speech impairment. *Doctor dissertation. University of Canterbury. Christchurch, New Zealand.*

LONGITUDINAL MONITORING VOICE QUALITY SPEECH THERAPIST

MARINA RANDJELOVIC, NINA STANOJEVIC
Institute for experimental phonetics and speech pathology

Abstract. Voice is an extremely variable dimension of speech. Lately, a great progress has been made in broad range of clinical tools that can help in effective measuring voice's attributes. Vocal problems, tiredness and exhaustion, are connected to continuous vocal production. Professional engagement vote means a highly specialized human activity, the preconditions high quality voice and speech, which requires optimal functioning of both biological and psychological, and social factors (Petrovic-Lazic, 2008).

The aim of this study was to examine a longitudinal study of acoustic voice characteristics for speech therapy for a time of one year with the help of a multidimensional voice analysis.

The study included 17 men and women, ages 25 to 45. Multidimensional Voice Program "Kay Elemetrics" 4300, was used for voice analysis in this research.

Statistical packet SPSSv. 13 was used in data processing. The methods of descriptive statistics were applied, as well parametric and non- parametric analysis of correlation between evaluated variables.

The obtained results show that the statistically significant differences in average values of parameters in most instances during the times, indicating that the changes in the average values of the parameters to vote, as a consequence of vocal fatigue. Professional use of voice, along with smoking habits can also be linked to voice change in a speech therapist.

Key Words: acoustic voice characteristics, vocal professionals, vocal tiredness.

INTRODUCTION

Vocal cords represent the source of the voice which lead to periodic congelation and dilution of air current by their vibration. The sound made in the throat spreads on all sides of the body and one part goes into the environment through air column corners of the mouth and reaches the ear of listeners and at the same time to the person who made the emission of sound. Pathological changes of the vocal cords deform the acoustic signal and affect the production of voice.

Professional engagement of voice means a highly specialized human activity, whose preconditions are high quality of voice and speech, and that requires the optimal functioning of both biological,psychological, and social factors (Petrovic-Lazic, 2008)[6]

Vocal professionals are mostly believed to be people whose voice is important to work. These are mostly singers and actors. According Titzey[7] and associates in the United States vocal professionals make up 15 to 35% of the workforce and include a variety of professions: teachers, lawyers, clergy, radio and television announcer and retailers, politicians, sports instructors, shareholders, cheerleaders. Kaufman and Isakson have divided people using the voice in their professions to the next level of use[8]:

Level I-elite vocal professionals (this group contains of opera singers and other singers and actors. A slight change of their voce can have serious professional consequences),

Level II-vocal professionals (including teachers, priests, telephone operators. Moderately damaged voice can obstruct professional activity),

Level III-nonvocal professionals (including teachers, lawyers, judges, businessmen, receptionists. For these people serious damage of voice can obstruct professional activity),

---

[6] Lazić M., Vokalna rehabilitacija, 199 str.
[7] Đukić V. i sr., Profesionalni glas, 71 str.
[8] Đukić V. i sr., Profesionalni glas, 73 str.

Level IV nonvocal-nonprofessionals (in this group are all other occupations (officers, employees) and the quality of their voice is not crucial for the profession, but it is important to communicate).

METHODS

The aim of this study is to compare the values of the acoustic parameters of voice in speech therapy for a period of one year and to examine whether there has been a change in the setpoint. We also aim was to determine whether smoking habits leads to major changes in voice quality of vocal professionals.

Sample

The study involved 17 speech therapists (15 women and 2 men) aged 25 to 45 years.. Speech therapists were filmed a year ago at the beginning of the week (experimental group) and after a year, also at the beginning (control group). The group consists of five smokers speech therapists, the smoking experience of more than 5 years, while the second group included 12 non-smokers examinees.

Procedure and processing of derived data

The research was conducted in the "Institute for Experimental Phonetics and Speech Pathology," Gospodar Jovanova street no. 35 in Belgrade. Voice parameters were recorded at the beginning and at the end of working week, in order to examine the changes in the parameters of voice after vocal fatigue. Examinee had the task to produce vocal A for 5 seconds calmly and spontaneously in a sitting position. Recording was repeated three times, and as the final result the best phonetic voice is taken.

We used computer laboratory for analysis of voice, model 4300, "Kay Elemetrics" corporations, software for multi-dimensional analysis of vowels.

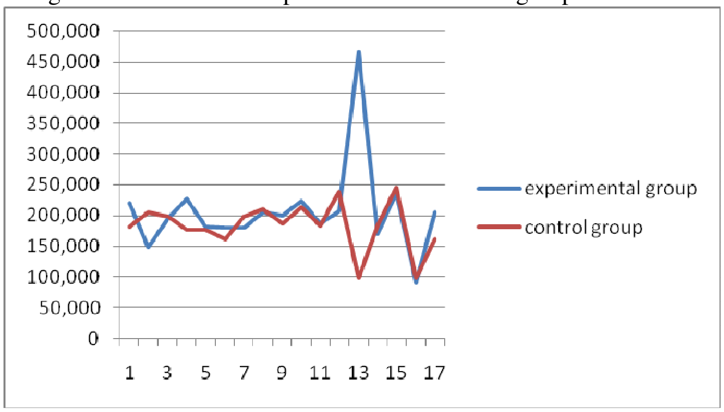
The following parameters were analyzed:

Uncer-tain short-term and long-term disturbance frequencies: Vfo (coefficient of variation of the fundamental frequency and is expressed as a percentage), Fo (the mean value of the fundamental frequency given in / Hz /), Mfo (an average value of the fundamental frequency given in / Hz /), Jita (describes the frequency-cyclical oscillations in voice and Fo variability and variability is the fundamental frequency), Jitt (a changing fundamental frequency and measure the difference between the value of a given period and the period immediately following it) and PPQ (mean coefficient of disorders of fundamental frequency altitude).

The collected data were analyzed using the statistical package SPSSv.13. Checking the difference between groups and within groups is done by monofactor analysis of variance (ANOVA) and t-test for paired samples.

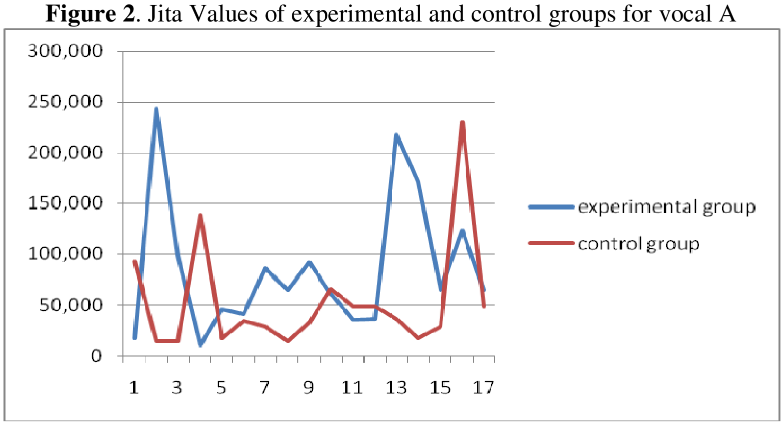
THE RESULTS OF THE STUDY

Figure 1. FO values of experimental and control group for vocal A



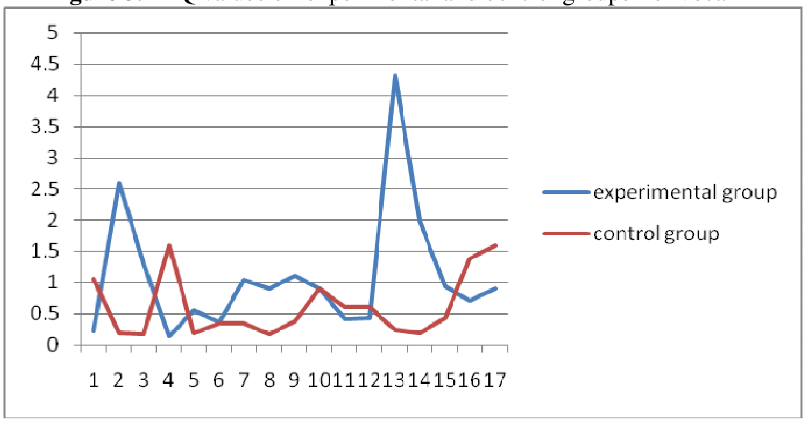
As for the values of the parameter Fo can be seen that the values of almost all the respondents lower than the average value (Fo for men is 145 233 Hz, and for women 243.973Hz). The biggest changes in the reporting period can be seen in the group numbered 13, I.B. (from 466.235 Hz to 99.134 Hz) and in subjects under number 4, I.P. (from 226.839 Hz to 176.790 Hz). Positive growth in this period is the best in the group number 2, K.S. (from 148.997 Hz to 205.235 Hz). There are slight differences observed between the experimental and control groups, which indicates that there is a change in the reporting period.

Figure 2. Jita Values of experimental and control groups for vocal A



Here we can see that the experimental values and the Control group significantly above average values (Jita for men is a 41.633 µs 26.927 µs for women), order of the male respondents, in which Jita exceed 218 µs. Substantial increase in this parameter can be observed in several subjects, but is most prominent in subjects numbered 1, A. B. (with 16,853 µs to 92421 µs) and in the group numbered 16, M.S. (from 123.697 to 230.203 µs µs). When a couple of them we can see the improvement value and is most pronounced in subjects under number 7, N.S. (from 86.361 to 28.733 µs µs). The differences between the experimental and the Control group were insignificant, but values of both groups were well above average.

Figure 3. PPQ values of experimental and control groups for vocal A



When observing this graph we can see a big difference between the experimental and control groups. During the period there was a decline in the value of this parameter, in almost all subjects, and are thus ispitanaci control group closer to normal values. Normal values for PPQ for men is 0.388%, and for women it is 0.366%. Significant reduction in PPQ's is observed in patients numbered 13, IB (from 4,317% to 0,234%) and respondents KS (from 2601% to 0.185%). The largest increase can be observed in the group numbered 1, AB (from 0.217% to 1.047%) and IP (from 0.134% to 1.594%). PPQ we measure the coefficient of the fundamental frequency disturbances on the basis of the data we can see that there are improvements in the fundamental frequency in almost all subjects.

Figure 4 and **Figure 5** Comparison of Fo and Mfo for smokers and non-smokers in experimental and control

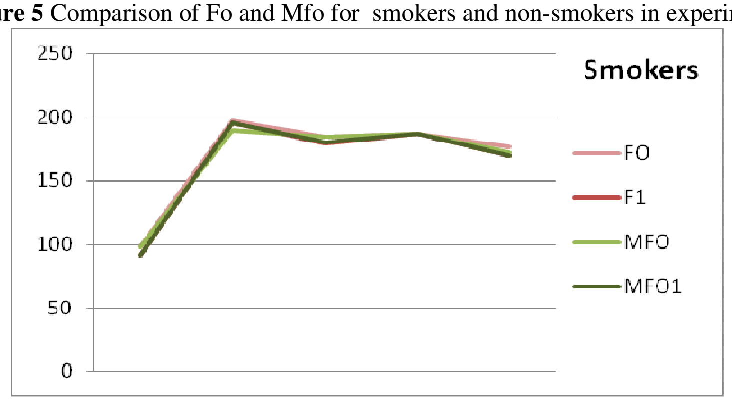
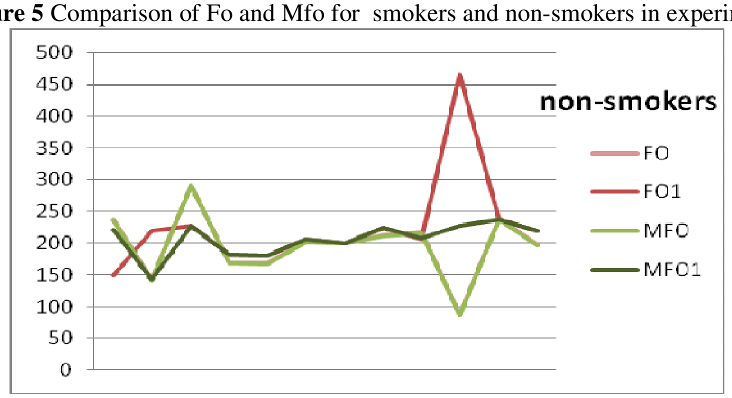


Figure 4 and **Figure 5** Comparison of Fo and Mfo for smokers and non-smokers in experimental and control



When observing these two figures we see significant changes of parameters with Fo and Mfo in smokers and non-smokers in experimental and control group. In smokers, we see almost overlapping lines of parameters between the experimental and control group. Also variations are much smaller, ranging between 100 Hz and 200 Hz, which is not the case in non-smokers. Variations in non-smokers were significantly higher than below 100 Hz to over 450 Hz. There is no overlap between these two parameters in experimental and control group.

The results are shown in Table .1 Looking at the table, we see that the values of processed parameters are not statistically significant, (except for the parameter JITA-indicating high statistical value). This indicates that the voice of examinees, although damaged by normal statistical values were not statistically significant due to the insufficient number of examinees.

If Jita parameters, realized t-value is greater than the limit value, t = 1.73, number of 16 degrees of freedom and significance level of p = 0.1, which implies that the confidence level of 90% of the claim that the difference is statistically significant.

Table 1 The acoustic parameters values of experimental and control group0.[9]

Acoustic parameters	**Experimental group**		**Control group**		**Difference**		**t**	**p**
	Mean value	**SD**	**Mean value**	**SD**	**Mean value**	**SD**		
FO (Hz)	188,80	49,17	208,18	74,90	19,38	94,60	0,845	
MFO (Hz)	187,80	7,05	193,67	36,02	5,87	39,36	0,615	
VFO (%)	5,78	0.052	9,44	24,48	25,50	71.73	0,592	
JITA (µs)	103,6	80,71	85,02	68,14	18,58	44,36	1,736	p<0.1
JITT(%)	1,65	1,00	1,55	1,22	0,09	1,10	0,369	
PPQ(%)	1,10	0,70	1,08	1,04	0,02	0,22	0,112	

DISCUSSION

In all tested parameters we can immediately see the difference, compared to the normal value and the value of experimental group. This suggests that examinees have somechanged parametersof voice due to vocal abuse. Based upon the analysis we can see the changes between experimental and control group (which was the aim of the study), but the changes were insignificant because of the smaller number of samples. The results also show that the average values of studied parameters of voice with smokers and non-smokers speech-therapists differ significantly. For parameters (Mfo and Fo) there is a certain statistical significance for vocal A, which indicates that the quality of this vocal in smokers group is slightly modified. Mfo parameter values, which is the average value of the fundamental frequency, significantly is lower in non-smokers in experimental group compared to normal values. Interestingly, this difference in relation to the normal values, slightly reduced in smokers in the control group.

[9] t-factor, the distribution of p-university students, SD-standard deviation (average deviation of individual values of the variables from the average in the sample)

In our country, there are no reports on this subject, so that the results can not be compared with the results of other studies. Speech therapists do not belong to a group of professional vocal speakers, based on the analysis and the obtained results, we can see that indeed there is a voice abuse.

CONCLUSION

During the research, we came to the following conclusions:

- The results show that there are changes in the measurement parameters, but it is statistically a small change in experimental and control group,
- The highest statistical value, when comparing the experimental and control group, has a parameter Jita ($t = 1.73$, number of 16 degrees of freedom and significance level of $p = 0$),
- The speech therapists who smoke, the changes in acoustic parameters of voice were statistically significant,
- The laboratory of voice plays an important role in the diagnosis and rehabilitation, but it should be stressed that this must not be the only method in the diagnosis and rehabilitation of persons with voice disabilities,
- Average values of the parameters short and long term disturbance frequency showed the greatest deviation from normal values. In smokers, on average, it is significantly higher in these parameters. The largest deviations from the normal values occur in the following parameters: Jita and Jitt. Parameter Jitt measures short-term, cyclical irregularities of period of voice and represents variability of the fundamental frequency. These irregularities are mostly associated with the inability of vocal cords to maintain the periodicity of vibration,
- Professional use of the voice, combined with the habit of smoking may be associated with changes in the parameters of voice in speech. Occupation of speech therapist is one of the most demanding vocally. For this reason people who hire professionally their voice, deserve special care, so it should improve the prevention of voice disorders and educate speech therapists about vocal hygiene.

Given that in our country there is no organized training for vocal profession, we believe that the prevention of voice disorders and vocal training should be extended to other vocal professions, so that people who commit these occupations enter into a career ready and efficient.

The results show that the acoustic structure are changed as a consequence of altered vocal mechanisms. Voice therapy program aims to educate speech therapists to keep or modify the factors that contribute to the improvement of voice. The most common characteristics of the voice change is the absence of work, the negative impact on quality of work, social activities, and emotions. Research shows that vocal professionals use different strategies to deal with voice problems.

LITERATURE

Đukić, V. i sr. (2011). Profesionalni glas. Beograd: Kaligraf.

Vuković ,R. i Vuković, V. (2011).Fonopedija-habilitacija, rehabilitacija i reedukacija glasa. Beograd: Specijalistička ordinacija iz oblasti dečje psihijatrije “KGGS”.

Sovilj, M. (2004). Govor i jezik. Beograd: Institut za eksperimentalnu fonetiku i patologiju govora.

Jugović, I. (2011). Akustičke karakteristike glasa kod nastavnika pre i posle vokalnog zamora. Neobjavljena magistarska disertacija, Univerzitet u Beogradu.

Keramitičijevski, S. (1990). Opšta logopedija. Beograd: Naučna knjiga.
Milutinović, Z. (1997).Klinički atlas, poremećaja glasa. Beograd: Zavod za udžbenike i nastavna sredstva.
Petrović-Lazić, M. (2008). Vokalna rehabiliotacija glasa. Beograd: Nova naučna.
Petrović-Lazić, M. (2010). Rezonatori glasa. Beograd: Nova naučna.
Sovilj, M. (2007). Poremećaji verbalne komunikacije. Beograd: Institut za eksperimentalnu fonetiku i patologiju govora.
Cvejić, D.-Kosanović, M.(1982). Fonijatrija. Beograd:Zavod za udžbenike i nastavna sredstva.
Đukić, V. Promuklost. Preuzeto 13.8.2013.sa Scindeks. http://cdcc.gradiskaonline.com/dokumenti/dokumenti/promuklost.pdf
James, A. (1988). Vocal fatigue dysphonia in the professional user: bogart-bacall syndrome. Preuzeto 17.8.2012. http://www.voiceinstituteofnewyork.com/wp-content/uploads/2011/01/bogart-bacall-syndrome.pdf
Cvejić, D. Grkljan. Preuzeto 14,8,2012. sa Orl6. www.famona.sezampro.rs/medifiles/OTOHNS/KATEDRA/orl
Hedžever, M. (2010). Osnove fiziološke i govorne akustike. Preuzeto 13,8,2012. sa Scribd. http://www.scribd.com/doc/49807800/50/GLASOVNI-REGISTRI
Simberg, S. (2004). Prevalence of vocal symptoms and voice disorders among teacher students and teachers and a model of early intervention. Preuzeto 17,8,2012. sa University ofHelsinki.http://ethesis.helsinki.fi/julkaisut/kay/fonet/vk/simberg/prevalen.pdf

PRENATAL COMMUNICATION:HOW IT REFLECTS ON EARLY CHILD DEVELOPMENT

LJILJANA DOBRIJEVIC[1,2], MARIJANA RAKONJAC[1,2], MARINA VUJOVIC[1], IVANA BOGAVAC[1,2]
[1]Institute for experimental phonetics and speech pathology, Belgrade
[2]Life activities advancement center, Belgrade
iefpg@iefpg.org.rs[1]
ifp2@ikomline.net[2]

Abstract:Certain stimulations in the prenatal period in most cases irreversibly affect all later stages of human cognitive and emotional maturity. The development of prenatal communication (unborn child-mother-parents) is extremely under the influence of emotions and is based on different types of stimulation.
Research aim was to estimate the early psychophysiological development of children who were intensely stimulated in the prenatal period. The study included four male children ages 2-2.5 years, who were intensely stimulated by their mothers during the prenatal period. Methodological procedures included: taking anamnestic data, the application of The Scale for estimation of psychophysiological abilities of children from 0-7 years, and testing by the Global articulation test (IEPSP Battery tests).
The paper discusses the achievements of the children in relation to the type of stimulation applied in prenatal period. It is emphasized the early stimulation and development of prenatal communication with the positive effects they have on children's early speech and language, cognitive, motor and emotional development.

Key words: prenatal communication, early stimulation, child development

1. INTRODUCTION

The prenatal period (time between conception and birth) is the critical time to establish the basic architecture of the brain and build the foundations for its future potential.

According to prenatal psychologists and professionals who deal with prenatal psychology, prenatal stimulations leads to healthy fetal and postnatal development. One of these world`s leading expert on the effects of prenatal and early postnatal environment on personality development is Dr Thomas R. Verny. In his work he describes how prenatal stimulation bodes well for healthy fetal development.

"Every minute, there are new brain cells being formed in the unborn child. And as the new brain cells are being formed, pathways or circuits are being formed along the lines that help assist communication for whatever the child the needs. For example, the child will obviously need to breathe, the child will need to move when he is born, the eyelids will need to open and close; so all these organs and all the nervous tissue that supply these organs has to start developing long before birth.

It's the same thing with the brain circuits. The more you stimulate a child's skin, or the more you stimulate its auditory nerves (hearing) the more those pathways will develop and become stronger so that when the child is born, he or she is better prepared for the world."

Researches in the field of prenatal auditory stimulation demonstrated that auditory stimulation may improve fetal physical and intellectual development (Dobrijevic, 2011). Early auditory stimulation before birth may improve sensory-motor development, prevent deprivation and even epigenetic widen limits of human perception. By auditory stimulation it is possible to activate somato-sensory system of unborn child on very early developmental stage. More than any other stimuli, auditory stimuli can activate intellect and intuition, which are basic components of our mind (Blum, 1998).

In examining of fetal capability for learning, it is demonstrated that auditory stimulation leads to a progress in motor skills and intelligence what lasts for years (Blum & Yew, 1993). By observing the postnatal development of prenatal stimulated fetuses, it is noticed that sensory stimulation improves motor performances, visual skills, emotional life and early speech and language. Prenatal musically stimulated babies are more superior in growth and fine motor activities, linguistic development, some aspects of physical-sensual coordination and certain cognitive behaviors (Lafuente et al., 1997). Beside motor and verbal development, prenatal hearing also stimulates psychological development. Mother voice is the most important factor in fetal world of sounds (Beckedorf, 1995).

2. AIM AND METHOD

Research aim was to estimate the early psychophysiological development of children who were intensely stimulated in the prenatal period. The study included four male children ages 2-2.5 years, who were intensely stimulated by their mothers during the prenatal period. Methodological procedures included: taking anamnestic data, the application of The Scale for estimation of psychophysiological abilities of children from 0-7 years, and testing by the Global articulation test (IEPSP Battery tests).

The prenatal stimulation consisted of: everyday conversation with unborn baby, providing the sense of love and stability to the baby by often thinking about the baby, talking about our everyday and common experiences to our baby and often touching our baby by touching the tummy, listening the classic music, listening the sounds of nature, utilizing some exercises which are comfort and suitable during pregnancy.

3. RESULTS

Accurately anamnestic date taken from parents included: family heredity, pregnancy condition, time of delivery, delivery type, APGAR score, prenatal, perinatal and postnatal risk factors.

Table 1. Anamnestic data

Examined children (N=4)	Pregnancy condition		The term of Labour		Type of labour		APGAR Score (Average)	Perinatal risk factors	Postnatal risk factors	Heredit y
	Regular pregnancy, without any complications	Risk pregnancy	On term	Pre-term	Natural child birth	Caesar ean section	9			
Number	4	0	4	0	3	1	4	no	no	no
Total	100%	0%	100 %	0%	75%	25%	100%	100%	100%	100%

The analysis of anamnestic data showed that there were no risk factors which may have **i**nfluence on early postnatal development in group of examined children (table 1).

Psychophysiological child development was analised through aspects of speech-language development, senzorymotron development and social-emotional development. It was examined by The Scale of psychophysiological abilities in children from 0-7years. It was analised weather the child was above, on or under the chronological year regarding developmental level of observed function.

Obtained results showed that 75% of examined children were one year above the chronological age and 25% of children were on the chronological age regarding speech and language development. None of children was under the chronological age regarding speech and language development (table 2).

Table 2. The estimation of speech and language development

Speech and language development	Number %	Examined children (N=4)
One year under the age	Number	0
	%	0%
At the age	Number	1
	%	25%
One year above the age	Number	3
	%	75%
Total	Number	4
	%	100%

The estimation of senzorymotorn development showed that all examined children were one year above the chronoligical age regarding observed developmental function (table 3).

Table 3. The estimation of sensory-motorn development

Sensory-motorn development	Number %	Examined children (N=4)
One year under the age	Number	0
	%	0%
At the age	Number	0
	%	0%
One year above the age	Number	4
	%	100%
Total	Number	4
	%	100%

The estimation of social-emotional behavior showed the same regularity as the estimation of senzorymotron development. All examined children were one year above the chronological age regarding development of social-emotional behavior. (table 4).

The estimation of pronunciation was done by Global articulation test (IEPSP battery tests).

Table 4. The estimation of social-emotional behavior

Socio-emotional behavior	Number %	Examined children (N=4)
One year under the age	Number	0
	%	0%
At the age	Number	0
	%	0%
One year above the age	Number	4
	%	100%
Total	Number	4
	%	100%

Table 5. The estimation of pronunciation

Group of voices	Pronounciation			Total (N=4 children)
	Correct pronunciatio n	Developmental distortions and substitution	Pathological distortions and substitutions and omissions	
vowels (5)	100%	0%	0%	(100%)
plosives (6)	91.7%	8.3%	0%	100%
nasals (3)	66.6%	33.4%	0%	100%
laterals (2)	25%	75%	0%	100%
affricates (5)	55%	45%	0%	100%
fricatives (9)	44.4%	55.6%	0%	

The estimation of pronunciation showed that all examined children had developmental deviations in their pronunciation, but not pathological forms. These deviations were least expressed in group of plosives (8.3%) and most expressed in group of laterals (75%), affricates (45%) and fricatives (55.6%) (table 5).

4. DISCUSSION

The analysis of anamnestic data did not point to significant presence of risk factors which may have influence on early postnatal development.

The psychophysiological child development was estimated in aspects of speech-language development, senzorymotron development and social-emotional development, by

The Scale of psychophysiological abilities in children from 0-7years. Obtained results showed that 75% of examined children were one year above the chronological age and 25% of children were on the chronological age regarding ***speech and language development***. All examined children were one year above the chronoligical age regarding ***senzorymotorn development*** and ***social-emotional behavior.***

The estimation of pronunciation was done according to standards in Serbian language. Taking into consideration the fact that all examined children were at the age from 2-2,6 years, their pronunciation was examined in relation to two categories:

- correct pronunciation,

- developmental distortions and substitutions – in which the place and the way of pronunciation is not significantly changed (mild distortions).

- pathological distortions, substitutions and omissions – in which the place and the way of pronunciation is changed in pathological manner (oclusive, interdental, palatal, lateral, nasal sigmatismus); substitutions which are not allowed regarding the chronological age.

Justifikation for this approach and estimation of pronunciation is substantiated bz other authors. Markovic et al., (1997) understores that pronunciation disorders may appear in any chronological age , but the most frequent are in early childhood. During language aquisition the voice pronunciation is developed from simple to complex forms and because of it the deviations from standards in developmental period are not pathological ones. Chronological age should be considered not only during the Global estimation of pronunciation but even during the consideration whether it is pronunciation disorder or just deviation characteristic for certain speech developmental level.

By observing the pronunciation quality it is noticed that all examined children have developmental deviations without any forms of pathological forms as distortions and substitutions. Such findings can be explained by childrens chronological age when developmental deviations are frequent what we took into consideration during the estimation and distinction the developmental from pathological pronunciation forms.

5. CONCLUSSION

On the basis of obtained date it can be concluded that:

1. Prenatal stimulated children did not have anamnestic data which would point to presence of any risk factors pre, during or after the pregnancy which may affect early postnatal development.

2. Prenatal stimulated children are superior in the field of speech and language development, sensory-motorn development and socio-emotional behaviour.

3. Prenatal stimulated children at the age from 2 - 2, 6 years did not have any pathological forms of distortions and substitutions in their pronunciation.

4. Early stimulation and development of prenatal communication have the positive effects on children's early speech and language, cognitive, motor and emotional development.

REFERENCES

Beckedorf, D. (1995). Prenatal Hearing and Psychic Development. *Int. J. Prenatal and Perinatal Psychology and Medicine*, Vol 7, Supplement 1.

Blum, T. (1998). Human Proto-Development: Very Early Auditory Stimulation. *Int. J. Prenatal and Perinatal Psychology and Medicine* Vol. 10, No. 4, 457-476.

Blum, T., Yew, D. (1993). A full bibliography is contained in Thomas Blum, Early Proto-Developmental Enrichment Stimulations and Possible Changes in the Functional Morphology of the Brain. In Thomas Blum and David Yew, (Ed.), *Human Prenatal Brain Development*, Berlin, Leonardo Publisher.

Dobrijevic, Lj. (2011). *Prenatal hearing screening in function of psychophysiological child development prediction.* IEPSP, LAAC,Belgrade.

LaFuente, M. J., Grifol, R., & Segarra, J. et al. (1997). Effects of the Firstart method of prenatal stimulation on psychomotor development: The first six months. *Pre and Perinatal Psychology Journal*, 11:151-162. (Group differences in breast feeding have not been ruled -out as contributory).

Markovic, M., Golubovic, S., Brakus, R. (1997) The frequency of pronunciation disorders in children at preschool age, *Beogradska defektološka škola*, No 1, Društvo defektologa Jugoslavije, Defektološki fakultet Univerziteta u Beogradu, Beograd.

Prenatalna komunikacija: kako se reflektuje na rani dečiji razvoj

APSTRAKT

Određene stimulacije u prenatalnom periodu u većini slučajeva nepovratno utiču na sve kasnije faze ljudskog kognitivnog i emocionalnog sazrevanja. Razvoj prenatalne komunikacije (nerođeno dete-majka-roditelji) izrazito je emocionalno obojen i zasniva se na različitim vrstama stimulacija.

Cilj rada je procena ranog psihofiziološkog razvoja dece koja su u prenatalnom period intenzivno stimulisana. Ispitivanje je obuhvatilo 4 muške dece uzrasta 2-2,5 godine, koja su tokom prenatalnog razvoja bila intenzivno stimulisana od strane majki. Metodološka obrada je obuhvatila uzimanje anamnestičkih podataka, primenu Skale za propcenu psihofizioloških sposobnosti dece od 0-7 godina, kao i Globalnog artikulacionog testa (Baterija testova IEFPG-a).

U radu se diskutuju nalazi i postignuća ispitivane dece u odnosu na vrste primenjenih stimulacija. Ističe se značaj rane stimulacije i razvoja prenatalne komunikacije sa pozitivnim efektima koje imaju na rani dečiji govorno jezički, kognitivni, motorni i emocionalni razvoj.

Key words: prenatal communication, early stimulation, child development

Dobrijevic Lj[1,2], Rakonjac M[1,2], Vujovic M[1], Bogavac I[1,2]

Institut za eksperimentalnu fonetiku i patologiju govora, Beograd, Srbija[1]

Centar za unapređenje životnih aktivnosti, Beograd, Srbija[2]

iefpg@iefpg.org.rs[1]

ifp2@ikomline.net[2]

SPEECH AND LANGUAGE INFORMATION PROCESSING OBSTRUCTION IN A BILINGUAL CHILD

ZORAN RADIČEVIĆ[1], LJILJANA JELIČIĆ-DOBRIJEVIĆ[1,2], MIODRAG STOKIĆ[1,2], MIŠKO SUBOTIĆ[2], IVANA STANKOVIĆ-MILIĆEVIĆ[1]
Institute for experimental phonetics and speech pathology, Belgrade, Serbia[1]
Life activities advancement center, Belgrade, Serbia[2]
iefpg@iefpg.org.rs[1]
ifp2@ikomline.net[2]

Abstract: This paper discusses aspects of impact of speech and language environment from an early age in relation to speech and language preference of parents, with special emphasis on the contribution of particular regions responsible for the participation of different levels of the central nervous system (CNS) in language processing. Theta EEG disturbance gives different effects in the processing of speech and language information in a bilingual child. Cartographic EEG was analyzed in a resting period and during stimulation procedures that include speech and language basis: listening and retelling of textual material. EEG neurofeedback measurements have shown that despite the relatively uniformly reduced total beta activity amplitude, in the child who uses two languages, there are significant differences in terms of regions loaded by high values of theta when analyzing periodic stimulation of listening and repeating, as well as read and observed material (shown graphically) presented in Greek and Serbian.

Keywords: theta dysfunction, cartographic EEG, bilinguals, speech-language processing, Neurofeedback treatment

1. INTRODUCTION

Development of society and communication among people and nations, as well as increased migration, more often leads children of typical and atypical development to live in a bilingual or multilingual environment, where often a one language is primary. Primary language environment is the environment in which the child lives at an early age, by the end of the third year, when the functional speech and language development ends. The primary language environment also means the environment in which the child is somehow educated and professionally treated if a speech and language processing disorder is present. There are very few studies on the basis, set out in our method of investigation of different language backgrounds in speech and language functioning, assessed by mapping EEG recordings strength (amplitude) of certain brain regions. Also, we have not found in the literature works relating to the assessment of this type of speech and language development, which is based on linking the closeness (the amplitude value) responsive region.

2. AIM AND METHOD

Objective of the research, mostly the diagnostic, was to investigate the effect of primary versus secondary language environment in terms of speech and language processing substrate after observing comic book, while listening to the text of fables and in the retelling the primary and secondary speech and language expression. The secondary objective was to examine the possibilities of improving a child's results on Neurofeedback (NFB) findings during application NFB sessions. This was a case study that included a boy aged 11, who was born in the Greek linguistic environment (a Greek father, Serbian mother), who lived up to 7th year in the Greek speaking environment. Sporadically he stayed with his mother in Serbian - speaking environment. His parents divorced when he was 6 years old. In the everyday situations the boy listened to both languages. The boy was at the NFB treatment because of difficulties with speech and language functioning and attention deficit disorder, in the Institute for experimental phonetics and speech pathology (IEPSP) in Belgrade. NFB treatment lasted for 3 months, during which time the standard and EEG mapping was recorded. Standard and EEG mapping was performed on the device Neurofax Nihod Kohden, in longitudinal bipolar electrode montage using the International system 10/20 for electrode positioning, in a resting period and during stimulation procedures that included speech and language processing. EEG indicated the existence of signs of theta dysfunction predominantly in frontal and central regions. Theta dysfunction means morphological changes in the shape of slow and fast theta rhythm (5-7 Hz), which had no clearly morphology of the epileptic changes (Martinovic Ž., 2009). Cartographic EEG recordings were done in the procedures: a) a description of picture story using the primary (Greek), and the secondary language (Serbian), b) listening to the story in the primary and secondary language c) retelling using Serbian language the auditory presented material in Greek language and retelling the auditory presented material in Serbian language using Serbian language. Recording is done in a relaxed environment in the presence of the mother in the early afternoon (maximum alertness), when alpha rhythm is mostly presented. During the EEG recording, a boy was not under active disease, had no primary neurological disorder that would require additional radiographic and roentgen assessment. Psychological testing that is performed when the boy was 6 years old showed the lover, but still average cognitive abilities of the boy.

EEG recording samples for analysis were taken from the central part of the recording, and were artefact-free and last for 10 seconds. Samples were analyzed using the amplitude maps (μV) of 19 surveyed brain regions. NFB treatment was conducted in a relaxed atmosphere and consisted of measurements of the NFB input parameters for 3 minutes and then was followed by the application of 5-6 stimulus programs that were combined in the period of 40-45 minutes. Measurement point was in the F3-C3 region of the 10/20 system for the electrode positioning, with the following programs: reducing the theta/beta ratio, increase the useful time of theta/beta ratio (when the theta/beta ratio was less than 2.5), an increase of the high alpha activity, decrease the theta amplitude expressed in μV). The results of processing of the primary and secondary language in those stimulation procedures are presented by EEG mapping.

3. RESULTS

Cartographic EEG mapping obtained results in the situation:

3.1. Picture description

High values of theta rhythm amplitude are registered, which imply a deeper closed awareness in primary and multifunctional related regions. During the picture description in Serbian language (secondary language) information processing is reduced due to the effect of: Alpha 1 (α1 – 8-10 Hz) rhythm (closed mind, internal focus), especially in the Alpha 2 (α2 – 10-12 Hz) rhythm which implies an open mind (external focus) and Beta 1 (ß 1 – 15-

20 Hz) rhythm that implies judgment and recognizing the importance of information. The above-mentioned effect is considered in relation to the description of the same image on the primary (Greek) language when the increase of theta activity is less present.

3.2. Listening fable

Significantly higher theta activity while listening to the secondary language (Serbian) compared to the first (Greek) indicates a stronger and deeper subconscious state that in both situations is responsible for the interference in region responsible for understanding the meaning and speech and language preparation. When listening to the primary language is noticeable increase in the activity of closed consciousness (α1) in the regions responsible for the understanding and preparation of speaking – transportation of the linguistic information to the regions for voice output program. The difference is evident when listening to a secondary language which is significantly less disrupted. Analysis of speech processing suggests a much more powerful processing in closed mind (α1) for exposure in the secondary language in relation to primary, or vice versa, for the open state of consciousness (α2), where a much larger number of networks (interconnected brain regions) exist for processing on primary vs. secondary language.

3.3. Retelling the fable

3.3. 1 Retelling fable that was auditory presented in the primary language using secondary language

In retelling fable using secondary language (Serbian) that was auditory presented in the primary language (Greek) a deeper subconscious high theta activity was registered. It is significantly higher than that of telling and listening to the secondary language. Registered interference in both cases occupy both language and speech motor areas (frontal-central). Interference is registered in α1 rhythm, practically in the same motor-speaking regions, but it is more than 2 times greater in the situation of retelling fable that was auditory presented in primary language using secondary language (compared to the situation of retelling fable that was auditory presented in secondary language using secondary language).

3.3. 2 Retelling auditory presented fable in secondary language (Serbian) using secondary language

Analysis show that the processing of retelling fable auditory presented in secondary language (Serbian) using secondary language is far more complex (due the networks formation) in the rhythm that implies open awareness and attention (α2 rhythm) and in the rhythm that implies understanding of spoken material (ß1 rhythm). There has been significant processing in networks, particularly in the area of open awareness as well as using processing “attempts” (without complete network formation). It is also evident that the attempts of processing are present even in theta rhythm, and they are far more pronounced than in the case of secondary language retelling of the story that was presented in the primary language. Finally, the prefrontal (Fp) regions are significantly more engaged in the processing and interpretation of listening material in the secondary language.

3.4. Neurofedback results

In the Table 1 the results of NFB treatment (total of 34 sessions) applied for a period of 3 months (an average of 11 treatments per month, 3 treatments a week, but variable rate). Findings show that there was no effect in reducing the theta / beta ratio or its useful time and that there was a discrete beneficial effect in reducing theta power. However, a significant effect was recorded in increasing activity (power) α2 and ß1 rhythm and discreetly reducing α1 strength.

Table 1. Comparation of NFB results (in μV)

NFB parameters	**Average values: from1st till 7th treatment**	**Average values: from28th till 34th treatment**	**Effect**
Theta/beta useful time (<2.5) %	43.37	37.35	0
Theta/beta relation	4.24	4.76	0
Theta (5-8Hz)	15.65	14.98	+
Low alpha (α1:8-10Hz)	6.69	6.63	+
High alpha (α2:10-12Hz)	4.56	5.21	+
Beta1 (13-20Hz)	5.08	5.62	+

4. DISCUSSION

Although the paper presents a case study of a boy, obtained results clearly show the influence of the complex relationship between the primary and secondary languages, in a situation where a boy live and where he was educated (in Greece). In our case, the differences between the findings of speech and language processing in some way are affected by the boy's borderline cognitive status. Increased theta activity with elements of the theta dysfunction was significantly more pronounced in all three situations observed in the use of secondary language. Disturbance during the description of a picture in the primary language affects speech and language regions in the left hemisphere, which is probably connected with mild cognitive limitations of the child, while the secondary language faults occur in the regions for interpreting complex perceptual characteristics of images that are not yet prepared for speaking (linguistic patterns).When listening, disruption is in the primary motor aspects of language, and only partly in meaning and reasoning activity zones, while in the listening of secondary language obstructed areas of thought and preparation areas for understanding the information, which despite a slight limitation of cognitive development indicate additional burden of material interpretation in the secondary language (in terms of global awareness and understanding of the material). In retelling (as a form of direct reproduction), in both cases are affected the primary motor area, both for the motor program performance, and those which activate the output of the speech program which include parallel and primary central region of the left and right hemispheres. This proves that the area of linguistic expression programming form (central region) are identical in both languages regardless of the primary linguistic background, although the interference of theta rhythm in the situation of retelling of fable presented in the secondary language using the primary language are significantly higher than in the situation of retelling a fable presented in the secondary language using the same language. When processing the information in all three situations there has been a distinct harmony and negative relationship (less processing) in a larger theta load. This negative impact of theta load was more pronounced with the use of the secondary relative to the primary language of the child. The biggest difference in the processing of primary and secondary language was during retelling the auditory presented material. It is logical given that in addition that retelling needs activation of the short-term memory and includes speech and language (thought) interpretation , which is particularly important when listening in the primary language , and retelling in the secondary. Prefrontal structures responsible for processing thoughts (the meaning and significance) were significantly less active during listening in primary language, and during the interpretation of the secondary language (translation), which is in full accordance with the understanding of the function of these regions (Thompson & Thompson, 2003). Looking at the open consciousness (α2 activity) during the processing of speech, there was a significant difference between speech and language activity while listening to the primary or secondary language. It was observed in the situation of picture observation and description, and is consistent with our previous findings on the existence of a "language of images" in children with developmental speech and language disorders (Radicevic et al., 2009). Activity that implies a deeper attention and learning capacity as presented in beta 1 rhythm (Thompson & Thompson, 2003), showed significant differences between the situation of primary and secondary language use. Generally speaking, it is to be expected due to the limited cognitive capacity of the child. However, this activity was markedly lower in the interpretation of material than in listening and interpreting visually perceived material (assuming an expression of cognitive deficits). The NFB treatment results, although derived through a relatively small number of sessions, are also consistent with the findings of the cartographic EEG findings and psychological tests, particularly with the findings of dysfunction in the standard theta EEG. With a lot of reasons, it can be argued that the failure to overturn the theta / beta ratio of theta dysfunction is due to disrupted activation of anterior brain region (Radicevic et al., 2013). Theta dysfunction seriously interferes with speech and language processing in the respective areas registered in cartographic EEG. Theta dysfunction observed over rhythms that imply an open and a closed mind and learning capacities significantly interferes with the processing of the secondary language than the one that is primarily used. Disturbance in speech and language processing is more present during retelling the auditory presented material than in telling visual presented one. Disturbance is present in each language. Unlike the processing of the primary language where the number of attempts of networking is less than the number of networks, in the secondary language processing an attempts of networking greatly exceeds the number of created full networks. When speaking of language presentation of the visual material in the situation the use of the primary language, more affected are areas of thought and verbal expression. When using a secondary language in the description of the image, processing is retained on the interpretation of the contents of image. NFB treatment in children who live in a bilingual environment, and have easily limited cognitive capacity accompanied by theta dysfunction can only be used as an auxiliary method, in the prolonged period, in order to achieve the theta activity decrease.

REFERENCES

Martinovic Ž. (2009). *Klinicka elektroencefalografija*. Naucna Knjiga, KMD, Beograd.

Radicevic Z., Jelicic Lj., Sovilj M., Barlov I. (2009). Comparison of mapping quantitative theta encephalograms during directed and required visual–verbal activity and passive period in children with different disorders of speech–language functioning**,** *Experimental Brain Research* ,Vol 195, (4), pp. 569574, ISSN 0014-4819.

Radicevic Z., Jelicic Dobrijevic Lj., Stokic M., Sovilj M., Subotic M. (2013). Theta disfunction influence in a1 and ß1 rhythm in children with developmental dysphasia, *Clinical Neurophysiology*, Vol 124, Issue 7, pp16-e17.

Thompson M. , Thompson L. (2003). *The Neurofeedback Book*. The association for applied Psychophysiology and Biofeedback, Wheat Ridge, Colorado, USA.

OMETANJE PROCESIRANJA GOVORNO-JEZIČKE INFORMACIJE KOD BILINGVALNOG DETETA

APSTRAKT

Rad razmatra aspekte uticaja govorno-jezička sredine od ranog uzrasta u odnosu na govorno-jezičku preferenciju roditelja, sa posebnim naglaskom na doprinos pojedinih regiona odgovornih za učešće različitih nivoa centralnog nervnog sistema (CNS) u obradu jezika. Teta EEG disfunkcija daje različite efekte u obradi govorno-jezičke informacija kod bilingvalnog deteta. Kartografski EEG je analiziran u periodu mirovanja i tokom stimulativnih procedura koje uključuju govorno-jezičku osnovu: slušanje i prepričavanje tekstualnog materijala. Neurofidbek EEG merenja su pokazala da je, uprkos relativno ravnomerno smanjenoj ukupnoj amplitudi beta aktivnosti, kod deteta koje koristi dva jezika, postoje značajne razlike u smislu regiona opterećenih visokim vrednostima teta ritma, pri stimulaciji slušanja i ponavljanja, kao i pročitanog i gledanog materijala (prikazanog grafički) predstavljenog na grčkom i srpskom jeziku.

Zoran Radičević[1], Ljiljana Jeličić-Dobrijević[1,2], Miodrag Stokić[1,2], Miško Subotić[2], Ivana Stanković-Milićević[1]

Institut za eksperimentalnu fonetiku i patologiju govora, Beograd, Srbija[1]

Centar za unapređenje životnih aktivnosti, Beograd, Srbija[2]

iefpg@iefpg.org.rs[1]

ifp2@ikomline.net[2]

THE ROLE OF BASAL GANGLIA IN SPEECH MOTOR CONTROL

MARINA VUJOVIĆ[1], LJILJANA DOBRIJEVIĆ[2], MARIJANA RAKONJAC[3], IVANA BOGAVAC[4]
Institute for Experimental Phonetics and Speech Pathology[1,2,3,4], Belgrade
Life Activities Advancement Center[2,3,4], Belgrade
marinazlatkovic@hotmail.com[1], lilijen@ymail.com[2], masadanicic@gmail.com[3], ivbogavac@gmail.com[4]

Abstract: This review addresses the possible bond between the basal ganglia circles (BG) and stuttering. BG are responsible for the automatic execution of a sequence of motor programs that are covered by the learned motor plan. Important conclusions about the impact of BG on stuttering were performed on the basis of facts when the stutter step up and when and in what situations people who stutter are fluent. Stuttering is reduced when introducing compensatory timing cues such as speech with a metronome, choral speech and singing. It is assumed that the thalamocortical motor circuit of the basal ganglia through the putamen plays a key role in the onset of stuttering. This paper discusses the presumed subcortical dysfunction in stuttering, which is reflected as a failure of the basal ganglia to provide timing cues for the initiation of the next motor segment in speech as well as the synchronization of speech in general.
Key words: basal ganglia, stuttering, timing cues

1. INTRODUCTION

Terms extrapyramidal system and the basal ganglia (BG) are usually used as synonyms, but there is a view that there is no theoretical or practical benefits of retaining and using the term extrapyramidal system. In fact, pyramidal motor system cannot be separated from other motor systems, such as BG, cerebellum and brainstem motor system, given that the motor and somatosensory cortex of the brain, from which the pyramidal pathways start, also operates and controls other motor systems (V.Kostić et al., 1990).

Marseden (1982) hypothesized that the BG are responsible for the automatic execution of a sequence of motor programs that are covered by the learned motor plan. This concept assumes that any complex motor activity or learned motor plan requires a simpler collection of different motor programs or subroutines. Although there is no evidence that these programs are collected in BG it is pointed out that BG may be responsible for the collection of such programs in other brain structures, for their placement in an appropriate order and further more for their transfer to the cortex, which would allow automatic execution of motor plan. Of course, the generality of this hypothesis significantly complicates its experimental and clinical verification.

Some simpler approach of BG is derived from De Long group (1981), which held that BG are responsible for determining the direction and determining the amplitude of voluntary movements.

The opposite approach is also interesting - that the BG are involved in the selection of those patterns of behavior that will be performed but also disabling unwanted patterns.

BG, under the umbrella term "extrapyramidal system" are a group of subcortical nuclei in diencephalon and mesencephalon, which includes:

- Caudatus, putamen striatum,
- External and internal part of the globus pallidus (GP),
- The nucleus accumbens (NAC),
- Subtalamical sail (STJ)

– Substanctia nigra (SN)

Striatum (caudatus, putamen) receives projections from virtually all parts of the cerebral cortex. After processing the signal in the striatum, the output paths are routed over the inner part of the GP and SNr, to the thalamus, and here in particular more limited regions of the cortex (mainly in the frontal lobe). BG represents a filter in which informations are collected from the vast cortical landscape, and after the elaboration are transferred to specific regions of the cortex.

Striatum in addition, receives afferent connections from different parts of the brain stem, diencephalic, SNc, and sails "Raphe" system. These links may modulate the flow of information reaching corticostriatal projections.

Functional organization of the BG is easiest to present as a set of interrelated informational neural circuits (loops) from which in various places efferent projections are going out.

1.1 We differ one main and 4 assistant circuits:

1) The main striatal circuit: **cerebral cortex -strijatum-gl.palidus-thalmus-cerebral cortex.**

The main efferent system of this striatopalidal complex consists of palidothalamical projections, which originate from the internal segment of the GP. These fibers initially consist of two beam-fasciculus lenticularis and ansa lenticularis, which after Forelov field H, together climb as thalamicus fasciculus. They end up on the front ventral thalamus nucleus, which is closely linked to other thalamic nuclei, and on ventrolateral nucleus of thalamus, which has rich connections with Brodman areas 4 and 6 of the cerebral cortex.

2) First assistant striatal circuit -**strijatum-globus palidus-thalamus-strijatum**.

It is shown that one part of the fibers of fasciculus thalamicus leaves the bundle before the ventral nuclei of the thalamus and ends on centromedial and parafascikular nuclei of thalamus. Fibers of these intralaminar nuclei after passing through internal capsul, have widely projection to the striatum.

3) Second assistant striatal circuit-**gl.palidus-subtalamical nuclei-gl.palidus**.

The lateral part of the GP is designed to somatotopic projects toward STJ, and from this nuclei a high number of fibers departs to all parts of the GP. In addition to the described afferent projections from the GP, it receives rich connections from the motor cortex, except as described eferences from this point depart fiberes for SNR. It is assumed that the efferent projections have inhibitory effects, so that STJ has a unique position that allows him to influence a large part of the output system of BG.

4) The third assistant striatal circuit **striatum**-**substantia nigra**-**striatum.**

5) The fourth assistant circuit **cortex**-**striatum**-**substantia nigra**-**thalamus**-**cortex** .

1.2 Stuttering

In the International Classification of Diseases (1977) Stuttering is defined as a disorder of rhythm of speech in which a person knows exactly what he wants to say, but at the same time is unable to say that because of the involuntary, repeated extension or termination of a voice.

On the cause of stuttering there are many theories that have been grouped into:

- Organic, people who stutter do not have the necessary dominance of one cerebral hemisphere and are easily susceptible to emotional stress or fatigue;
- Cybernetic, an error occurs in one of four channels: auditory, visual, tactile and kinesthetic;
- Psychological, stress the emotional conflict and stuttering is caused by a conflict between a society and the child that cannot adapt to the requirements of the environment and react by suppressing his feelings;
- Pedagogical, they believe that stuttering occurs because natural disfluensy in child's speech listeners declare as stuttering;
- Linguistic, the cause of stuttering lies in the language.

Stuttering can be divided into physiological, primary, secondary, transiently and traumatic stuttering.

Almost all the world's statistics agree that the number of male children who stutter is greater than the number of female children (4-1).

In 20-40% of cases, the role of hereditary factors has been proved. Where heritage is excluded or when there is a predisposition the following causes of stuttering are stated: physical trauma, fear, conflict in the family, hanging out with a person who stutters underdeveloped speech and language, unknown factors.

2. THE EFFECT OF RITHAM, MOTOR CONTROL AND TIMING

2.1 The effect of rhythm

Execution of a complex motor sequence requires control of two main aspects: the spatial pattern of muscular activation and the exact timing of each sub movement. One of the most effective ways for persons who stutter to instantly create fluency is to speak to the pace of a metronome, the so-called rhythm effect. This effect is reported to be independent of speech rate, with marked reduction of stuttering even at high speeds like 184 beats per minute (Van Riper, 1982).

The rhythmic stimuli provide external cues for the timing of each syllable. This penomenon has a direct parallel in persons with Parkinson's disease, a disorder of basal ganglia functions due to reduced release of dopamine. In Parkinson's disease the ability to perform movement sequences is greatly improved by auditory or visual cues (Georgiou et al., 1993; Glickstein & Stein, 1991).

2.2 Chorus speech

Many people who stutter show no dysfluency when read alongside the other (Van Riper 1982). It seems that the mechanisms behind this effect are similar to the effect of rhythm. In chorus reading another person's voice provides external timing cues that the timing pattern that can be traced.

2.3 Song

Also singing creates fluency in many people who stutter (Van Riper 1982). Singing is the production of musical tones by voice (Encyclopedia Britannica, 2003 b). Music consists of several elements, but an indispensable element in music is rhythm. The melody cannot exist without rhythm. Rhythm in music is the classification of sounds in time (Encyclopedia Britannica, 2003 a). The conclusion is that for singing the brain must have internal representation of the intended timing for each sound. This is the difference between singing and speaking. Rhythm is an essential element of speech. As mentioned above when a certain rhythm is applied to speech stuttering disappears (the effect of rhythm). It seems reasonable to assume that during the singing rhythm is an internal representation of internal timing cues for the initiation of each syllables in a similar manner that metronome provides external timing cues. That the mechanisms of cerebral control of singing differ from the control of speech has been shown by Jeffries, Fritz, and Braun (2003). An interesting finding was that speech resulted in increased activity in the left dorsal putamen (the basal ganglia motor circuit) while singing did not result in such activation of either left or right putamen. This result is well in line with the suggestion discussed above, that normal speech requires timing cues from (the left) basal ganglia system, while singing is based on a different strategy for timing of syllables, mainly involving right hemisphere structures.

2.4 The effect of increased attention

Persons with stuttering are often able to speak fluently for a while if they change to a non-automatic way of speaking, like imitating a foreign accent or acting in a role (Bloodstein, 1995). In a similar way, persons with Parkinson's disease can achieve improved motor ability without external cues, merely by being instructed to consciously attend to an articular aspect of the movement (Cunnington, Iansek, & Bradshaw, 1999). An interpretation of these observations is that structures outside the basal ganglia system, for example the preMC, have the ability to provide internal timing cues for movement sequences, but only during de-automatization of the movements.

2.5 Basal ganglia timing cues

Studies of monkeys have shown that neurons in different parts of the globus pallidus (GP) signal just before the end of a sub movement in a well-learned and predictable motor sequence. It has been proposed that this signal is an internal cue that is generated by the basal ganglia to mark the end of a component in a movement sequence. This signal would be appropriate to serve as a trigger for the SMA to switch to the next movement in the sequence (Brotchie, Iansek, & Horne, 1991; Mushiake & Strick, 1995). According to this model is the first segment of a movement sequence initiated by structures outside the basal ganglia (e.g. by the motor cortex). Then the basal ganglia provide cues for the initiation of the following segments in the sequence (Mink, 1996).

One can discuss whether this model can explain one of the main symptoms of stuttering-repetition of the first sound or syllable of the words. In this case, the first component of the phrase would be initiated outside of the basal ganglia structures, but then the basal ganglia fails, for some reason to produce a cues that mark the end of the first component. The result is that the sequence of the wastage and a first component repeat.

Neurogenic stuttering occurs after lesions in almost all parts of the brain except the occipital lobe lesions (Van Borsella, Van Der Made and Santers 2003). The largest number of reported cases had lesions within the basal ganglia circuits. It seems clear that the lesions at the level of BG-thalamocortical motor circuits are common cause of neurogenic stuttering.

Most cases of neurogenic stuttering occur after lesions of the left hemisphere and only a few reported cases of neurogenic stuttering occur following right hemisphere lesions (Lebrun, Leleux and Retief 1987). However, some of these cases may have some undetected lesions of the left hemisphere that cause stuttering.

3. CONCLUSIONS

As discussed above, the basal ganglia appear to have a role in a wide range of sensorimotor, cognitive, and behavioral processes that are closely associated with the executive and motor functions of the (pre)frontal cortex. The selection of motor or behavioral programs, or elements thereof, appropriate for a particular context, might be one of the primary functions of the basal ganglia (Mink, 1996; Redgrave et al., 1999). Plasticity in the basal ganglia circuitry and learning processes are important fundaments for these functions. In particular, the ventral striatum might be crucial for the learning and execution of reward-related behavior, whereas the dorsal striatum is important for stimulus-response behavior (habits).

There are clear indications that the thalamocortical motor circuit of the basal ganglia via the putamen to the SM plays an important role in the pathophysiology of stuttering. It is assumed that one of the major dysfunctions in stuttering is the impossibility of the basal ganglia to produce timing cues. Stuttering is reduced when introducing compensatory timing marks such as speech with a metronome, chorus speech and singing. The influence of emotions and stress intensity on stuttering may also be associated with the dysfunction of BG.

Stuttering is a complex speech and language disorder that can have major consequences on both the emotional and the social field of person functioning. No one has offered a model of treatment for stuttering that gives a permanent solution. Research should continue to better understand the causes of stuttering, the lesion location and thus offer better therapeutic models.

REFERENCES:

Bloodstein O., (1995). A handbook on stuttering (5th ed.). San Diego: Singular.

Brotchie P., Iansek R. & Horne M. K. (1991). Motor function of the monkey globus pallidus. 2. Cognitive aspects of movement and physic neuronal activity. Brain, 114, 1685–1702.

Georgiou N., Iansek R., Bradshaw J. L., Phillips J. G., Mattingley J. B., & Bradshaw J. A. (1993). An evaluation of the role of internal cues in the pathogenesis of parkinsonian hypokinesia. Brain, 116, 1575–1587.

Glickstein M. & Stein J. (1991), Paradoxical movement in Parkinson's disease. Trends in Neurosciences, 14, 480–482.

Jeffries K. J., Fritz J. B. & Braun A. R. (2003), Words in melody: An H-2 O-15 PET study of brain activation during singing and speaking. Neuroreport, 14, 749–754.

Kostić V., Šternić N. (1990) Terapija nevoljnih pokreta, Savremena administracija, Beograd 1990.

Lebrun Y., Leleux C. & Retif J. (1987). Neurogenic stuttering. Acta Neurochirurgica, 85, 103–109.

Ludlow C. L., Rosenberg, J., Salazar, A., Grafman, J., & Smutok, M. (1987). Site of penetrating brain lesions causing chronic acquired stuttering. Annals of Neurology, 22, 60–66.

Marsden, C. D., & Obeso, J. A. (1994). The functions of the basal ganglia and the paradox of stereotaxic surgery in Parkinson's disease. Brain, 117, 877–897.

Mink, J. W. (1996). The basal ganglia: Focused selection and inhibition of competing motor programs. Progress in Neurobiology, 50, 381–425.

Reynolds, J. N., Hyland, B. I., & Wickens, J. R. (2001). A cellular mechanism of reward-related learning. Nature, 413, 67–70.

Parent, A. (1996). Carpenter's human neuroanatomy (9th ed.). Baltimore: Williams & Wilkins.

Van Borsel, J., Van Der Made, S., & Santens, P. (2003). Thalamic stuttering: A distinct clinical entity? Brain and Language, 85, 185–189.

Van Riper, C. (1982). The nature of stuttering (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

ULOGA BAZALNIH GANGLIJA U MOTORNOJ KONTROLI GOVORA

Vujović M.[1], Dobrijević Lj.[2], Rakonjac M.[3], Bogavac I.[4]
Institut za eksperinetalnu fonetiku i patologiju govora[1,2,3,4], Beograd
Centar za unapređenje životnih aktivnosti[2,3,4], Beograd
marinazlatkovic@hotmail.com[1], lilijen@ymail.com[2], masadanicic@gmail.com[3], ivbogavac@gmail.com[4]

Abstrakt: Ovaj pregledni rad bavi se mogućom vezom krugova bazalnih ganglija (BG) i mucanja. BG su odgovorne za automatsko izvršavanje sekvence motornih programa koji su obuhvaćeni naučenim motornim planom. Važni zaključci o uticaju BG na mucanje se izvode na osnovu činjenica kada se mucanje intenzivira a kada i u kojim situacijama osobe koje mucaju imaju fluentan govor. Mucanje se smanjuje kada se uvedu kompenzatorni tajming znakovi kao što su govor uz metronom, horski govor i pevanje. Pretpostavlja se da talamokortikalni motorni krug bazalnih ganglija preko putamena ima ključnu ulogu u nastanku mucanja. U radu se razmatra pretpostavljena subkortikalna disfunkcija kod mucanja koja se ogleda kao nesposobnost bazalnih ganglija da obezbede tajming za inicijaciju sledećeg motornog segmenta u govoru kao i sinhronizaciju govora u celini.
Ključne reči: bazalne ganglije, mucanje, tajming znaci

EVALUATION OF PHONEMES QUALITY ARTICULATION USING NEURAL NETWORK ENSEMBLES

DRAŠKO FURUNDŽIC[1], SLOBODAN JOVIČIĆ[2], MIŠKO SUBOTIĆ[3], ĐORĐE GROZDIĆ[2]

[1]Mihajlo Pupin Institute, Belgrade, Serbia[1]
fudra07@gmail.com[1]
School of Electrical Engineering, University of Belgrade, Telecommunications Department, Belgrade, Serbia[2]
jovicic@etf.rs[2]
Life Activities Advancement Center, Laboratory for Psychoacoustics and Speech Perception, Belgrade, Serbia[1]
djordjegrozdic@gmail.com[3]

Abstract: Ensembles of neural networks show greater ability to generalize over all the individual members of the ensemble. The advantage of the ensemble are based on the uniformity of the distribution of knowledge representation which is a generator of training data and test data set. Generalization ability of individual members of the ensemble are based on the representation of knowledge stored in the form of weight matrix. The determination of the weights is an optimization process with multiple local minima, which depends on the initial values of weight and training data set. Aggregation of ensemble members is effective if all members are different and at the same time have the high level of accuracy. The problem is how to combine members in order to find compromise between two conflicting conditions. Here we present several different methods of aggregation ensemble of neural networks applied to assess the quality of articulation. Results obtained by the ensemble were compared with the results of the best ensemble members. On the basis of the comparison showed that the ensembles are more reliable and accurate tool for detection of articulation irregularities of phonemes, compared to the ensemble member with best performance.
Keywords: neural network ensembles, feature extraction, phoneme, articulation

1. INTRODUCTION

Speech, the most common type of communication, is a source of manny scientific problems. One of them, the perception of the speech signals, becomes more complicate when the speech pathology is included. Acoustic signal carries information's that are needed for speech recognition (Ohala, 2002). Based on our experience in the treatment of hearing impaired children as well as the children with verbal communication problems, we accept theoretical approach which assumes that perception is based on detection of the distinctive features from speech signal. Also we assume that acoustic features in speech signal are strongly correlated with corresponding features in perceptive domain. Speech therapists acquire the ability to evaluate and classify the quality of articulation through long-term experience. Articulation quality assessment procedures require lengthy and synchronized operation of larger groups of speech therapists and in that sense are time consuming and expensive. The above facts represent strong motivation for the automation of this procedure. The problem of automatic evaluation of the quality of articulation based on the acoustic characteristics of the speech signal, is reduced to the problem of determination of the relevant vectors of acoustic characteristics and the problem of classification of these vectors in dinstiktivne categories, defined on the experiences of a speech therapist. The first part of the problem (feature extraction) is relatively well resolved in practice because it uses a wealth of experience in the field of speech recognition (Haykin,1998). The main emphasis here present research is focused on methods of robust and accurate classification of the acoustic vectors, which is based on ensembles of neural networks. This method has considerable advantages in relation both to the single specific structure neural networks, and in comparison with other classification methods. These advantages are manifested in the field of reliability and accuracy of the classification.

2. NEURAL NETWORK ENSEMBLE

Neural network ensemble is a learning model composed of a collection of a reasonable large set of neural networks trained to perform the same task. This method, based on "divide and conquer" rule, is used for solving supervised learning tasks. According to this rule, a complex task is divided in into a certain number of partial tasks which are combined to give an overall solution (Haykin,1998). Computational simplification here is achieved by distribution of the learning task among a number of *experts*, dividing the learning space into a set of subspaces (Sollich,1996). The term *expert* here represents multi-layer perceptron (MLP) structure. The set of *experts* constitute a *committee machine* or *ensemble*. Main attributes of combined expert structures are: improved generalization ability, impruved robustnes and minimized structural complexity. Actual trained ensemble unifies the knowledge obtained by single experts to produce an overall decision which is superior to individual expert. Every MLP is independently trained on the same learning data. Ensembles are universal approximators that are usually classified into two main groups (Sollich,1996):

1. *Static ensembles*. This class represents ensembles where responses of many independently trained predictors (MLP) are combined by algorithm that does not include input signal. There are two main methods applied to this class of ensembles:
   - *Ensemble averaging*, where overall output is obtained as a linear combination of individual expert outputs. This can be performed as majority voting, decision performed by more than half of the experts in case of two classes, and plurality voting in case of more than two classes.
   - *Boosting*, where the weak learning algorithm is improved and accuracy is significantly increased.
2. *Dynamic ensembles*. In this class of ensembles, the input signal is incorporated in the algorithm that integrates the individual unified outputs into an overall output, so that is why they are called dynamic structures.

In our experiment we have chosen static ensembles with averaging method to obtain robust and reliable classifier. There are two reasons for this decision:

- If ensemble of experts were replaced with single structure, we would need a structure which is more complex in sense of larger number of parameters. This would increase the training time.
- The risk of overfitting data also increases when the number of parameters is much larger than the number of training input output pairs.

In any case, when ensemble of experts is used, reasonable expectation is that independently trained networks tend to different local minima, so the combined performance improves the individual results. The papers: (Sollich, 1990), (Hansen, 1996), show in detail how the generalization ability of neural networks can be significantly improved through ensembling a certain number of neural networks. The Figure1 represents the scheme of applied algorithm in exploitation phase. Ensemble modules are multilayer perceptrons. The MLP module has one input layer; one hidden and a one output layer. The Levenberg-Marquardt training algorithm has been used. These structures are adaptive data driven models of cognitive processes. Final output of ensemble is obtained in accordance with equation (2). Weight parameters a_i are defined with following constraints:

$$\sum_{i=1}^{N} a_i = 1, 0 \leq a_i \leq 1, \tag{1}$$

The ensemble output is defined as:

$$O = \sum_{i=1}^{N} a_i O_i . \tag{2}$$

In our model the a_i factor in equation (1) is defined as:

$$a_i = 1/N , \tag{3}$$

Where N represents number of MLP experts. Hence, the output value of ensemble is equal to mean value over all expert output values.

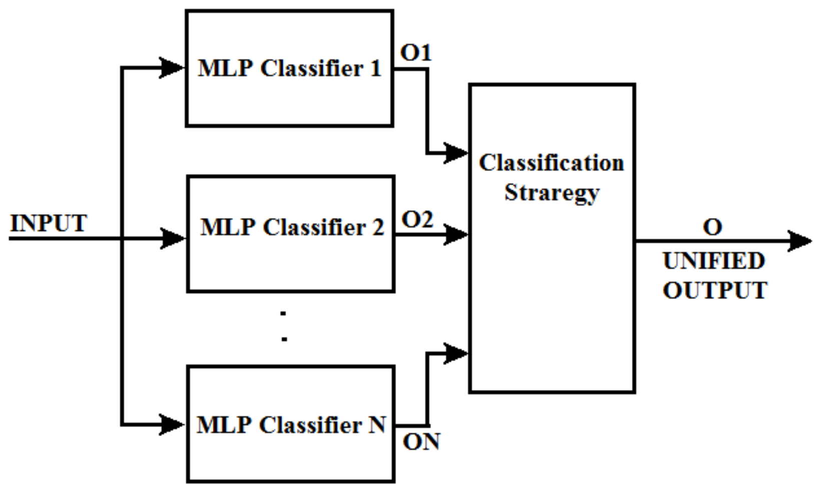


Figure1. Ensemble with unified output.

2.1 Majority Voting

An ensemble of networks ia usually more accurate than the individual classifiers only when individual classifiers disagree with one another (Hansen and Salamon 1990). To proove this statment, imagine the next: We analize an ensemble of three classifiers producing hypoteses: $\{h1, h2, \ldots hn\}$, and consider a new input vestor **x** of features to be classified. If all classifiers produce identical output in sence of agreement, then when *h1*(**x**) is wrong all classifiers are wrong. But, if the errors produced by the classifiers are uncorrelated, then when *h1*(**x**) is wrong, other classifiers might be correct, so that a majority of them correctly classifies unknown fwture vector **x**. Simply stated, if the error rate probabilities p of N expert hypotheses *hn* are $p < 1/2$ and the actual errors are independent, then the probability that the majority vote is wrong is
defined by binomial distribution:

$$P(k\,errors\,in\,N\,networks) = \binom{N}{k} p^k (1-p)^{N-k},$$

$$P(Ensemble\,make\,mistrake) = \sum_{k > N/2}^{N} \binom{N}{k} p^k (1-p)^{N-k}.$$

Figure 2 shows this probability for a simulated ensemble of 20 expert hypotheses, each having an error rate of 0.4. The area under the curve for 12 or more hypotheses being simultaneously wrong is 0.035, which is much less than the error rate of the individual hypotheses (0.4). When the individual hypotheses give uncorrelated errors at rates which are greather than 0.5, then the error rate of the actual ensemble increases. Therefore, the main problem in majoriti voting procedure is to construct individual classifiers with uncorrelated error rates below value of 0.5.

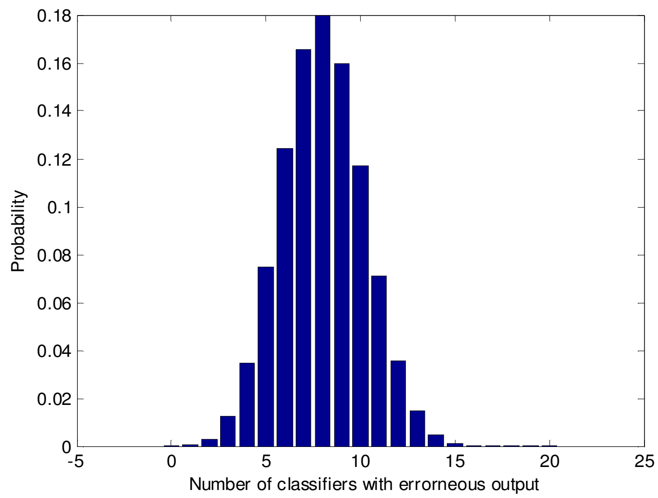


Figure2. The probability distribution of error rate for 20 classifiers.

2.2 Applied Algorithm

Simplified presentation of the ensemble algorithm is given in the following steps:

● Divide entire data set into two subsets, (learning and test set), of equal size taking a care of equal representation of both classes.
● Balance the potential class representation in available data set.
● Use 80% of learning set for training and the rest of 20% for validation set. The validation and training date are randomly chosen.
● Determine the MLP structure by gradual increase in structure complexity.
● Repeat the training procedure several times and keep acquired knowledge in the form of vectors referring to weights and biases.
● Use the test set input data to obtain predicted MLP output values for all experts.
● Define the performance of experts in accordance with equation (4).

$$e_j = mse(t - o_j), \qquad (4)$$

where $j = 1,2,3,...J$, t represents the target vector and o_j is output vector predicted by the *j*-th expert. The term *mse* stands for mean squared error. In our research: $J = 100$;
● Sort performance vector in an increasing order,
● Take first M experts as the individually best trained. $M \geq 10$, $M < J$ which depends on the computing
time available and model reliability required. In this work: $M = 20$. Take care of Error Rate for every expert *Xi* of being correct: $p\ (Error\ i) < 0.5$.

● Take N experts from the set M, such $M > N$, and find all C combinations of N elements from a given set of M elements in accordance with next equation:

$$C_N^M = \binom{M}{N} = \frac{M!}{N!(M-N)!} \quad , \tag{5}$$

We compared results for ensembles composed of $N = 4, N = 5, N = 6,$ and $N = 10$ experts.

● For all C combinations of N experts find the unified output defined by (2) and (3) to obtain vector of O_c values, $c = 1,2,3,...C$.

● Calculate unified performance values for all ensembles in the fallowing way:

$$E_c = mse(t - O_c) , \tag{6}$$

● Finally, find the best ensemble by means of next equation:

$$\arg\min_c(E_c) . \tag{7}$$

3. ARTICULATION QUALITY EVALUATION

Articulation of individual voices and voice groups reaches level of maturity at different ages and the pronunciation of voice is correct only when the child properly pronounces it in all positions in the word regardless of the surrounding voices. Distinctive features of individual phonemes, vowels and consonants, have a development order in children. Diversity in the development of voices pronunciation, which is manifested in children, should fit into standard norms. One group of authors represents the opinion that the stabilization of articulation in all positions occurs at age between 5 and 6 years of the child, the other extends that period to 8 year. Our research is in accordance with the first group of authors and shows that the system of automatized articulation habits in their native language establishes up to six years. This means that 6 years old child should have correct pronunciation of all voices in the system, in all types of phonetic positions (initial, medial, final, in co articulation and consonant sets), in one and many words, and should also use automated intonation forms and other elements of suprasegmental structures. This is the basis for children articulation evaluation. To assess the quality of pronunciation in the Serbian language, the global articulation test (GAT) and the test of analytical evaluation of articulation of the Serbian language (AT) (Kostić, et al., 1983) are used.

3.1 Data and Acoustic Features

Training data for multilayer perceptron (MLP) classifier contains the set of 200 input vectors each representing the features of the speech segment, and the set of 200 output binary values {1, 0}, representing two categories: correct "1" and incorrect "0" pronunciation. In the GAT test, the grades 3 and 4 represent the correct pronunciation, while 5 and 6 incorrect. Distribution of respondents for quality articulation of phonemes /ʃ/ and /ʒ/, is such that about 88% and 77% respondents respectively, had acceptable speech quality (3, 4). Evaluation was performed using GAT test for actual fricatives (Kostić, et al., 1983). Errors in the articulation of the fricatives /ʃ/ and /ʒ/ in Serbian language are much more likely than other fricatives, so these phonemes are the main problem to be solved. Evaluation of articulation performed group of eight speech therapist and final scores are formed by averaging all the individual results. All speech signals were recorded in the software package PRAT. The acoustic features for training are prepared by feature extraction procedure. Relevant features selected for this purpose are:

1. *Mel Frequency Cepstral Coefficietns (MFCC),*
2. *Real values for the signal length,*
3. *Standard deviation and the mean values of sound energy.*
4. *Sound energies contained in initial consonant /ʃ/ and following vocal u, extracted from actual Serbian word (Shuma).*

4. SIMULATION RESULTS

The results of this research are presented in Table I. There are four ensembles presented. Ensemble 4 represents mixture of four the best ranked experts, while Ensemble 5 stands for the best five experts and so on. In the same table we use abbreviations MLP1,…, MLP3 for the first best ranked individual experts.

Table 1. Binary classification accuracy of the neural networks

MODEL	**Classification Accuracy %**	
	LEARNING	TEST
ENSEMBLE 5	100.00	85.00
ENSEMBLE 6	100.00	88.00
ENSEMBLE 7	100.00	91.00
ENSEMBLE 10	100.00	98.00
ENSEMBLE 100	77.00	66.00
MLP1	95.00	75.00
MLP2	97.00	77.00
MLP3	99.00	81.00

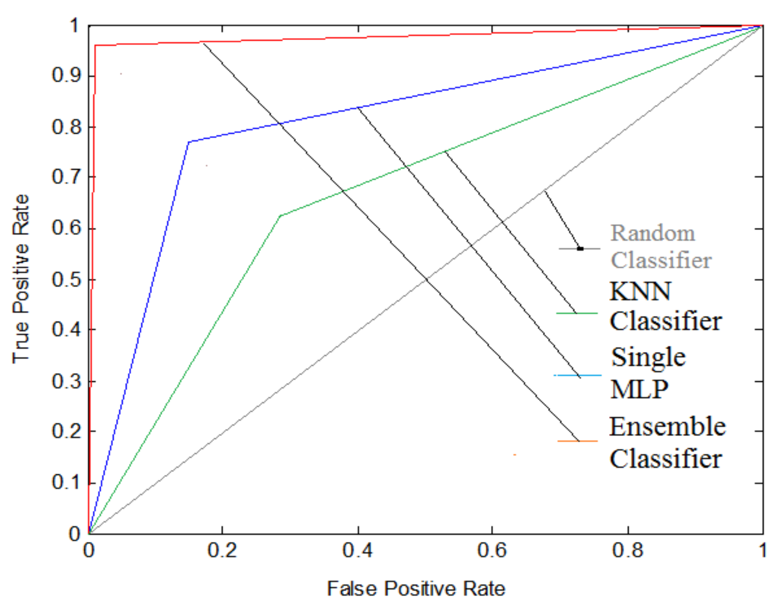


Figure3. ROC curve for different classification approaches.

Ensemble models showed the best results, as we expected. The best of individual experts, the MLP1 model, gave slightly worse result. Inclusion of small number of experts in the ensemble decreases generalization ability. The same think happens when the number of experts is too large, since we include in process with low classification accuracy. The similar behavior referring to generalization ability, show the KNN (K Nearest Neighbors) models. The numbers of the examined combinations for the ensembles found were: 4845, 15504, 38760, and 184756 respectively. Comparative results of different classification approaches are presented by the Figure3. The Receiver Operating Characteristics (ROC) curve is the tool for the best interpretation results for the classification procedure, (Fawcett, 2006). The area under the curve is the indicator of the classification performance for actual classifiesr. As we can see the best performace showed the ensemble of 10 MLP experts with majority voting procedure.

5. CONCLUSION

Obtained results indicate that multilayer neural network ensembles can adequately model speech perception process and help in investigating perceptual phenomena. In these models, the most important phenomenon is the influence of input parameters that describe the speech signal on classification performance. The complex relation of relevant parameters with actual evaluation obtained by network ensemble has been presented. The chosen parameters appeared to be good predictors for observed output values. It is well known that the trained ear of the speech therapist may perceive differences in pronunciation of voices that would make a clear distinction between typical and atypical pronunciation. This assessment is can be modeled by an ensembles of multi-layer neural networks, while achieving high accuracy. The results indicate that the speech signal contains the acoustic correlates that allow distinction between correct and incorrect pronunciation. The results also showed superiority of the ANN ensembles in classification performance comparing to standard classification methods, as it was expected.

ACKNOWLEDGMENTS

This research was supported by TR32032 from the Ministry of Science and Technological Development of the Republic of Serbia.

REFERENCES

Fawcett, T., “An Introduction to ROC Analysis,” Pattern Recognition Letters, vol. 27, no. 8, pp. 861-874, 2006.

Haykin, S., Neural Networks: A Comprehensive Foundation (2nd Edition). Prentice Hall, 1998.

Hansen, L. K., Salamon, P., Neural network ensembles, IEEE Trans. Pattern Analysis and Machine Intelligence 12 (10), 1990, pp. 993-1001.

Kostić, Đ., Vladisavljević, S., Popović, M., (1983). *Tests for assessment of speech and language.* Zavod za udžbenike i nastavna sredstva, Beograd (in Serbian).

Ohala, J. J., (1986). Against the direct realist view of speech perception. *Journal of Phonetics*, 14: 75-82.

Sollich, P., Krogh, A., Learning with ensembles: how over-fitting can be useful, in: Touretzky, D.S., Mozer, M.C., Hasselmo M.E., (Eds.), *Advances in Neural Information Processing Systems 8*, Denver, CO, MIT Press, Cambridge, MA, 1996, pp. 190-196.

SEMIOTIC ANALYSIS OF SPANISH ADVERTISMENT ENTITLED "AUTISMO HABLA" – "AUTISM SPEAKS"

IVANA MITROVIĆ DJORDJEVIC[1], VOJISLAV TODOROVIĆ[2]
OS"Dusan Dugalić", Beograd
Faculty of Culture and Media
mitrovicdjordjevic@gmail.com
vojatodorovic@gmail.com

Abstract: This work was performed semiotic analysis of Spanish commercial " Autism Habla " meaning " Autism Speaks ", produced by the Madrid Federation of autism. Sometimes the child does not communicate with others as expected. Instead, it appears to have been in "his world" and the world that has a repetitive routines, odd and specific behaviors, communication problems and a complete lack of social awareness or interest in another. These are characteristics of developmental disorder called autism. A child with autism is usually difficult to cope with anything that has to do with social communication. Social practice shows that it is necessary to implement various activities for the children to gain the opportunity to develop their skills, expand their interests and knowledge, and as much as possible participate in social life (different types of workshops, sports, concerts, theater...). Advertising of such themes, different types of social groups, approaching the problems of children with mental disabilities in a certain way, enforce signal for increased occurrence of autism as well as the willingness of families to recognize the symptoms of autism spectrum.
Keywords: Semiotics, autism, children with developmental problems

1. AUTISM AND COMMUNICATION DISORDERS

1.1 Language and Speech

Language and Speech: each of these two categories apparently gets its designation only in the dialectical process that links them : there is no language without speaking and there is no speaking outside language. In this exchange linguistic praxis is made , what is said by Maurice Merleau-Ponty. [1]

Autism is a developmental biological disorder of brain.[2] Autism belongs to the PDD . One of the main characteristics of autism is the lack of social interaction and communication. The difficulties that children with autism have are classified into three main areas as the triad of difficulties :

1 communication
2 social interaction
3 imagination

In the field of communication difficulties lack of desire for any mode of communication is emphasized . Children with autism have difficulty with the very important areas of non-verbal communication. There is a misunderstanding of the words but not to the complex meanings of these words.

Children with autism can not speak or have very poorly developed speech , mainly those related to the satisfaction of their own needs . They will usually understand what other people say to them , but they themselves will be more to introduce alternative forms of communication , such as sign language or as visual symbols .

Others will have a relatively good language skills, but still find it difficult to understand the nature of the call and will speak extensively only about their interests and needs.

1. Rolan Bart Literature, Mythology, Semilogija. O speech and language in linguistics, Nolit, Belgrade, 1979
2. Svetomir Bojanin, general functional diagnosis, the Institute for textbooks and teaching resources, Belgrade, 1997

The attention and understanding of what is being said is very weak. Usually they may avoid eye contact and be very active or calm and self-centered . They are not aimed at drawing attention to certain things and interest to others . They have difficulty in imitating voices and gestures , as well as determining the meaning of the gestures and voices .

Early communication skills overlap with social interaction and play. Children with autism may develop hypersensitivity to sounds , touch, tastes, smells, light and colors. *As person with autism , I have always experienced the world differently. When I was in elementary school , school bell offended my ears like a dentist's drill which irritates the nerve. I was terrified of loud noises such as the one when the balloon burst . Stiff petticoats and woolen clothes I felt as if I had sandpaper on the skin "*

- Temple Grandin , a person with autism , animalistic associate professor at the State University of Colorado [3].

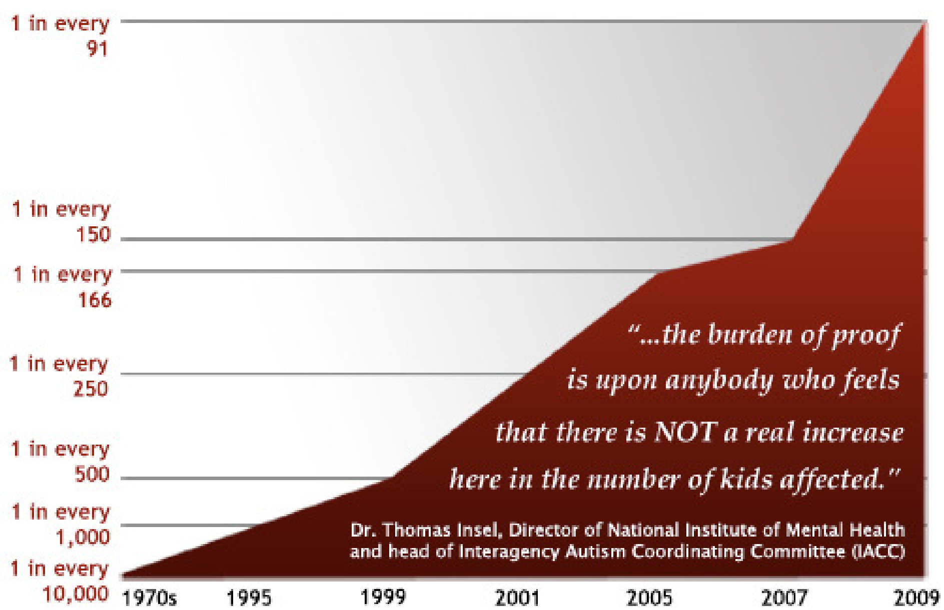


Chart 1: Frequency of autism

The possibility of better communication and socialization of children with autism need to refer to learning symbol systems .

Exercise semantic and syntactic level of language and the use of multimedia programs in order to encourage the development of non - verbal communication.

Exercise of non-verbal aspects of communication – video games with the theme – the body language and facial expression as well as enriching the vocabulary development of speech and listening skills, so that the text fits into the picture and verbal labeling symbols in one place.

---

3. http://www.templegrandin.com/

List of famous historical figures with highly functional autism [4] :
1 Hans Christian Andersen writer
2 Emily Elizabeth Dickinson, American poet -
3 Charles Robert Darwin - British scientist
4 Stanley Kubrick - American film director
5 Thomas Jefferson, third president of the United States
6 Wolfgang Amadeus Mocart -songwriter
7 Michelangelo Buonarroti - painter , sculptor , poet

2. SEMIOTIC ANALYSIS OF SPANISH ADVERTISMENT "AUTISMO HABLA"

2.1. Advertisement

Advertisement is a type of communication with which director tries to convince the public in usefulness of certain act. In order to succeed in this goal director is using consciously and unconsciously messages, respectively combination of information and emotion in advertisement message. In the era of saturation of mass media it is needed to present needs of certain social group to integrate in society in specific, fast, human, clear way.

2.2.The motivation

The motivation for choosing this commercial for a semiotic analysis is the growing phenomenon of newborn children with autistic spectrum. Data suggest that the prevalence of autistic disorder in the past 50 years increased for 15 times; recent studies estimate the prevalence of autism spectrum disorders in approximately 20 per 10 000 newborns.

Picture 1: Logo of Spanish association of autism

4 . High-functioning autism (HFA engl.) is an informal term used for people with autism, IQ of 80 or above, which have slightly more or less the ability to speak, read and write. Due to higher speech skill is often replaced with Asperger's syndrome. During interacting and socializing classical restraint is present and it is one of the main features of autism. The source: www.britannica.com

The apparent increase in the prevalence of autism is the result of more accurate diagnosis, changes in diagnostic criteria and more sensitizing the public then before to the problems of people with autism. For individuals with autism to be productive and responsive to the educational process, it is essential that the environment in which the acquired knowledge is structured be clearly and specifically defined. Analysis of these advertisement rests on the basis of theoretical settings semiotic, Frederic de Saussure. Advertising on autism is a complex sign by itself which contained other characters. Access to the syntagmatic interpretations required because its structure carries interdisciplinary guideline.

Pedagogy, which forms part of the interdisciplinary nature of Communication Sciences, is primarily concern for children with autistic spectrum.

This constitutes a new paradigm where the upgrade through structural analysis reveals a new phrase . Here we can see the social role of a advertisement that stands out. De Saussure emphasized the role of advertisements. Also, we can see here that we can speak of visual substances (advertisement), confirming its importance ingeminate with the linguistic message.

Advertising deals with the increasing emergence of autistic spectrum disorders in children after the age of three, which is the nominal time of the diagnostic elements of autism as a form of support to families in Spain. Through the media , in this case is about television, it is given a specific statistical indicator up autism in the population of children in the same statistical overview of lightning - probability that a child struck by lightning is 1 in 600,000.

The main characters in the commercial are human subjects . One of the parents, in this case the father, carefully watches over his son, providing a sense of security for his child and emphasize importance of the family as the nucleus of society. Presenting a carefree child, as well as iconic figure, that symbolizes autism in full frame, when the father takes him out of a small swimming pool in his arms . The space in which the action takes place represent sintagma , a paradigm of a purged world. In one of the video frames movements are coded and tone of voice when the father takes the child in his arms. At the denotative level, we picture of a man - in this case his father , a strong personality, who with his parental care provides safety for child, which can determine the positive connotations of this figure .

The story follows the sound of thunder, which has a symbolic designation and text incorporated into the verbal message, which makes it one acoustic image, and at the same time calls into question the willingness of the population of the modern era to seriously deal with children with special needs in the case of autism.

The advertisement underlines the willingness of families to accept children with autistic spectrum, and points out that they are also part of the family.

This text below is a sign by itself that contains more than one character , a double structure.

The probability of being struck by lightning is 1 in 600,000

" Come on buddy. " – father in tender voice.

And the probability to be given a diagnose of autism is 1 to 150

Advertisement ends with info :Get to know signs of autism, call ...000333…….

Blue puzzle, at the end of the advertisement and info of the support center for children with autism represents in this case part of society to fit into a whole, which is followed by voice as , another linguistically determinant.

2.3 Interpersonal communication with autism spectrum

In the normal development of the child , there are three phases of communication:

1. DEVELOPMENT OF COMMUNICATIONS FUNCTIONS and the way in which children express communicative intentions - it may be searching for something or giving inform the child about their condition or their environment, through diverse communication behaviors, such as gestures , vocalization or the use of language.

2. RESPONSE TO COMMUNICATION - the way that child understand and respond to communication between people.

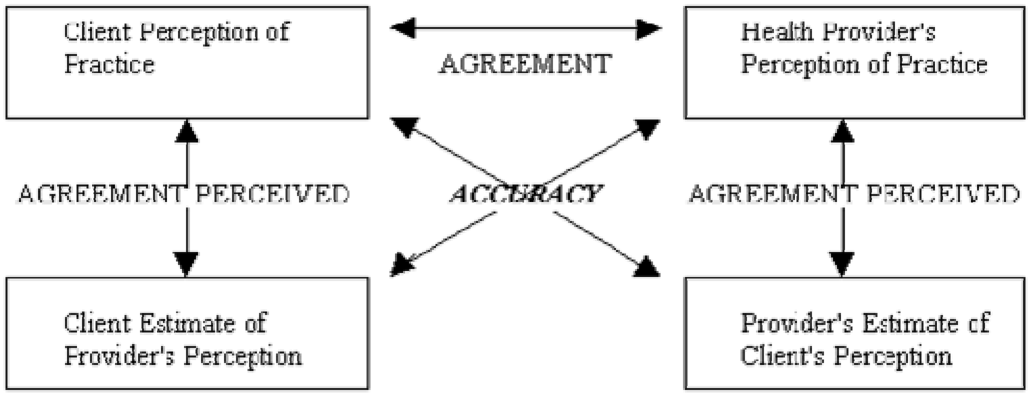
3. The third part deals with the way in which the child participates in the INTERACTION AND COVERSATION. Seen as a participant in social interaction and it is included , the interaction begins , following the rule of speakers and discussion.

In practical terms it is of importance of how these three aspects of pragmatics subject to changes related to the context, such as time and the place, and people involved in the communication. Communicating with child with disabilities in nowadays is social interaction with two - person, teachers and students or more, depending on the methodological part of the paper, games, and structure of the lesson. Act of communication in interpersonal communication is determined by a series of situational factors that make a particular communication situation . (Miletic Radojković , 2008 , 58)

Model of correlation orientation of relationship helps us in understanding the communication between children with autism and other people, as communication as exchanging the opinions between two people rely on cognitive processes of the individuals. This is the basic point in the understanding of the concepts and relationships. In this case children with autism and their parents , teachers and peers , take into account the two structures: a cognitive orientation, what single person thinks and the possibility of understanding what the other person thinks.

Dysfunctional forms of autistic spectrum disorders in children that use non-verbal mode of communication and gestures and the facial – expression , also correlate to situation where have overlapping cognitive - overlap with another person, in the sphere of social simpler elements of functioning (the need to respect school rules, preservation of hygiene, various forms of methodological skills ...). At the stage of compliance - accuracy there is a complete imbalance with the person in the case of children with autism compared to other respondents .

They are completely different possibilities in the fields of perception, experience a range of subjects in the communication of children with autism and their teachers and parents, which occurs fairly non-coverage, objective and unbiased discrepancy inaccuracy. Lower and higher cognitive function are directed by the caller to another in the form of thoughts, which are transformed into words, but in children with autistic spectrum with non-verbal, gesture and emotional functioning, they manifest with the symbols, which are transformed by manipulating arms, movements, the head, of the whole body, hopping ... the same way and with their mutual communication.



Communication - Charrter

There are three relevant factors that are important in communication:
- situational relevance
- intimacy
- convenience

In these three factors, we can recognize the importance of communication of autistic child who has verbal skills and his conversational partner. Here we have a situation of open communication. In verbalization process both participants are focused on the use of language. In the field of higher cognitive function, cognitive orientation towards the environment, and the perception of another person's knowledge (in this case the communication partner of the child), there is a move away from the act of correlation of the area of intimacy and convenience. Autistic child with language skills only in certain situations in the communication accepts. Childs acceptation of the communication is based on selectivity, imposed by the shape of attention and memory and thinking. The same principle is shown by children that express themselves in writing, that makes the correlation with respect to spoken language and written language and vice versa. Only the message formatting is not possible without adequate knowledge, assessment of participants, using proper grammatical sentences spoken as well as knowledge of the situation in which communication occurs.

Feedback or personal feedback includes both, verbal and non-verbal reactions to interpersonal communication between autistic children and other participants in conversation.

In shown advertisement, logical connection is incomplete since there is no

(A) - a logical connection with the previous situation, which is why we the need to constantly repeat phrase by the participant (father), and

(B) - the very purpose of the interaction - feedback is lacking since there is no minimum feedback from autistic child, there is not interaction and coherence, only father translation of childs needs.

It should also be noted that autism is one of the most common disorders that occurs in child development. It occurs in people of all races, ethnicities and socio-economic groups. Boys are four times more likely to have elements of the autistic spectrum than girls. According to a study by the Centers for Disease Control and Prevention, autism spectrum disorder, occurs in 1:150 live newborns and no later up to 8 years of age when their clinical symptoms are showed.

The word "autism" has its origin in the Greek word "autos" meaning "self." Children with autism are often closed in themself and it seems that they are in the private world where they are unable to communicate effectively interact with others. They can have difficulty developing language skills and to understand what others are saying about them. They may also have difficulty in communicating non-verbal, such as the use of hands, eye contact, gestures and facial expressions. Not everyone child with autism has spectrum of disorders that includes problem of linguistic forms. A child's ability to communicate will vary depending on his or her intellectual and social development. Some children with autism may be able to speak.

Others may have a rich vocabulary and be able to talk about specific topics and details. Most children with autism have little or no problems pronouncing words. Most, however, have difficulty using language effectively, especially when talking to other people. A number of children use only a voice in communication. Many have problems with the meaning and rhythm of words and sentences. They may also be able to understand the body language and vocal tones. Children with autism that are associated with narrow interests and abilities are exceptional. Some children may be able to enter into a deep monologue about a topic that concerns their interests, even though they may not be able to handle two-way conversation on the same topic.

Others have musical talents or advanced ability to count and do math calculations.

About 10% of children with autism show "savant" skills or extremely high abilities in specific areas, such as knowledge of calendars, music or mathematics....

3.CONCLUSION:

The incidence of autism is the same in all communities regardless of race, national or ethnic affiliation, social and economic status. People with autism are part of the family, which means that autism is deeply concerned over 1% of the world population. The development of mass communication makes a number of meanings are addressed different populations. The science enriches this interdisciplinary linking and the communicational and pedagogy science, making a strong and unbreakable structure, which has its own guidelines in the human sciences.

REFERENCES

1. Roland Barthes, Literature, Mythology, Semiotics Nolit, Belgrade, 1979
2. Svetomir Bojanin, general functional diagnosis, the Institute for textbooks and teaching aids, Belgrade, 1997
3. Support for children with learning difficulties from autism spectrum, Liz Hannan, The National Autistic Society, 2007
4. source of advertising: http://www.youtube.com/watch?v=AVzBmIIM0zw&feature=player_embedded
5. http://www.templegrandin.com/
6. Literary theory in the twentieth century, Anna Burzyńska Michał Paweł Markowski, theories LITERATURY Wiek XX, Copyright © JP Official Gazette, 2009
7. Readron, K, (1998), Interpersonal communication - Where minds meet, "Alinea", Zagreb
8. Miletic, M., (2008), Communication, Media and Society, Faculty of Education, University of Belgrade
9. Nedović G. (2000) The structure of motor programs in patients with closed brain injury, Ph.D., Special Education, University of Belgrade
10. Bojanin, SS (1985), developmental neuropsychology and general reedukativni method, Belgrade: Institute for Textbooks
11. H Dewart and Summers, S. 1995 - The Pragmatics Profile of Everyday Communication Skills in Children. NFER-NELSON

ASPECTS OF RELATIONSHIP BETWEEN SPECIFIC LANGUAGE IMPAIRMENT AND SPECIFIC DYSLEXIA

TSVETANKA TSENOVA
Sofia University „St. Kliment Ohridski"
cenova_cc@abv.bg

Abstract: The early deficit in oral language is a factor for occurrence of dyslexia but it is not known whether this deficit relates to all children with dyslexia. This issue is a subject of experimental study. The purposes of this study were: (1) to explore the status of oral language in children with specific dyslexia in comparison with their peers without disorders, (2) to find out the differences between both populations (overall and by gender), and (3) to determine what part of the children with dyslexia have oral language disorders. The oral language of 60 4-grade children was examined: 30 with dyslexia and 30 without disorders. They were tested by 4 samples, revealing the status of vocabulary and semantics. Results showed lower level of oral language for the children from the experimental group. Gender differences were not found in both groups. The comparison of individual scores showed the same level of language development in some students from both groups, despite the general differences between the groups. This led to conclusion although the oral language disorders are in general typical for children with dyslexia such disorders are not present in all of them. The study contributes to the knowledge about causes of written language disorders and emphasizes the necessity of early treatment of oral language disorders as prevention of developmental dyslexia.
Keywords: Dyslexia, Early Language Impairment, Specific Language Disorders

INTRODUCTION

The question of relationship between the disorders of oral and written language is often discussed in the speech therapy. It is associated with the concept explaining the reading and writing disorders as a continuation of early language impairment (Matanova, 2001). This is one of the most indisputable and unanimous adopted thesis in the speech therapy, but this area contains discussions and questions which have not found yet a conclusive answer.

Until 70s of twentieth century the developmental dyslexia was determined mainly as visual-perceptual and / or auditory-perceptual disorder. It was defined as a language disorder after the entering of behavioral approach to communication disorders in the speech therapy (Wilsenach, 2006) and since then, a searching of link between specific language impairment (SLI) and specific dyslexia started.

Both are conceptually similar – they are primary language disorders (in oral and in written language), which are not due to intellectual, sensory, motor, social factors and psychiatric disorders. Both have an expressed hereditary nature: Estienne (1985) reported studies of Debray, showing 50-60% heredity in all studied cases; Tomblin & Buckwalter (1998) found specific language impairments in both groups – fraternal and identical twins, and found that fraternal twins are more affected than identical.

In recent years the specific language disorders and the specific dyslexia are intensively studied, separately and in correlation. The early language impairments are often examined in relation to clarifying the predictors for occurrence of dyslexia and this has been proven in retrospective studies of children at risk for dyslexia (the risk is marked by the presence of dyslexia in parents and siblings). Scarborough (1990) found 65% of these children are diagnosed as dyslexic later, when they are 8 years old. They had many grammatical difficulties at an early age that have changed throughout their growth. At 30 months the children had levels of vocabulary like children without disorders, but they showed a limited knowledge of syntax and more articulation errors. Between 36 and 42 months their vocabulary skills were better developed, but their syntactic difficulties have not been overcome. At 60 months these children had deficiencies in phonological awareness and understanding of letters, but their syntactic difficulties were not already visible. Exploring 63 children at risk for dyslexia aged 45-68 months, Galagher et al. (2000) found nearly half of them have school difficulties later. Slight delay in all aspects of oral language was revealed. The study of the knowledge of letters and the length of sentences as a measure of mastering of syntax indicated these children knew fewer letters and had shorter sentences at 45 months. Lyytinen et al. (2001) found the children at risk for dyslexia generated significantly shorter sentences at two years and showed grammatical difficulties in preschool age - less sensitivity to the coordination between nouns and verbs.

On this basis, nowadays the specific language disorders and the specific dyslexia are sometimes interpreted as one category with different manifestations in different stages of child's development. The proof is essentially that the phonological deficit is the same and has a paramount importance in both syndromes. According to Wilsenach (2006), some researchers advocate even both to be labeled with a common name - language learning impairment. However, some authors do not agree. Bishop & Snowling (2004) offer arguments for maintaining the distance between them: disorders which look identical or similar in behavioral level, may appear by different causes; research of neurobiological and etiological basis of these two disorders leads to inconsistent results that can not encourage their integration - some studies show changes in planum temporale in both disorders, other studies do not prove it. Bishop & Snowling concluded although the specific language disorders and the specific dyslexia look directly connected, their relationship has not been established. Wilsenach also accepts this connection insufficiently clarified, because neither the origin nor the clinical parameters of both disorders have not fully clarified, although their similar profile: poor phonological processing, poor short-term memory, deficits in speech perception, heterogeneity of both populations.

Many anamnestic data were found not only for delayed language development in children with dyslexia, but also for deficits in their oral language in primary school age (Volkova & Shahovskaya, 2000; Matanova, 2001, 2003, Todorova, 2005, 2008, etc.). The early language impairments may not be noticed at first glance, but they are not fully overcomed. There is a deficit, mainly expressive, combined with minor disorders in understanding. The phonological component remains imperfect, the syntax is primitive, the mastering of complex morphological patterns is slower, the vocabulary is poor, comparable to the vocabulary of younger children. The dyslexic children can not name quickly objects and actions, painted in pictures, colors and letters. They show problems in understanding of abstract concepts and complex grammatical structures, in use of more than one meaning of the word. The use of pronouns, prepositions, particles, conjunctions is often impaired. The composition of sentences and stories is difficult both in oral and in written communication. Difficulties in separation of the parts of a sentence and in their composing into an entirety are observed. The sentences are vague, semantically confused, and usually very too long or too short and incomplete. There are an inconsistence, redundancies and lacks of essential details in the stories and paraphrases of these children.

A survey of Loginova and Eletskaya (2006) confirms these facts. It shows deficits in oral language in the children with difficulties in mastering of written language. The children have difficulties in the selection of adjectives, they use neologisms instead of adjectives, synonyms instead of antonyms (sorrow - grief) or inadequate antonyms (fall - no fall). They explain the words primitively, just from their personal experience, they mix adjectives with nouns and verbs, nouns with verbs, they create atypical grammatical structures and have difficulties to use prepositions and maturities, to coordinate nouns and numerals.

Whether the disorders of oral and written language represent a pathology with two-age manifestations, the relationship between them is undeniable. But the question about the extent to which the deficits in oral language concerns the population of dyslexia and plays a predetermining role for its appearance, remains in the speech therapy. Observations and studies lead to the conclusion of partial presence of such deficits in children with dyslexia. This is confirmed by the study of McArthur et al. (2000) that reveals oral language disorders only in 50% of dyslexics. Therefore, although the children with dyslexia are often described as carriers of oral language disorders, this does not apply to all children, this applies to a part of them. Hence, such disorders are not the only factor for occurrence of dyslexia.

The clarifying of this problem correlates directly with the option to clarify the clinical features of dyslexia and to refine the correctional-therapeutic interventions in dyslexia. The next experimental research is organized and conducted by the idea that an exact answer to the problem would be only its empirical verification.

METHOD OF THE STUDY

The aim of this study was to check the status of oral language in children with specific dyslexia (experimental group - EG) in comparison with their peers in norm (control group - CG). The aim required: 1. to specify the differences in the status of oral language between the groups; 2. to examine gender differences with relation to oral language in each group; 3. to find out individual differences of oral language between the children of both groups. The hypothesis of the study was: the language disorders are inherent in most of children with dyslexia from both gender, but there are dyslexic children without language disorders.

Sampling

A total of sixty fourth-grade children (from 4 primary schools) with dyslexia (n = 30) and without dyslexia (n = 30) were included in the study. Sex ratio (boys to girls) for each group was 3:2. Mean age was: 10;7 years for experimental group (EG) and 10;4 years for control group (CG).

Data Collection

The following samples for assessment of vocabulary and semantics were implemented:

1. Enumeration of objects in a semantic range for 1 minute

Instruction: "List all animals, birds, fish and insects you know." *Pre-training phase*: The investigator demonstrates an enumeration of several objects in other semantic range (e.g. fruits and vegetables). The investigator records the time and the number of objects listed by child. To evaluate child's performance was used five-point scale. The scale was developed depending on the diapason, emerging between minimum and maximum number of the listed items.

Here the results were evaluated after the data collection. It was found the number of responses varies from 8 to 26 and it outlines a range of individual scores which can be represented as an evaluation scale as follows:

score 0-5	evaluation 0
score 6-9	evaluation 1
score 10-14	evaluation 2

score 15-19 evaluation 3
score over 20 evaluation 4

The estimates vary evenly at intervals of 5 units, and they are identical to the estimates which the studied subjects received by the other procedures.

2. Filling of missing first word in 4 written sentence

Instructions: "I am giving you this list, where a few sentences are written. The first word miss in each sentence. There are a few words below each sentence - choose one word and write it at the beginning." A set of four words, prepositions and conjunctions was written below each sentence. *Pre-training phase*: it is performed with other sentence outside the four, which are given to the child later. The investigator notes how they are filled. One point is awarded to a correct answer - 4 points in general.

3. Addition of missing last word in 4 auditory perceived sentences

Instruction: "I'll say sentences in which there is no**t a** final word. You have to say it and to complete the sentence." *Pre-training phase*: it is performed with other sentence outside the four, which are given to the child later. The investigator notes how the child performs the task. One point is awarded to a correct answer - 4 points in general.

4. Selection of 4 antonyms and 4 synonyms to words spoken by investigator

Instruction: "I'll say a word and you have to say an other that means the same / an other that is opposite on the matter." *Pre-training phase*: it is performed with others words outside the words, which are given to the child later. The investigator notes how the child performs the task. One point is awarded to a correct answer - 8 points in general.

The maximum score is 20.

The survey data were interpreted on the basis of values of average - $\overline{X}$ and of t-criterion of Student - P (t).

RESULTS

Correct answers, obtained in EG, are equal to 69.2%. This is about two-thirds of the maximum and far from the good performance. The studied persons in EG coped better with certain tasks than with others tasks. The result of the first sample was quite low: the children achieved a score little more than half of the maximum. The results of all samples in this group are ranked in descending order in the following sequence:

I. Addition of missing last word in 4 auditory perceived sentence - 84,2%

II. Filling of missing first word in 4 written sentence – 72,5%

III. Selection of 4 antonyms and 4 synonyms to spoken words - 67,5%

IV. Enumeration of objects in a semantic range for 1 minute - 54,2%.

The children in EG listed between 8 (minimum) to 17 (maximum) animals, fish, birds, insects, and no one received the highest rating – 4. They have listed in total 394 words in this semantic range. The result of selection of synonyms and antonyms is also low. These two samples are obviously the most difficult, but they reveal most directly the level of language development and to a great extent prove the presence of language disorders in EG. The total score of this group is 415.

The correct answers, obtained from the CG, are equal to 91,3%, which is nearly to the maximum level of performance. The children from this group also coped with some tasks better than with others, and their result from the first sample was also the lowest. The results of all samples in this group are ranked in descending order in the following sequence:

I. Addition of missing last word in 4 auditory perceived sentence - 95,8% and filling of missing first word in 4 written sentence - 95,3%

II. Selection of 4 antonyms and 4 synonyms to spoken words – 92,5%

III. Enumeration of objects in a semantic range for 1 minute – 80,1%

The children from CG achieved equal success regarding samples 2 and 3, unlike those from EG. Their difficulties in selection of prepositions and conjunctions were equal to the difficulties in addition of last word and smaller than the children from EG. The number of listed animals, fish, birds, insects for CG was between 12 (minimum) and 26 (maximum), a total 542 words are listed in this circle. The enumeration of animals and the generating of synonyms and antonyms was also more difficult for children from this group, but they achieved significantly higher scores than their peers with dyslexia. The total score for CG is 548 - much higher than for EG.

The statistics of the comparison between experimental and control group are summarized in Table 1 and shown in the diagram.

Table 1. Status of oral language

Group	Sample 1	Sample 2	Sample 3	Sample 4	Total	P(t) EG – CG
EG	65 = **54,2%**	87 = **72,5%**	101 = **84,2%**	162 = **67,5%**	415 = **69,2%** $\overline{X}$ = **13,76**	**0,000**
CG	97 = **80, 1%**	114 = **95%**	115 = **95,8%**	222 = **92,5%**	548 = **91,3%** $\overline{X}$ = **18,31**	

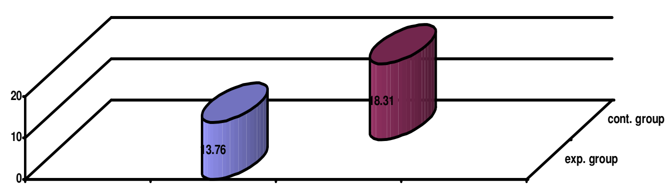


Diagram - Differences between EG and CG in a state of oral language

The comparative analysis leads to conclusion: there are significant differences between the groups. The statistical indicators relate to entire population, not only to these studied persons. The data testifies to better development of vocabulary and semantics in the control group. Certainly, it can be considered there is a deficit in oral language in dyslexia, which consists of understanding and use of fewer words, fewer synonyms and antonyms.

The gender influence on the oral language is also checked (Table 2).

Table 2. Influence of gender on the state of oral language

Group	Value of average	P(t)
EG boys	$\overline{X}$ = 13,29	**0,316**
EG girls	$\overline{X}$ = 14,18	
CG boys	$\overline{X}$ = 18,29	**0,809**
CG girls	$\overline{X}$ = 18,55	

The data show no gender differences in the level of development of oral language in the groups. Both boys and girls from EG have very similar level of lexical-semantic component of language, with a slight but statistically insignificant advantage for the girls.

The level of this language component for the boys and girls from KG can be defined as the same.

The study provides evidence of disorders in the oral language development in children with dyslexia, but it is not yet clear whether the disorders occur in all children. An intragroup analysis of individual scores in the both groups can answer this question (Table 3).

Table 3. Individual scores of children in both groups

EG		CG	
Individual scores	Number of children with one ball	Individual scores	Number of children with one ball
8	1	8	-
9	3	9	-
11	2	11	-
13	5	13	-
14	4	14	-
15	6	15	-
16	***6***	**16**	***2***
17	***3***	**17**	***8***
18	-	18	4
19	-	19	5
20	-	20	3
21	-	21	2
22	-	22	2
23	-	23	1
24	-	24	1
25	-	25	1
26	-	26	1

The individual scores in EG are between 8 and 17, and they are between 16 and 26 in CG. No one student from EG has passed the limit of 17, but there is a considerable number of students from EG - total 9 (30%), with score 16 and 17, which is similar to the score of 10 children (33,3%) from CG. The coincidence of data indicates the same level of development of language ability in some students from both groups and rejectes the thesis for a low capacity of oral language in all children with dyslexia. Such a capacity can be discussed for part of them, only for those, whose score is below 16 - 21 children with dyslexia or total 70% of EG. But it is not sure this conclusion applies to all these 21 children, because the differences between their scores are very large - between 8 and 15.

The analysis of individual scores of children from both groups reveals the presence of both differences and similarities between the groups in individual aspect.

CONCLUSIONS AND RECOMMENDATIONS

The study confirms many literary evidence for deficits of oral language in dyslexia and proves it refer equally to both gender. Some kind of decreasing of severity of oral language deficit could be noticed during the next ontogenetic stage but nevertheless the insufficiency influence on metacognitive development and mastering of written language in children.

However, the results do not give reason to believe the deficit in oral language is typical for all children with dyslexia. This fact confirms the results obtained by McArthur et al. (2000). Although the survey data require in-depth statistical verification, we can conclude that oral language disorders could be noticed not in all children with dyslexia.

Therefore the verification of oral language level in children with a risk of dyslexia or diagnosed with dyslexia is indispensable part of assessment. This should be done with appropriate, age-tailored procedures to lead to reliable results. In case of proven disorders in oral language it is important to work on improving of this skill before to start work on mastering of reading and writing. In case of such disorders are not proven, we should search for other pathology underlying the disorders of written language.

The most efficient tasks are early assessment of oral language disorders and to take measures accordingly to their overcoming during the preschool age. This is also the most important measure to prevent the negative effects of dyslexia, and to mitigate its manifestations in primary school age.

REFERENCES

1. Bishop, D. V. M. & Snowling, M. J. (2004). Developmental Dyslexia and Specific Language Impairment: Same or Different? - Psychological Bulletin, 130 (6), p. 858-866.

2. Estienne, F. Dislexie. (1985) – Dans: Mardaga, P. (Ed.). Troubles de language (diagnostique et rééducation). Bruxelles, p. 397-431.

3. Galagher, D., Ftith, U., & Snowling, M. J. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. - Journal of Child Psychology and Psychiatry, 41 (2), p. 203-213.

4. Loginova , E. A. & Eletskaya, O. V. (2006). Status of lexical and grammatical component of language in students with dysortografia. – Logopedics, 4 (14), p. 22-28 (in Russian).

5. Lyytinen, H., Ahonen, T., Eklund, K., Guttorm, T. K., Laakso, M-L., Leinonen, S., Leppanen, P. H. T., Lyytinen, P., Poikkeus, A-M., Puolakanaho, A., Richardson, U. & Viholainen, H. (2001). Developmental pathways of children with and without familial risk for dyslexia. - Journal of Speech, Language and Hearing Research, 44 (4), p. 837- 885.

6. Matanova, V. (2001). Dyslexia. Sofia (in Bulgarian).

7. Matanova, V. (2003). Psychology of Abnormal Development. Sofia (in Bulgarian).

8. McArthur, G. M. & Hogben, J. H. (2001) Auditory backword recognition masking in children with a specific language impairment and children with a specific reading disability. - Journal of Acoustical Society of America, 109, p. 1092-1100.

9. Scarborough, H. S. (1990). Very early language deficit in dyslexic children. - Child Development, 61, p. 1728-1743.

10. Todorova, E. (2005). Diagnosis of Language Deficits in Dyslexia. Sofia (in Bulgarian).

11. Todorova, E. (2008). Dyslexia. Sofia (in Bulgarian).

12. Tomblin, J. B. & Buckwalter, P. (1998). Hereditability of poor language achievement among twins. - Journal of Speech, Language and Hearing Research, 41, p. 188-199.

13. Volkova, L. S. & Shahovskaya, S. N. (2000). Logopedics. Moscow (in Russian).

APPLICATION OF EEG IN RESEARCH OF AUDITORY CORTEX IN CHILDREN WITH COCHLEAR IMPLANTS[10]

SANJA ĐOKOVIĆ[1], VANJA NENADOVIĆ[2], SANJA OSTOJIĆ[1], SLAVICA MAKSIMOVIĆ[2], SELENA TODOROVIĆ[3]
University of Belgrade, Faculty of special education and rehabilitation[1],
Center of promotion life activity[2]
Institute for experimental phonetic and speech pathology[3]
ingo@eunet.rs

Abstract. Functional monitoring of the effects of cochlear implantation at the level of reorganization of cortical structures requires a very complex methodological procedure, expensive apparatus, and appropriately, in a high-quality way trained professionals. Around the world, different methods such as EEG, AEP, PET, SPECT and others are used. The aim of this work was to do a meta-analysis of contemporary EEG research with the purpose of defining a high-quality methodological framework for similar studies in the future, as well as to present the results achieved so far. In the preparation of this paper meta-analysis was used, as a method of combining and synthesizing various unrelated studies. The results of this study are important for future planning of similar studies. It was also found that there are very few EEG studies in the population of people with cochlear implants in Serbia. The importance of the results of EEG studies is that it can be widely applied in all phases of cochlear implantation from the selection of candidates for cochlear implantation to monitoring the functional reorganization of the auditory cortex under the influence of the process of re/habilitation of people with cochlear implants.

Keywords: EEG, cochlear implant , auditory cortex

1. INTRODUCTION

EEG is a method used to register the electrical activity of the brain. It is a diagnostic, non-invasive neurophysiological method and at the basis of it lies constant change of potential at the level of the membrane of ganglion cells of CNS. Changes of potential, particularly at the level of dendrites, are registered through an intact skull in the form of a sinusoidal curve called "rhythm". In other words, this method allows the registration of the difference of potential between two points on the skull of a man as a function of time. EEG is a method which also deals with analysis of spatial temporal patterns of brain's electrical activity during mental processes. This field of neurophysiology is a part of cognitive psychophysiology, an interdisciplinary field that studies physiological functions in order to clarify the processes and mechanisms which form the basis of cognition (Radivojevic et al., 1996). These scientific disciplines and the use of EEG method in the research on people with cochlear implants are what made it possible to monitor psychophysiological processes occurring at the level of CNS.

A cochlear implant can improve hearing in people with very severe hearing impairment. Currently, more than 219 000 deaf people are using this technology (ASHA, 2013). However, in different individuals the benefits from the use of cochlear implants are different. Some implant users develop good speech and language skills, while others advance poorly. Answers about the causes that lead to this are partly obtained by using

[10] This work has been funded by Serbian Ministry of Education, Science and Technological Development within Project "Interdisciplinary research of verbal communication quality"– 17802.

electroencephalography (EEG).

Studies done using EEG methods have most often dealt with: reorganization and plasticity of auditory cortex.

Starting with the fact that in domestic literature there are very few works related to the study of characteristics of the development of CNS and cognitive processes in a typical population of children, especially children with cochlear implants, has led to creating ideas for writing this paper. The lack of research in this area has not been caused by the experts being uninterested, but the reasons are largely of financial and professional nature. Lack of devices and lack of trained professionals, as well as a small number of institutions engaged in care of children with cochlear implants, and their poor territorial allocation, are the main reasons for this publicistic deficit.

The aim of this work was to do a meta-analysis of contemporary EEG research with the purpose of obtaining the guidelines for defining a good-quality methodological framework for future research, as well as to present the results achieved so far. In the preparation of this paper, meta-analysis was used as a method of combining and synthesizing various unrelated studies.

2. USE OF EEG IN RESEARCHING THE NEAT DEVELOPMENT OF CENTRAL AUDITORY PATHWAYS

A major contribution to better understanding of the functioning of the auditory cortex has primarily been provided through EEG studies on normal hearing persons. In order to be able to interpret the results obtained in deaf persons, it is necessary to know the characteristics of neat development and functioning. These characteristics have been found out partly through research on animals, and partly through research on people.

Some surveys point out that internal development of the central pathways is a biological process that occurs independently of auditory stimulation. For example, in animals the synaptic connections within the auditory system are formed before the animal it begins hearing. However, the final development of auditory pathways in the cortex is at least partly conditioned by auditory stimulation. Tonotopicorganization of the auditory cortex may be formed under the influence of heavy exposure to a narrow range of stimuli during early prenatal and postnatal development. Auditory cortex is formed in accordance with the specificities of the acoustical environment (Zhang et al., 2001). This phenomenon helps children in the process of directing their auditory attention and selecting useful voices from their environment in the process of starting to speak.

Kilgard and Merzenich (1998) combined auditory stimulation with electrical stimulation of the basal nuclei in rats, and compared the created maps of auditory cortex with those formed without stimulation of the basal nuclei. Cortical maps were significantly altered when the auditory signals were combined with the stimulation of the basal nuclei, and the changes suited the specificities of the stimulation. The maps were different for modulated and unmodulated tones, as well as simple and complex tones

Changes in auditory cortical pathways or maps under the influence of stimulation, may occur after a shorter or longer period of time. These changes are caused by various factors, such as the balance of excitatory and inhibitory stimulation after a short period of time, or restructuring of dendrites and axons after an extended period of time (Darian-Smith and Gilbert, 1994).

In humans, long-term restructuring of the auditory cortex can be measured by different techniques. Huttenlocher and Dabholkar (1997), counted synapses in the auditory cortex after a person's death and found that from birth to early childhood the number of synapses increases, and then it decreases until adulthood. Moore and Guan (2001) examined the laminar development of the auditory cortex and found differences in the development of axons of infragranular and supragranular layers. Since these changes reflect on central auditory evoked potentials (CEAP) of the cortex, in a lot of research CAEP is used for determining changes in cortical development.

2.1 Auditory evoked potentials of the cortex in the neat development

Auditory Evoked Potentials (AEP) represents EEG activity that occurs as a response to auditory stimulation. In infants and children the positive peak of the first wave R1 is the most prominent and it occurs 100-300 ms after stimulation. With age the negative peak N1 becomes visible. N1 component may or may not be observed in children aged 3-5 years. At this age, the N1 component occurs later compared to children aged 12, in whom it is always observed immediately after stimulation. R1 component is generated at the level of primary and secondary auditory cortex, while the N1 component appears as a result of reciprocal activity of auditory cortex, including intrahemispherical and interhemispherical activity (Makela, Harry, 1992; Mäkelä & McEvoy, 1996 Ponton et al., 2000). With respect to the fact that auditory input reaches the auditory cortex in 20-30 ms, and the latencies of components R1 and N1 are longer, especially in childhood, it can be concluded that for generating R1 and N1 components, higher processing within the auditory cortex is required, and it includes feedback between primary auditory cortex and association areas.

CAEP's latencies vary with age, therefore they can be used as biomarkers to assess the maturation of the central auditory pathways. Sharma (1997) and his colleagues described in detail the neat development pathway of R1 responses from birth to adulthood. The results showed that the person's age and latency of the R1component are inversely proportional. Shortening R1 latencies with increasing age suggests that over time the efficiency of synaptic activity improves and the development of auditory pathways ends. These data are the standard based on which we can assess the development of the central pathways in congenitally deaf children with cochlear implants.

2.2 Application of EEG research in examining cortical reorganization in patients with cochlear implants

The development of sensory pathways in the cortex is determined by internal factors and external stimulation. Because of that, the absence of sensory stimulation, as in the case of hearing loss, interferes with the formation of a functional sensory system. Since normal functioning of the sensory pathways is a prerequisite for the development of speech and language skills, hearing impaired children are at risk of impaired development of these skills. A cochlear implant bypasses the damaged cochlea and directly stimulates the nerve cells of the spiral ganglion and makes it possible to overcome the adverse effects of auditory deprivation. Studies of children and adults with cochlear implants are very interesting and useful for the study of the plasticity of the central auditory system as well as cortical reorganization. Research conducted with children of various ages with cochlear implants provides evidence of the existence of a sensitive period in the childhood for the development of specific skills such as speech and language and confirm the theories that support that.

Experiments on animals with congenital deafness showed abnormal formation of auditory nerve fibers that end in the lower part of the cerebral stem (Lee et al., 2003). Other experiments have shown that because of the hearing loss, auditory cortex shows reduced synaptic activity when it is stimulated electrically (Kral et al., 2002). Reduced activities of these physiological mechanisms are most likely consequences of damage to and/or reorganization of anatomical structures.

Since the organization and development of the auditory pathways are partly conditioned by auditory stimulation, in the case of congenital deafness these parts of CNS must be changed. Congenitally deaf cats are useful in the study of cortical organization and the changes in them arising from deafness and due to stimulation by the cochlear implant. They show atypical patterns of activities within the layers of the primary auditory cortex in comparison with normal hearing cats and show signs of non-synchronized activities between different cortical layers. As a result, modified potentials appear, and they are recorded on the surface of the cortex (Kral et al., 2002; Kral& Tillein, 2006; Kral et al., 2005).

When electrical stimulation is started four months after deafness occurred, i.e. at the end of a sensitive period for the development of the central auditory system in cats, there is a delay in activities of supragranular layers of the cortex and almost an absence of activities in infragranular layers (layers V and VI) (Kral et al., 2005). The absence of activity in layers IV and III in congenitally deaf cats indicates an incomplete development of inhibitory synapses and altered flow of information from layer IV to supragranular layers. Associative auditory cortex projects axons back to the primary auditory cortex to infragranular layers V and VI, and from there axons are sent to subcortical auditory areas. The absence of activity in infragranular layers may indicate a functional separation of the primary auditory cortex from the associative auditory cortex, which also overtakes the projections towards subcortical auditory structures (Kral et al., 2000, 2002, 2005). This separation allows other sensory modalities to become dominant in the associative auditory cortex in children deprived of auditory stimulation over a long period of time. Then the associative auditory cortex engages in processing visual and somatosensory information most often.

In humans, auditory evoked cortical potentials (CAEP) provide information about the maturation of auditory pathways that end in the auditory cortex. These auditory pathways may be damaged due to reduced auditory stimulation. After cochlear implantation, it is possible to improve the function of these pathways, if the plasticity of the central auditory system (CAS) is preserved and if degeneration has not been completed. Based on experiments on animals it was found that the function of auditory pathways can be improved at least to some extent if continuous electrical stimulation of these pathways is carried out (Klinke et al., 1999). While early implantation at the time of the greatest plasticity of CAS allows for maturation of auditory pathways, with later implantation the chances for successful maturation are reduced.

Development disturbed due to auditory deprivation causes altered CAEP in deaf children with cochlear implants. Ponton (1996) pointed out the different CAEP development in children and adults with cochlear implants by comparing the appearance of waves with that of the waves in normal hearing persons. The results of that research show that there is a delay of the latency of component R1 and the absence of N1 component. Sharma (2002) studied the R1latency in congenitally deaf children with cochlear implants and concluded that early implanted children (younger than 3.5) have regular R1 latencies, and late implanted children (after 7 years of age) have changed latencies. In the group of children who had cochlear implants implanted between the ages of 3.5 and 7, great variability of latencies was discovered. After 3-6 months of cochlear implantation latencies in early implanted children were within the range of normal values and continue to mature in the following years (Sharma et al., 2005, 2002). In late implanted children latencies change immediately after implantation, but they do not mature over time. For most late implanted children latency did not reach the proper values even after several years of using a cochlear implant (Sharma et al., 2005).

Appearance of the waves is another way to evaluate the development after implantation. In early implanted children the appearance of the waves is neat, and in the late implanted children it is altered, usually with lower amplitudes. Eggermont and Ponton (2003) concluded that the N1 component is absent in people with cochlear implants whose deafness occurred before they were 6 and lasted for at least 3 years, so they state this period as a critical one for the maturation of the cortex and achieving good-quality auditory perception.

The most recent research shows that in children implanted after the age of 7 the N1 component never develops. On the other hand, children implanted before the sensitive period of 3.5 years of age will develop the N1 component that is similar in appearance and latencies to the N1 components found normal hearing children (Sharma, 2006). Components R1 and N1 indicate that the period until 3.5 years of age is a sensitive period for development during which it is necessary that there is auditory stimulation in order to ensure the maturation of CAS.

2.3 The use of EEG research in examining the reorganization of the auditory cortex due to deafness

The basic principle of neurophysiology is that cortical zones will be reorganized due to periods of auditory deprivation. In children who were born deaf, at some point in their childhood, most likely at the end of the sensitive period, cortical reorganization will occur in the areas that are responsible for auditory perception.

In their research Gilley et al. (2006) used two techniques based on EEG: a) CSR (Current source reconstructions) and b) DSA (Dipole source analyzes) to estimate R1 and N1 components of CAEP in three groups of children: normal hearing children, congenitally deaf children with cochlear implants implanted before they were 4 years old, congenitally deaf children with cochlea implants implanted after the age of 7, in the task of passive listening to syllable /ba/ being pronounced. The aim was to examine whether cortical organization was the same in all three groups.

It was shown that the latencies and amplitudes of R1 of CAEP are identical in children with normal hearing and early implanted children, and later implanted children show significant variations, with lower amplitudes and prolonged latencies.

- Results of CSR (Current source reconstructions) show where the source of neural activity for R1 of CAEP is. In children with normal hearing the primary source of activities is around the right lower temporal curve (ITG), and bilaterally in the upper temporal sulcus (STS). Similarly to them in early implanted children with the implant in the left ear the largest activity is that around the right ITG and the contralateral i.e. left STS. In later implanted children it was shown that the source of activity is focused in parietotemporal cortex and the postcentral curve contralateral to the implanted ear.

- The results of DSA (Dipole source analyses) show that children with normal hearing showed bilateral symmetrical activities in the transversal temporal curve, medially. In early implanted children there is a one-sided activity contralaterally to the implanted ear in the transversal temporal curve, medially and slightly posterior in comparison to those in normal hearing persons. In late implanted children there is a one-sided activity contralaterally to the implanted ear in the parietotemporal lobe in the dorsal part of the back cingulate cortex.

This research shows that there are different places where R1 of CAEP is generated in normal hearing children, early implanted children and late implanted children. The study authors suggest that those differences are due to different degrees of cortical reorganization which depends on the duration of deafness.

Above-mentioned research showed that in children with cochlear implants there is only one-sided activity of the auditory cortex, and that is contralateral to the implanted ear. Other research shows that in adults who later went deaf in one ear or in both ears, but had cochlear implants in one ear only, there is a mutual activity of the auditory cortex. It is assumed that their ipsilateral and contralateral pathways are both preserved, although they can only receive unilateral auditory stimulation. The authors of this research believe that in the case of congenital deafness bilateral auditory pathways cannot develop fully.

It is important to note that in this research the auditory cortex activity was not found in any of the late implanted participants, but that it is focused in parietotemporal cortex. So if it is found that the highest activity is the one in parietotemporal cortex, it can be concluded that the degree of cortical reorganization is rather high.

Since the existence of reciprocal connections between primary auditory cortex and association areas is necessary for generation of R1 and N1 components, the lack of activity of auditory cortex in late implanted children in the above-mentioned research indicates the absence or weakening of connections between primary auditory cortex and association areas which also leads to weakening of links with thalamus. These results are consistent with Král's hypothesis of separation (Kral et al., 2005), and the functional interruption of links between the primary auditory cortex and associative auditory cortex.

2.4 The use of EEG research in examining cross-modal (cross-modal) plasticity and reorganization

Research in animals and humans has shown that there is a certain level of cross-modal reorganization in cases when there is reduced sensory stimulation of a sensory modality, and then this modality gets reorganized so that it performs the function of another modality. After a longer period of decreased auditory stimulation, auditory cortex may get reorganized to such an extent that receiving the sound after cochlear implantation becomes limited. Therefore, it is important to provide auditory stimulation at an early age at the time of greatest plasticity of auditory system, in order to increase the chances of developing typical auditory function.

The Gilley study (2006) shows that in late implanted children associative auditory cortex does not get activated under the influence of auditory stimulation. Associative auditory cortex is engaged in processing the information coming from other sensory modalities. Numerous studies indicate that auditory areas of deaf adults respond to visual stimuli. Finney (2001) presented the visual stimuli to congenitally deaf adults and observed the brain activity by fMRI. The results showed that as a response to visual stimulation there is considerable activity in the temporal cortex, especially in the auditory cortical areas. Similarly, fMRI studies on deaf adults who communicate in sign language showed that there is increased activity in auditory areas when they follow statements in sign language or read lips , as well as when they watch simple visual stimuli (MacSweeney et al., 2002; Sadat et al., 2005).

Bavelier (2006) report that deaf people have better abilities in visual and tactile activities than normal hearing persons. It is assumed that these improvements are a result of the reorganization of the auditory cortex (Lomber et al., 2010).

Sandmann (2012), in his EEG research, examined visual abilities in cochlear implant users with moderate and good ability of speech recognition and in hearing persons. The aim of this research was to analyze the activity of the visual and auditory cortex during visual stimulation, in users of cochlear implants and normal hearing people.

By comparing the visually evoked potentials study authors concluded that the potentials are greater when participants are watching a series of images in which white patches are more intense. It was also showed that in the users of cochlear implants the activity of the visual cortex was reduced in relation to that activity in normal hearing persons. On the basis of that, the authors concluded that in the users of cochlear implants there were functional changes of the visual system as a result of altered auditory experience. So poor auditory experience or lack of it affects not only auditory, but visual processes as well. On the other hand, the activity of the auditory cortex, and especially the activity of the right auditory cortex, gets increased in the users of cochlear implants. This visual activity of the auditory cortex is associated with the ability of speech recognition

It has been shown that, in individuals with moderate ability of auditory speech recognition, greater visual activity of the auditory cortex is exerted, compared with people with good ability of auditory speech recognition. On the basis of the above-mentioned we can conclude that during the processing of visual information the cochlear implant users engage their visual as well as auditory cortex.

In Baldwin's study (2002), the brain activity in deaf and hearing adults and normal hearing people was recorded during vibrotactile stimulation of their hands. It was shown that in normal hearing persons the somatosensory cortex gets bilaterally activated. In deaf people, in addition to bilateral activation of the somatosensory cortex, the activation of the back parts of the upper temporal sulcus was also observed, bilaterally, which means that in deaf persons the associative auditory cortex is activated under the influence of somatosensory stimuli. These results indicate that there is a degree of cross-modal plasticity and reorganization between auditory and somatosensory areas due to auditory deprivation.

During the early development it is a characteristic of the cortex that there is a large number of neural connections, complex axonal endings and complex development of dendrites. The completion of the development of neural connections under the influence of stimuli forms sensory and multisensory cortical zones. In the case of sensory deprivation during development, unstimulated pathways in auditory cortex remain incomplete. These incomplete pathways and connections between sensory and multisensory zones allow other modalities to access the auditory zones. If reorganization occurs during deprivation and after thesensitive period of development, the introduction of a new sensory stimulus can disrupt the already established neural connections. Gilley (2006) studied the reactions to basic auditory, visual and auditory-visual (AV) stimuli in cochlear implanted children and children with normal hearing. The results showed that late implanted children show a delay in auditory, visual and auditory-visual reactions in comparison with early implanted children and children with normal hearing. Schorr (2005) stated that in late implanted children AV integration was changed. These results suggest that when a new stimulus is introduced, by a cochlear implant, in the reorganized cortex in late implanted children , that leads to altered perceptual skills, atypical reactions to multisensory stimuli and a slowed down sensory system.

3. CONCLUSION

Around the world, research based on the use of EEG method in the field of studying the functioning of CNS in normal and in the changed circumstances is very popular and numerous. It can be said that the studies regarding the auditory cortex and the processes that occur in it are available to expert and scientific public. Unfortunately, in our country there is not much of this fundamental neurophysiological research.

On the basis of analysis of read literature and discussion of methodological frameworks of EEG research we come to the conclusion that, in the future research should be devised with more structured tasks in order to obtain more precise indicators of the functioning of auditory cortex in specific tasks in persons with cochlear implants In particular, it would be very interesting to do the research of the functioning of auditory cortex of CI persons while they are listening to various segments of speech or more complex linguistic structures. Such research is very demanding in terms of spatial, technical and personnel requirements so it would be justified to do it through case studies.

The survey results discussed in this paper provide theoretical as well as practical providing and implications. Theoretical implications are related to confirmation of the theory of a sensitive period, which was discussed and emphasized by many scientists like Ebbin, Vygotsky and Piaget. These findings confirm the importance of early re/habilitation of the deaf and hard of hearing people and the deleterious effects of missing the optimal time for the development of specific abilities such as speech and language skills.

Practical implications arising from the results of EEG research of auditory cortex functioning are related to the criteria for selecting candidates for cochlear implantation. The findings unambiguously suggest that people who are congenitally deaf and implanted after the age of 7 have a cortex so reorganized in the part that receives and processes external stimuli that it significantly influences the course and outcome of aural re/habilitation programs. This raises the ethical dilemma of how purposeful it is to perform very complex and demanding surgical intervention in these candidates. In the future, probably on the basis of findings obtained from EEG research, there will be intense debates about this.

REFERENCES

ASHA, (2013). Cochlear implant Quick Facts. American speech, language and hearing association. http://www.asha.org/public/hearing/Cochlear-Implant-Quick-Facts/

Baldwin, L. (2002). *Functional reallocation of the auditory cortex inindividuals who are deaf* (Doctoral dissertation). District ofColumbia, Gallaudet University.

Darian-Smith, C., Gilbert, D. (1994). Axonal sprouting accompaniesfunctional reorganization in adult cat striate cortex. *Nature* 368,737-740.

Eggermont, J., Ponton, W. (2003). Auditory-evoked potential studiesof cortical maturation in normal hearing and implanted children:Correlations with changes in structure and speech perception. *ActaOtolaryngol*.123, 249-252.

Finney, M., Fine, I., Dobkins, R. (2001). Visual stimuli activate auditory cortex in the deaf. *Nature Neuroscience*, 4(12), 1171-1173.

Gilley P., Sharma, A., Dorman M. (2006). Reorganization of auditoryand visual cortical pathways during auditory deprivation. 2ndShanghai International Conference on physiological Biophysics:Audition and Vision. Shanghai, China, Chinese Academy ofSciences.

Gilley, P., Sharma, A., Dorman, F. (2008). Cortical reorganization in children with cochlear implants. *Brain Research* 1239, 56-65.

Giraud A. L., Price. J., Graham J. M., Frackowiak R. S. J., (2001), Functional plasticity of language-related brain areas after cochlear implantation;

Huttenlocher,R.,Dabholkar,S. (1997). Regional differences insynaptogenesis in human cerebral cortex. *Jour. Comp. Neurol*. 387, 167-178.

Kilgard, P., Merzenich, M. (1998). Cortical map reorganizationenabled by nucleus basalis activity. *Science* 279, 1714-1718.

Klinke, R., Hartmann, R., Heid, S., Tillein, J., Kral, A. (2001). Plasticchanges in the auditory cortex of congenitally deaf cats followingcochlear implantation. *Audiol. Neurootol.* 6, 203-206.

Kral, A., Hartmann, R., Heid, S., Tillein, J., Klinke, R. (2000).Congenital auditory deprivation reduces synaptic activity withinthe auditory cortex in a layer-specific manner. *Cereb. Cortex* 10, 714-726.

Kral, A., Hartmann, R., Heid, S., Tillein, J., Klinke, R. (2002). Hearingafter congenital deafness: Central auditory plasticity and sensorydeprivation. *Cereb. Cortex* 12, 797-807.

Kral, A., Heid, S., Tillein, J., Hartmann, R., Klinke, R. (2005). Postnatalcortical development in congenital auditory deprivation. *Cereb. Cortex* 15, 552-562.

Kral, A., Tillein, J. (2006). Brain plasticity under cochlear implantstimulation. *Adv. Otorhinolaryngol*. 64, 89-108.

Lee, J., Cahill, B., Ryugo, K. (2003). Effects of congenitaldeafness in the cochlear nuclei of Shaker-2 mice: An ultrastructuralanalysis of synapse morphology in the endbulbs of Held. *Jour.Neurocytol*. 32, 229-243.

Lomber, G., Meredith, A., Kral A. (2010). Cross-modal plasticity in specific auditory cortices underlies visual compensations in the deaf.*Nature Neuroscience13*,1421-1427.

MacSweeney, M., Woll, B., Cambell, R., Mcguire, K., David, S. (2002). Neural systems underlying British Sign Language andaudio-visual English processing in native users. *Brain* 125, 1583-1593.

Makela, P., Hari, R. (1992). Neuromagnetic auditory evoked responsesafter a stroke in the right temporal lobe. *Neuroreport* 3, 94-96.

Makela, P. Mcevoy, L. (1996). Auditory evoked fields to illusory soundsource movements. *Exp. Brain. Res*. 110, 446-454.

Moore, K., Guan, L. (2001). Cytoarchitectural and axonal maturationin human auditory cortex. *Jour. Assoc. Res. Otolaryngol.* 2, 297-311.

Ponton, W., Don, M., Eggermont, J., Waring, D., Masuda, A. (1996). Maturation of human cortical auditory function: differencesbetween normal-hearing children and children with cochlear implants.*Ear and Hear* 17, 430-437.

Ponton, W., Don, M., Eggermont, J., Kwong, B. (2000). Maturationof human central auditory system activity: evidence from ultichannelevoked potentials. *Clin. Neurophysiol.* 111, 220-236.

Radivojević, V., Rajković, M., Timotijević, D., Car, M. (1996). Deterministički haos u EEG signalu. *Svest – naučni izazov 21. veka*. ECPD, 217-240.

Sadato, N., Okada, T., Honda, M., Matsuki, K., Yoshida, M. (2005). Cross-modal integration and plastic changes revealed by lipmovement, random-dot motion and sign languages in the hearingand deaf. *Cereb. Cortex* 15, 1113-1122.

Sandmman, P. (2012). Visual processing in the auditory cortex of cochlear-implant users. *Brain Products Press* 42, 10-19

Sharma, A., Kraus, N., McGee, J., Nicol, G. (1997). Developmentalchanges in P1 and N1 central auditory responses elicited byconsonant-vowel syllables. Electroencephalogr. *Clin. Neurophysiol*. 104, 540-545.

Sharma, A., Dorman, M., Spahr, J. (2002). A sensitive period forthe development of the central auditory system in children withcochlear implants: implications for age of implantation. *Earand Hear.*23, 532-539.

Sharma, A., Dorman, F., Kral, A. (2005). The influence of a sensitive period on central auditory development in children with unilateraland bilateral cochlear implants. *Hear. Res.* 203, 134-143.

Sharma, A., Dorman, F. (2006). Central auditory development inchildren with cochlear implants: Clinical implications. *Adv. Otorhinolaryngol.* 64, 66-88.

Sharma, A., Gilley, M., Dorman, F., Baldwin R. (2007). Deprivation-induced cortical reorganization in children with cochlear implants.*Int. Jour. Aud.* 46, 494-499.

Zhang,I., Bao, S., Merzenich, M. (2001). Persistent and specificinfluences of early acoustic environments on primary auditorycortex. *Nat Neurosci* 4, 1123-1130.

PRIMENA EEG-A U ISTRAŽIVANJIMA AUDITIVNOG KORTEKSA KOD KOHLEARNO IMPLANTIRANE DECE

Funkcionalno praćenje efekata kohlearne implantacije na nivou reorganizacije kortikalnih struktura zahteva veoma složen metodološki postupak, skupu aparaturu, kvalitetno i adekvatno obučene stručnjake. U svetu se koriste različite metode kao što su: EEG, AEP, PET, SPECT i druge. Cilj ovog rada je bio da se uradi meta analiza savremenih EEG istraživanja u svrhu definisanja kvalitetnog metodološkog okvira za buduća slična istraživanja, kao i da se prestave razultati do kojih se do sada došlo. U izradi ovog rada korišćena je meta analiza kao metod kombinovanja i sintetizovanja različitih međusobno nezavisnih studija. Rezultati ovog istraživanja su značajni za

buduće planiranje sličnih istraživanja. Takođe, utvrđeno je da postoji veoma malo EEG istraživanja u populaciji kohlearno implantiranih osoba u Srbiji. Značaj rezultata EEG istraživanja se ogleda u tome što se mogu široko primeniti u svim fazama procesa kohlearne implantacije od odabira kandidata za kohlearnu implantaciju do praćenja funkcionalne reorganizacije auditivnog korteksa pod uticajem procesa re/habilitacije kohlearno implantiranih.

Ključne reči: EEG, kohlearni implant, auditivni korteks

SANJA ĐOKOVIĆ[1], VANJA NENADOVIĆ[2], SANJA OSTOJIĆ[1], SLAVICA MAKSIMOVIĆ[2], SELENA TODOROVIĆ[3]

Univerzitet u Beogradu, Fakultetzaspecijalnu edukacija I rehabilitacija[1],
Centarzaunapređenježivotnih aktivnosti[2]
Institutzaeksperimentalnufonetikugovornu patologiju[3]
ingo@eunet.rs

INTRODUCING PUPILS INTO WRITING SKILLS

ZORICA CVETANOVIĆ, KRISTINA ŠULOVIĆ PETKOVIĆ
University of Belgrade, Teacher Training Faculty,
Educational Centre Torbica, Belgrade
zorica.cvetanovic@uf.bg.ac.rs

Abstract: The development of writing skills in lower classes of primary school has a communicative function which is used to convey thoughts, ideas and descriptions through writing clearly and precisely. The aim of developing the skills and habits of writing is to make a pupil gradually become independent when it comes to written forms. Pupils are not supposed to improvise. They should be gradually introduced into the technique of writing a comprehensive expression with the help of a teacher by encouraging their creativity. The paper shows methodical fundamentals for introducing pupils into writing skills that comprise constructive elements, making a plan and forms that are applied from the first grade of primary school. 380 teachers have been surveyed about these segments of literacy classes. The aim of this paper is a review of theoretical and methodical fundamentals for introducing pupils into initial literacy.
Keywords writing skills, writing sentences, essay, retelling, narration, describing.

1. INTRODUCTION

One of the main goals of education in elementary grades is learning to read and write. When writing technique is developed, it should start with systematic exercises to develop independent writing skills of pupils. The development of literacy is a process of linguistic culture within the Serbian language in classroom teaching. Language and culture includes oral expression, vocabulary enrichment, practice of oral and written expression. All these segments are intertwined, especially oral and written expression. However, the written speech is more abstract than the voice, the speech without interlocutors, i.e. imaginary conversation with the interlocutor. "Oral and written expression are interrelated, writing affects speech and vice versa. Exercises of oral expression have their own goals in the teaching, but they strongly support written expression. The speech was prepared to write, and writing encourages speech" (Milatović, 2011: 331). Exercises of oral and written expression are organized from the first grade. Basic forms of oral and written expression in the first grade of primary school are retelling, talking about the events, experiences according to the given images, as well as describing objects, plants and animals (Regulation on the curriculum for first and second grade of primary education, 2004: 5). In the following grades, the basic forms of expression remain the same with the practice of productive and creative ways of implementation. Talking, retelling, describing and reporting are organized as oral and written exercises, and there are other forms of written expression. The classes are organized by less written exercises and essays. "Less written exercises improve some elements of literacy, without which there is no good writing (spelling, grammar, style, method of composing text, etc.), and the essays include integrity, form and content of writing (retelling, telling, writing, etc.)" (Milatović 2011: 363). Written expression of pupils are gradually and systematically developed by constant methodical guidance.

2. GRADUAL WORK ON THE DEVELOPMENT OF WRITTEN EXPRESSION OF PUPILS

The initial teaching of literacy elements that build pupils' ability to write correctly are lexical, syntactic and textual. During development of writing there is also a contextual element, usually with students who have a talent for writing. Initial efforts to write a broad statement hampered by practicing writing, so pupils need care about correct spelling and joining letters, which in adults brought to automatism. In addition, the rules they have just learned, for example, capitalizing, applying to write their own text. These start-ups are difficult for children to lose their thoughts as they write, focusing on the technique of writing. Therefore, it is important to practice writing full-time, with proper methodical guidance by teachers. Therefore, after mastering the basic techniques of writing, you should work on developing and expanding vocabulary words that pupils use when writing. Syntactic elements of expression are related to the formation of sentences in written form and it must be properly formed and clear. That doesn't mean you should run into schematism, use the same circuits sentence, but in the earliest stages of developing literacy learners indicate that the sentence is the basis of linguistic expression. In some languages the word order in the sentence can be changed, and students should be given to use such property of languages. Text elements of writing are first related to the set of related sentences, and then to the text as a whole. These elements combine two basic aspects of linguistic expression: its meaning and its significance. Text that student in class of Serbian language develop and write by himself is usually called an essay or written assignment. The role of the teacher is to motivate students to write and adapt them in the process. After the initial literacy teacher gradually introduces students to the techniques of writing through stages that help students master the basic rules of writing, and that every written work is particular and that is an expression of individuality.

Pupils as they learn to write letters, copy or independently write words and sentences, and the more advanced pupils are expected to write sentences linked into a whole. However, learning to write broad written statements requires the adoption of specific rules. These rules are not adopted all at once, but gradually, and always with examples, models and exercises, because, only while you're writing, you learn to write. The basic rules that pupils need to learn, at the initial literacy, are:

– grammatically correct formation of sentences – subject and predicate set of words;
– basic spelling rules – capitalizing and punctuation;
– linking sentences – logical one another and joined together;
– structure of the statement – composition, structure and deployment of thematic material;
– unity of statement – a statement must follow thoughts, and be clear and complete;
– every statement has an aesthetic component – influenced by the richness of the words used and it must be interesting.

Respect the basic rules of writing is to write correct, clear, fluent and nice (Cvetanović, 2010: 24).

Stages in learning writing as a basis for developing functional literacy pupils, help them to use normative knowledge of the language and to write what they have to express. Talking and writing are connected, and thus should be considered expressions of pupils, who can tell at first what to write, and then to write. There are pupils, who already at an early age distinguish by their expression. It is important to note that these phases help pupils to express themselves better. If a pupil is restrained by questions or plan in writing, the teacher will give him instructions on how to use them. Questions or plan to write are basic, and they can always be upgraded or modified. Practically, in class, this means that the student for each question or plan thesis could write a few sentences, or can use them as a reminder. However, each pupil must have a plan that will help him to think about the topic, form of expression, distribution of materials and a personal touch that will make the composition. This does not mean that the pupil should be restrained in expression, but to have guidelines to organize and shape his thoughts. Not even the greatest speakers and writers did not speak or write without designing their speech or text. It is always necessary to arrange the analysis and comments on students' written texts after writing. Evaluation of pupil essays is a topic that is extensive and beyond the scope of a work, and we will here only point out its significance. The pupil must know what is expected of him and to be able to analyze how his peer respond to those requests. "The goal of the evaluation of expression is that the student knows that he has fulfilled the set criteria, and which elements of his speech should be corrected. By constantly practicing with the instructions and requirements, as well as, by evaluating, the student improve his speech" (Cvetanović, 2009: 238). Therefore, the teacher must constantly refers students to the requirements of the correct spelling, gradually introducing requirements relating to forms of expression, the structure of statements and aesthetic component.

3. FORMS OF WRITTEN EXPRESSION OF STUDENTS IN ELEMENTARY GRADES

Basic forms of oral and written expression of pupils in elementary grades are retelling, narration, describing and reporting. The teacher usually organizes special classes in which students first orally express themselves, and then write.

Retelling is the form of oral and written expression in which the pupil repeats the plot he has read or heard. It is useful for pupil who narrates and for student who listens (reads). In teaching practice, literary, scientific and other texts, plays, cartoons and films, radio and television shows are often retelled. There are several types of retelling: retelling by answering questions, literally, informative, in parts, with the change of the end of the story, with the change of point of view, the change of grammatical person. Selection of materials and facts is important in retelling text, obligation to constantly take care of chronology is also important, and finally, the entity must be ensured. Retelling develops and promotes creative expression of pupils. "When students are allowed to express their creativity, besides their individual work, it is called a creative retelling. What distinguishes creativity is at least represented in the literal retelling, since its function, as the name stands out, is that some content may be reproduced in full" (Cvetanović, 1996, 32). Retelling begins systematically, when students learn the technique of writing. At first it is simple, and it usually is by answering the questions. Pupils read the questions and answer them in written form, and all the answers are entity, i.e. retold story. The next level is retelling by order of events, with a plan that guides students through the content. These forms of written retelling are realized in the first grade. From the second grade teacher organizes creative types of written retelling, first with collective, and then with individual plan. A creative retelling implies that the basic content is reproduced with small finishing or the story is used as a basis to obtain production with elements of creativity. In class, a few pupils first orally, and then everybody, in class or as a homework, retell the story in written form. The teacher can organize special classes where students orally, and then in written form paraphrase story.

Narration is the independent design and the presentation of content by speech or writing. Pupil talks about something he has experienced, what has happened or what is fictional. The basis of narration is reality or imagination. While he talks, pupils shapes the content at the same time, and the composition of story, too, enlarge the characters, imagines situations. The pupil can talk about his experiences, events, or according to series of images, or about the picture with an event, then according to the imagination, according to the given start or a free theme. A pupil may be required to give his narration a different order than chronological (e.g. to start talking about the most exciting moment of the story, to begin with the end, to give dramatic places a dialog shape, and enter into the essay other complex elements, and their own narration). Narration is characterized by special features that clearly separate it from other forms of expression. They consist of the following: "1) subject to presentation of the story is an interesting, exciting, dynamic event that leaves a strong impression on student and evokes the appropriate cognitive and emotional reactions, 2) such an event can be a personal experience of student, where he was a witness, or one of his players, but it can be the product of student's creative imagination and his ability to reconstruct what he has just heard, 3) narration is a personal view of a particular event, it reflects the subjective opinion of each individual to the event, and it also has a free interpretation (both stylistic and linguistic) of what is said" (Vučković, 1993: 121).

Description talks or writes about the sensory perception of objects, creatures, landscapes, portraits, and more. This form of expression has an effect on the development of visual culture of pupils, especially in developing observational skills. Students in lower grades haven't developed enough observation experience and they see things in general and in the particulars that usually aim to differentiation of major and minor things. Therefore, it is necessary, by systematic exercises of description, to develop observational skills of students - sense of observation, analysis, and then synthesis and sensual experience. According to the participation of the senses description can be: visual (observation), auditory (hearing), olfactory (smell), gustatory (taste) and tactile (touch). In the lower grades, generally practiced visual descriptions are generally practiced, but it shouldn't neglect other forms of description.

Reporting is the notification of an event, which is objective and real, without the emotional and imaginative. It introduces pupils to the news reporting. About the event is written in a simple, clear and objective way, accurate information about an event is transmitted, no personal comments. The report must answer the following questions: what happened, who were the participants of events, where it happened, when it happened and how it happened. Pupils report on all the events of their environment (school, street, sports events, television, internet, etc.).

The teacher appoints forms of expression and refers pupils to their specific methodological guidance and instructions. If a student knows that when he retells he needs to reproduce the contents of a literary work, and must follow the sequence of events in the story, he has the initial guidance on how to write. When he writes about the event he pays attention to bring his personal touch, his feelings, intentions, writes about his environment and tells what happened to him. All these specifications are the basis for setting up the first criteria which relate to the content of the essay. When pupils learn the specifics, then they gradually introduce criteria related to the richness and expressiveness of expression. Later, when they learn the technique of writing and basic forms of expression, pupils are introduced to the independent and creative writing. Sometimes in teaching practice only the basic forms of written expression are used, which has no methodological justification. They need to have equal representation of various forms of exercising written preparation, because the pupils are more interested in writing that way.

4. ORGANIZING THEMATIC MATERIAL AND WRITING COMPOSITION

Gathering of thematic material for writing a collection of more facts that will explain and confirm the set theme, which uses the senses, memory, imagination, thinking, emotions and so on. To talk about a certain theme in be a logical order, in a written essay it should achieve regularity and beauty of language expression. Regularity of expression consists of the written literary language for which complete management a good knowledge of grammar and spelling is needed. Beauty of expression is a higher level in the development of literacy, which is achieved by individual linguistic expression (style). For a quality written expression a good choice of words and properly formulation of sentences are of great importance. Therefore, it is necessary to the overall preparation of student's direct attention to this side of a written assignment. Each word has its own meaning and the clarity of thought depends on the choice and order of words, and thus the beauty of written expression. In preparation for the written expression, pupils should get used to use the shorter and longer sentences, provided that each sentence expresses a complete thought. If a pupil shared his thoughts and feelings in his essay, it is necessary to respect grammatical rules, which should be dealt with not only in language classes, but in all situations when pupils write something. Writing plan is very helpful for students in writing essay. It can be made by a teacher (given plan), by students together (collective plan) or each pupil can make his own (individual plan). The plan usually emphasizes (it is written on the board, showed on the slide), and the students write it down in their notebooks. Creating a plan always starts with a collective work, frontal. When pupils are enabled to successfully carry out this operation, then they can constitute a plan individually. Methodical process of introducing students to written expression implies a gradual complexity of tasks and self-reliance. Initially, the teacher gives a writing plan, then the plan arranges frontally, and then the formation of the individual plan of writing begins.

Methodical steps which lead students through the initial writing can contribute to that the students gradually adopt the ways and forms of written expression with the fewest errors. The first stage in this process is to answer the questions when pupils practice writing, and the questions are helpful, because according to them and their answers, they form sentence and write a whole more easily. To advanced pupils, these questions only serve as a plan and a reminder for writing. In the second phase, students write according to the plan, using it as a reminder, that guides them through the topic they need to write. While they write according to the plan, pupils structure their work in parts and revolve how to arrange thesis into a structure of written essay. When they learn the correct formation of sentences, their connection and writing a comprehensive essay, changes to the individual plan. It is made according to the theme and form of expression. While they make a plan, pupils share their opinions on what should be written and so the plan for writing is individualized. Teacher encourages pupils to make their own plan based on their ideas, thoughts and content of essay. Writing according to questions, and on the basis of given, and later a group plan, are only stages that should direct students to the third stage which is the goal of the initial functional literacy. It is a self-writing based on an individual plan, as each student individually creates a plan for writing, collects material, determines the flow of thoughts and expression of ideas. Individual writing then carries on practicing and improving throughout the school with the constant replenishment of requests.

5. METHODOLOGICAL FOUNDATION OF RESEARCH

The subject of research is the method of preparation and methodical introducing pupils to the initial written expression. Methodological guidance suggests that teacher directs and makes students become independent to write, is discussed here. One of the factors of this research is a form of written expression, and it is commonly used in classrooms. The aim of the research is to determine how teachers prepare and introduce pupils to the initial written expression. **The aims of the research are**: 1. investigate the methodical introduction of first grade pupils in written expression; 2. determine how students immediately prepare for writing essays; 3. examine which forms of expression are infected with practice in teaching and 4. determine how teachers methodically lead pupils as they write. The basic **method of the research** is descriptive, and the technique that was used in the study is a survey of teachers. The survey instrument was a questionnaire.

Hypotheses of the research. During the research, we set the following assumptions:

1. teachers introduce pupils to written expression with detailed methodological guidance;
2. teachers plan and implement all forms of written expression.

We expected that teachers methodically introduce pupils in the preparation and implementation of written expression. Also, we assumed that the students are introduced to use all the basic forms of written expression.

The sample of the research. The study included 380 teachers from primary schools in Serbia. The majority of teachers surveyed have a university degree (79.5%), a small number of higher and secondary education.

Table 1. Education College teachers surveyed

Education University	**f**	**%**
Secondary	2	0,5
Higher	76	20,0
University	302	79,5
Totally	380	100,0

It was crucial for the research to determine the length of service of teachers surveyed, as shown in table 2.

Table 2. Teachers' length of service

Length of length of service	**f**	**%**
0-9 years	57	15,0
10-19 years	164	43,2
20 and over	159	41,8
Totally	380	100,0

The majority of teachers surveyed have more than ten years (43.2%) or over twenty years of (41.8) of service. It can be concluded that the majority of teachers who participated in this study have many years of experience.

6. INTRODUCING STUDENTS TO WRITE – THE RESULTS OF THE RESEARCH

In the lower grades of elementary school teachers gradually introduce students to written expression. For this study it was important to identify how the teachers in the first and the other grades prepare students to write the essays of forms of expression commonly realize and how the preparation is realized immediately before writing. Introducing pupils in written expression begins in the first grade of primary school and because of that the teachers testified about how they methodically administer the first attempts of pupils to write independently, and the results are shown in table 3.

Table 3. Introducing pupils to write in the first grade

When pupils in the first grade are introduced to write retold text, then you	f	%
introduce pupils with written questions whose answers are provided by retold text	146	38,4
make the plan of text	127	33,4
give pupils verbal instructions	33	8,7
allow students to retelling independently	73	19,2
Unanswered	1	0,3
Totally	380	100,0

Teachers who participated in the study (38.4%) often first introduce pupils to written questions whose answers provide a retold text. Often, as a preparation for retelling, the plan of text is made, to suit the teachers surveyed (33.4%). Thus, about two-thirds of respondents give specific instructions for retelling text. These data indicate that teachers gradually introduce pupils to written expression, because the plan is to write with a question or thesis, adequate preparation for future independent writing. One of the interviewed teachers remind pupils to retell individually (19.2%). Self-expression in writing in the first grade of elementary school is very complex for pupils, since they focus first on writing techniques, and then on the content. Also retelling is a form of expression where you can follow the action of a literary text, and thus, in the course of writing, the student must remember the chronological order of events. 8.7% of teachers surveyed give oral instructions to students for written retelling, indicating that the preparation for this form of expression is implemented with these methodological guidelines.

For this study it was important to determine how teachers prepare pupils to write an essay.

Table 4. Preparation for writing

How you prepare pupils for writing an essay?	f	%
I make a joint plan of writing with pupils.	160	42,1
I refer pupils to make an individual plan of writing.	41	10,8
I organize an oral exercise.	138	36,3
I give an example of a well-written essay.	6	1,6
I refer pupils to the subject and manner of writing.	33	8,7
Unanswered	2	0,5
Totally	380	100,0

According to the survey results which are shown in Table 4, there were two ways in which teachers prepare students for writing composition. The first is the creation of a common plan of writing, and the second relates to the organization of oral exercise as a preparation for writing. These two ways of introducing pupils to write are methodically adequate. The plan indicates students to the content of an essay and to the logical order of presentation. During the oral exercise students tell what they write, so an organized speech is a good preparation for writing.

Forms of written expression that can be practiced at school are different and that's why it was important to examine the teachers of the most basic forms of organizing in classrooms.

According to the surveyed teachers, pupils often write about their experiences or events. The average rank (1.74) shows that it is practiced more frequently than other forms of expression. Second rank is a written description, and the third form is written retelling. The average rank of these forms of expression indicate that it is approximately the same number of teachers placed in second place in the representation in the teaching of language culture. Students' writing on the basis of imagination is in fourth place, indicating that this form of expression is used less than others in the elementary grades, according to the teachers surveyed.

Table 5. Forms of expression that are commonly practiced

When you develop written expression, pupils are usually given to	the average rank	Rank
write about events or experiences	**1, 74**	1.
written description	**2,69**	2.
written retelling	**2,70**	3.
write to the imagination	**2,79**	4.

Table 6 shows the manner in which teachers guide the pupils to write essays. The teachers selected the given answers, which give students the opportunity to write with the help of the plan, with oral instructions or to write independently. These three ways of writing include introducing students to write independently, first under the guidance, and then independently.

Table 6. Methodological guidelines for writing an essay

How pupils **often write essays?**	**f**	**%**
With the plan	238	62,6
With oral instructions	102	26,8
write independently	37	9,7
Unanswered	3	0,8
Totally	380	100,0

The interviewed teachers (62.2%) often indicate pupils to the plan as they write essays. Plan writing is a good methodical way to introduce students to independent written expression, especially as the plan may consist of a variety of ways, as well as frontal and individually. While a pupil thinks about the plan, he prepares to write, brings together the thematic material, decides how to start, what to write and how to finish the essay. Thesis for writing lead pupils and help them to connect sentences, lead their thoughts and write a complete essay. Oral instructions are given by about a quarter of teachers surveyed (26.8%), which indicates that such a methodical conduction is mostly represented in the elementary grades. The lowest percentage of teachers surveyed (9.7%) let pupils to write independently. Although pupils from second grade write independently, it is still necessary that a teacher leads them methodically, focuses and prepares them for writing an essay.

3. CONCLUSSION

A pupil in the first grade of primary school learns to write. This is only the beginning of methodically organized training for writing as a specific means of expression. For pupils who have just learned how to write, writing individually is very complex and difficult, and beginner difficulties make them lose their thoughts as they write, focusing on the technique of writing. Writing without rules and guidance comes down to learning from mistakes, and so the pupil can correct his mistakes when he made them. Teachers gradually introduce students to writing, first with the help of the questions that must be answered by writing, and then use the plan to write an essay independently. Pupils learn to write retold texts, describe the environment, write about the events, and experiences based on imagination. Various types of these basic forms of expression that are practiced at the school, prepare students for written expression, especially for the preparation of comprehensive texts, i.e. essays. A pupil has to practice to write an essay, because it is necessary that from the first learned letters to first written texts, methodical ways are designed. The empirical survey of methodical ways and means of introducing students to written expression, involved 380 teachers. The results show that teachers in the first grade give pupils the instructions for retelling text, usually with questions whose answers are provided by retold text. Students prepare to write an essay prepared by a real plan for writing or oral practice, which precedes writing. Based on these results it can be concluded that teachers introduce students to written expression with detailed methodological guidance. Teaching writing about events or experiences are the most common types of written expression that are practiced. Methodological guidance of pupils in written expression is well organized, which should be adequate preparation for independent and creative writing. The pupil will express their creativity when he applies operational knowledge and master the basics of written expression, gradually and with teacher's direction. Guidance during the initiation of writing helps pupils to be able to write their texts later, and to become real creators of written expression.

REFERENCES

1. Vučković, M. (1993). *Metodika nastave srpskog jezika i književnosti*. Beograd: Zavod za udžbenike i nastavna sredstva.
2. Milatović, V. (2011). *Metodika nastave srpskog jezika i književnosti u razrednoj nastavi*. (prir. Cvetanović Z., Janićijević V., Mićić V.). Beograd: Učiteljski fakultet. (ћир.)
3. Regulation on the curriculum for first and second grade of primary education: Pravilnik o nastavnom planu i programu za prvi i drugi razred osnovne škole (2004). Beograd: *Službeni glasnik RS – Prosvetni glasnik*, br. 10.
4. Cvetanović, V. (1996). *Samostalni i stvaralački rad u nastavi srpskog jezika*. Beograd: Bodex.
5. Cvetanović, Z. (2009). „Praćenje, vrednovanje i poboljšavanje učeničkih postignuća u nastavi govorne kulture". U: *Inovacije u osnovnoškolskom obrazovanju – vrednovanje* (dr I. Radovanović, dr B. Trebješanin, ur.). Beograd: Učiteljski fakultet, 231–239. (ћир.)
6. Cvetanović, Z. (2010). „Developing initial functional literacy in students". In: *A pupil and a teacher in contemporary education* (doc. dr. Zaclona, prof. dr I. Radovanović, eds.). Nowy Sącz: State higher vocational school in Nowy Sącz; Belgrade Faculty of education, University of Belgrade, 20–30.

UVOĐENJE UČENIKA U PISMENO IZRAŽAVANJE

Razvijanje pismenog izražavanja u mlađim razredima osnovne škole ima komunikativnu funkciju kojom se misli, ideje i opisi pisanjem prenose jasno i precizno. Cilj razvijanja umenja i navika pisanja je da se učenik postepeno osamostaljuje i sam stvara pisane tekstove. Prelaz sa pisanja rečenice na pisanje kraćeg sastava najvažnija je etapa u funkcionalnom opismenjavanju učenika, a taj prelaz treba da je postupan i metodički osmišljen. Učenici ne treba da improvizuju, već je potrebno da ih nastavnici uvode u tehniku pisanja celovitog iskaza postupno, uz podsticanje kreativnosti i stvaralaštva. U radu su prikazane metodičke osnove za uvođenje učenika u pismeno izražavanje koje obuhvataju graditeljske elemente, sačinjavanje plana i oblike koji se praktikuju od prvog razreda osnovne škole. Ispitano je mišljenje 380 učitelja o ovim segmentima nastave pismenosti. Cilj ovog rada je pregled teorijskih i metodičkih osnova za uvođenje učenika u početnu pismenost.

Zorica Cvetanović, Univerzitet u Beogradu, Učiteljski fakultet
Kristina Šulović Petković, Centar za edukaciju Torbica, Beograd

NEURAL NETWORK-BASED RECOGNITION OF WHISPERED SPEECH

ĐORĐE GROZDIĆ[1,2], BRANKO MARKOVIĆ[3], JOVAN GALIĆ[4], SLOBODAN JOVIČIĆ[1,2], DRAŠKO FURUNDŽIĆ[5]

Life Activities Advancement Center, Laboratory for Psychoacoustics and Speech Perception, Belgrade, Serbia[1]
djordjegrozdic@gmail.com[1]
School of Electrical Engineering, University of Belgrade, Telecommunications Department, Belgrade, Serbia[2]
jovicic@etf.rs[2]
Čačak Technical College, Computing and Information Technology Department, Čačak, Serbia[3]
brankomarko@yahoo.com[3]
Faculty of Electrical Engineering, University of Banja Luka, Department of Electronics and Telecommunications, Banja Luka, Bosnia and Herzegovina[4]
jgalic@etfbl.net[4]
Mihajlo Pupin Institute, Belgrade, Serbia[5]
fudra07@gmail.com[5]

Abstract: This paper presents experimental results of whispered speech recognition in comparison to normal speech recognition, using the artificial neural network (ANN). *Whi-Spe* corpus, which consists of the whispered/ normal paired words, was used in speaker depended experiments. As an input of the ANN three sets of acoustic features, the MFCC (Mel Frequency Cepstral Coefficients), the TECC (Teager Energy Cepstral Coefficients), and the TEMFCC (Teager Energy based Mel Frequency Cepstral Coefficients), were applied. Results showed nearly equal efficiency of the ANN in normal speech recognition (99.9%) and whispered speech recognition (99.86%) and preferred both the TECC and the TEMFCC over the MFCC feature. Specifically, in the case of whispered speech recognition with the TECC feature, when ANN was trained for normal speech, the recognition was 68.32% and, in the opposite case, when ANN was trained for whispered speech, the normal speech recognition was 74.32%.

Keywords: speech recognition; whisper recognition; neural networks; whisper-red speech database.

1. INTRODUCTION

Whispered speech is a specific form of speech that is often used in verbal communication. It is whispered in different situations, for example when we want to make a discreet or an intimate atmosphere in conversation, in the library so as not to disturb other people, or when someone tries to conceal some confidential information from the ears of other people. Whispered speech is often used in criminal activities, especially in telephone conversations where criminals try to disguise their identity. However, despite of the conscious production of a whisper, whispering may occur due to health problems which appear after rhinitis and laryngitis, but for some people it seems like a chronic disease of the larynx structures [Ito, 2005; Jovičić, 2008].

By its nature and mechanism of production the whisper is significantly different from the usual speech. It is characterized by a noisy structure and the absence of glottal vibrations. Due to the absence of glottal vibrations, whispering lacks the fundamental frequency of the voice, intonation contours and, consequently, a good part of other prosodic information. It was found that vowel formants at lower frequencies were shifted to the higher frequencies, and that the slope of the spectrum of whisper was much flatter than in speech [Zhang, 2007; Jovičić, 1998]. In addition, whispered speech has a significantly lower energy as compared to normal speech [Jovičić, 2008].

The mentioned features of whispered speech are a significant problem in speech technology, especially in speech synthesis, speech recognition, as well as in the identification of the speaker. Therefore, whispered speech is the hot topic in recent researches [Ito, 2005, Fan, 2011]. On the other hand, it is interesting that this type of speech communication, in spite of increased efforts in perception, performs perfectly understandable. The question is: how does whispered speech have such a high intelligibility despite its significant differences regarding normal speech?

There are different approaches, techniques and methods of speech recognition. These techniques are usually based on algorithms of the HMM (Hidden Markov Model), the DTW (Dynamic Time Warping), the ANN (Artificial Neural Network) and their hybrid solutions [Holms, 2001]. Due to the similarity of the ANN with the structure of the human brain and its way of speech perception, it was hypothesized that the ANN could yield good results in the recognition of whispered speech. To analyze this hypothesis, a study of the application of the ANN in recognition of whispered speech in comparison to normal speech was performed. As an input to the ANN three sets of features in normal speech and whispered speech were used: Mel Frequency Cepstral Coefficients (MFCC), Teager Energy Cepstral Coefficients (TECC) and Teager Energy based Mel Frequency Cepstral Coefficients (TEMFCC).

MFCC are one of the most widely used cepstral features in speech analysis computed from the log-energies in frequency bands distributed over a Mel-frequency scale [6]. TECC are computed by the estimation of the cepstrum coefficients of the short-time average Teager-Kaiser energy operator (TEO) for each one of the Gammatone filter bank output signals [Dimitriadis, 2005]. TEMFCC are obtained by taking the absolute value of the TEO of the short-time Fourier transform of the signal (STFT), warping it to a Mel-frequency scale, and taking the discrete cosine transform (DCT) of the log-mel Teager-energy spectrum [Georgogiannis, 2012]. The primary difference between Teager Energy features and MFCC feature is the use of TEO instead of squared energy in feature extraction process. As noted in [Quatieri, 2002], an important property of the TEO in discrete time is that it is nearly instantaneous and that only three samples are required in the energy computation at each time instance:

$$\Psi(x[n]) = x[n]^2 - x[n-1]\,x[n+1]. \tag{1}$$

The Teager-Kaiser estimated energy incorporates both amplitude and frequency information and represents the "true" source energy [Dimitriadis, 2005]. The hope is that the additional information in the estimated energy can be translated into improvement in whispered speech recognition accuracy. The difference between two Teager Energy features is that TECC employs the Gammatone filter bank as opposed to TEMFCC that employs the Mel-frequency filter bank.

Recent studies [Dimitriadis, 2005; Georgogiannis, 2012] showed that both TECC and TEMFCC are more robust than MFCC in noisy conditions and it is supposed that both features can be worthwhile in whispered speech recognition.

The paper is organized as follows: in Section 2, a description of speech corpus is given, Section 3 contains the description of features extraction of speech stimuli used as an input to the ANN, Section 4 describes the characteristics of the ANN, Section 5 presents experimental results, and the Conclusion summarizes the results and indicates directions for further research.

2. CORPUS DESCRIPTION

In order to confirm the effectiveness of the ANN in whispered speech recognition, this study uses the Whi-Spe (Whispered Speech) corpus especially developed for this purpose [Marković 2013].

Whi-Spe corpus contains 50 whispered/normal paired words: 14 numbers, 6 colors and 30 words. Words were taken from the Serbian emotional speech database GEES [Jovičić 2004], which satisfies the basic linguistic criteria of Serbian language (phonemes distribution, syllable composition, accentual structure, consonant clusters). The whispered and normal speech was collected from 5 male and 5 female speakers. Each speaker had read all 50 words ten times in both speech modes, so the Whi-Spe corpus contains 10.000 recorded words.

The corpus was recorded in a quiet laboratory room using Optimus omni-directional tie-clip microphone at a distance of 25cm from the speaker's mouth for neutral speech and 5cm for whispered speech. Speech data was digitized using a sampling frequency of 22.050Hz, with 16 bits per sample, in Windows PCM wav format.

In each session, subjects pronounced the whole set of 50 words continuously in both speech modes, and sessions were separated by longer time intervals for several days. The segmentation of the words from the recordings was manually performed and each word was one entry to the Whi-Spe corpus. Quality control of the recordings found various errors, of subjective and objective nature. In normal speech there often occurred a wrong pronunciation of a given word or an incorrect articulation of some voices (which is common in everyday speech), while the recording was often featured with an acoustic shock effect in the microphone because of the intensive pronunciation of words. However, most of the bad recordings are referred to the words spoken in whispered speech. The most typical mistakes in pronunciation and recording of whispered words were: a too weak form of pronunciation in whispering (significantly masked by noise), a heavily emphasized whisper (amplitude distortion), penetration of sonority in the pronunciation of a whisper, omission of phones, blowing directly into the microphone (acoustic shock), irregularity in articulation (stridence phenomenon [Jovičić, 2008], the moment of lift-off tongue palate, etc.).

3. FEATURES EXTRACTION

In spoken word recognition based on ANN we have used a fixed number of frames for MFCC, TECC and TEMFCC feature extraction. There are two methods to get a fixed number of frames for speech signals if they have different lengths, as in the case of the Whi-Spe corpus: (1) dynamic numbers of sample points over windows, and (2) dynamic windows overlap rates [Pan, 2007].

We have used the first method, and each word from the Whi-Spe corpus was segmented into eleven frames that overlap 50%, using *Hamming* windows. The number of frames (eleven) was determined by the statistical distribution of the number of phones in words from our speech database. The range of the number of phones per word is from 3 to 9 (with the exception of two words that have 12 and 13 phones). The average number of phones per word is 5.58, so the most common case is to have 4, 5, or 6 phones per word. Using 11 frames per word gives an average of one frame per phone in long words, while in short words there are two or three frames per phone. We assumed that this finer temporal and spectral resolution of shorter words should contribute their identification while, on the other hand, a richer phonetic content of long words contributes their identification.

Every speech frame was represented by three feature vectors: 12 MFCC coefficients, 12 TECC coefficients and 12 TEMFCC coefficients, and theirs first and second derivatives. Finally, each vector consists of 132 coefficients per word, or 396 coefficients per word including first and second derivatives, for each feature, MFCC, TECC and TEMFCC, in both normal and whispered speech.

4. NEURAL NETWORK

In this paper Feedforward ANN with Back Propagation algorithm in training process was used. ANN was realized as multilayer perceptrons (MLP) using MATLAB Neural Network Toolbox [Demuth, 2002]. Two identical networks were formed – one for normal speech and other one for whispered speech. Each network had three layers: the input, the hidden and the output layer. Depending on the length of the input vector, the input layer contained 132 or 396 input nodes, the output layer contained 50 neurons and the number of hidden neurons was experimentally determined and shown in next section. Tansig (hyperbolic tangent sigmoid) function was used as the transfer function of neurons. Total database of words was divided into three parts: 60% of the data were used for training, 20% for validation and 20% for testing. The networks were trained using the trainscg function which is based on the scaled conjugated gradient algorithm. This algorithm was developed by Martin Moller and represents a combination of the Levenberg-Marquardt algorithm and the scaled conjugated gradient principle [Masters, 1993]. Trainscg network training requires a large number of iterations but it significantly reduces the total number of arithmetic operations and the time required to train the network, which makes this function suitable for large neural networks. The criteria for stopping the training of the network were: the defined maximum number of iterations (1000), the mean square error (0.00), the maximum number of consecutive errors in validation, the so-called early stopping method (6) and the minimum gradient (10^{-6}). The analysis of network topology, in terms of the number of hidden layers, showed no significant influence on the results of recognition, so we stuck to the original network structure with three layers.

5. RESULTS

This section presents the results of the analysis of spoken word recognition of ten speakers from the Whi-Spe corpus - five males and five female. Three experiments were done. In the first experiment, we analyzed word recognition in normal and whispered speech based on cepstral coefficients depending on the used speech feature (MFCC, TECC, TEMFCC) and the number of neurons in the hidden layer. The second experiment tested the simultaneous use of speech features and their first and second derivatives. The third experiment analyzed the behavior of the ANN in different types of train/test scenarios.

5.1 Experiment I

Several different recommendations were tested for finding the optimal number of neurons in the hidden layer ("rule of the thumb", "geometric pyramid rule") [Pan, 2007]. All calculated values were in the range 60-130 neurons. In this experiment we analyzed the word recognition depending on input vectors MFCC, TECC and TEMFCC (length 132 coefficients) and the number of neurons in the hidden layer, which had been changing 10 neurons per step.

The results are shown in Figure 1. It is observed that, even with 60 neurons in the hidden layer, the ANN has a high level of word recognition, so with further increasing the number of neurons the ANN quickly attain a maximum performance. For normal speech, recognition for the male speakers ranged from 97.8% to 100%, and for whispered speech recognition ranged from 96.2% to 99.6%. Similar results were obtained with the female speakers: normal speech recognition ranged from 95.9% to 99.6%, and recognition of whispered speech from 95.2% to 99.6%. Therefore, whispered speech recognition of both male and female speakers is slightly worse as compared to normal speech recognition. In almost all cases, the TECC and the TEMFCC features generally demonstrated better normal speech and whisper recognition than the MFCC feature. In Figure 1. we can clearly see that the TECC feature had the most success in whisper recognition compared to other features, with the score that ranged from 97.7% to 99.6%, and that the MFCC had the least success among them.

The results also show that in all cases the ANN already has maximum recognition with 80 neurons in the hidden layer. This number of neurons is very well matched with the theoretical prediction based on the "geometric pyramid rule" [Pan, 2007]:

$$N_h = (N_i \text{ x } N_o)^{1/2}, \tag{2}$$

where N_h is the number of hidden neurons, N_i is the number of input nodes, N_o is the number of output neurons, which in our case gives 81 neurons.

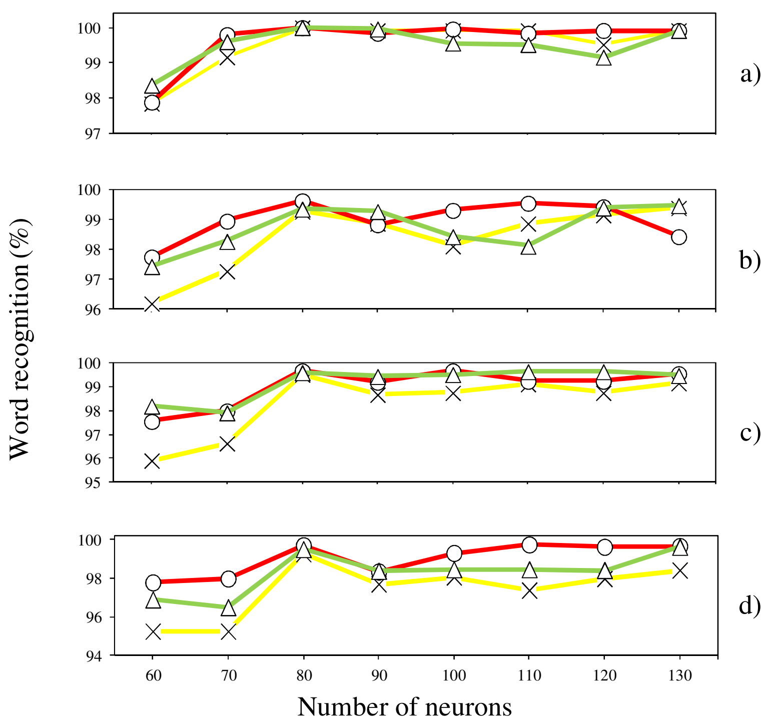


Fig. 1. Impact of number of hidden neurons and input features on word recognition. (a) male speakers – normal speech; b) male speakers – whispered speech c) female speakers – normal speech; d) female speakers – whispered speech. Legend of features: ○ – TECC, Δ – TEMFCC, × – MFCC).

5.2 Experiment II

The purpose of this experiment was to show the maximum capabilities of the ANN in normal and whispered speech recognition, taking into account the extended sets of cepstral coefficients by adding their first and second derivatives for all three types of speech features. In this case the structure of the ANN was: 396 input nodes, 140 hidden neurons (determined by (2)), and 50 output neurons.

Table 1. Maximum capabilities of MFCC, TECC and TEMFCC features in normal and whispered speech recognition (in %).

Mode of speech	Normal speech			Whispered speech		
Features	MFCC	TECC	TEMFCC	MFCC	TECC	TEMFCC
Male speakers	99.96	99.96	100	99.8	99.96	99.84
Female speakers	99.72	99.76	99.8	99.36	99.76	99.84

The results are shown in Table 1. ANNs showed very high efficiency in both speech and whisper recognition and reached almost 100%. It is obvious that the first and second derivatives additionally improved ANNs performances in word recognition. Because of reached "ceiling effect" it is hard to determine which feature gives better results.

5.3 Experiment III

The usual problem of the ASR (Automatic Speech Recognition) systems occurs at the point when a speaker switches from normal speech to whisper, or vice versa. The problem is related to different train/test scenarios in the ANN application. This experiment analyzes whispered speech recognition with the ANN that was trained to recognize normal speech, and vice versa, normal speech recognition with the ANN that was trained to recognize whispered speech. We used the ANN with the same topology as in the previous experiment. The results for all speakers are given in Figure 2.

Fig. 2. Word recognition scores for four train/test scenarios.

For speech/speech and whisper/whisper scenarios, recognition scores were very similar for all tree features, around 99.9%. The mismatch train/test scenarios, such as speech/whisper and whisper/speech, showed significantly lower recognition scores. For instance, the use of the

TEMFCC features has word recognition of 60.72% in the case of speech/whisper scenario and of 74.06% in the whisper/speech scenario. The TECC feature showed higher recognition score in speech/whisper scenario than other two features, 68.32% compared to around 61.29%. This result once again shows as in experiment I, that the TECC feature has the best results in whisper recognition. The relative relations of results in Figure 2 are in agreement with the results of the experiments performed on the HMM based recognition method [Ito, 2005].

6. CONCLUSION

In this study we examined the application of the ANN in whispered speech recognition. ANN shows almost equal success in recognition of both speech and whisper. Comparison of acoustic features MFCC, TECC and TEMFCC highlights TECC as the promising feature in whisper recognition. Interesting results have been obtained for the mismatch whisper/speech scenario where normal speech recognition was near 74.32%, with the ANN trained with whispered speech. Further evaluation of these phenomena will be in the focus of our future investigation.

ACKNOWLEDGMENT

This paper was supported by the Ministry of Education and Science of the Republic of Serbia under Grant numbers OI-178027 and TR-32032.

REFERENCES

Demuth H., Beale M. (2002). "Neural Network Toolbox User's Guide," The MathWorks, Inc, 2002.

Dimitriadis D., Maragos P., Potamianos A. (2005)."Auditory Teager Energy Cepstrum Coefficients for Robust Speech Recognition", *Proc. of European Speech Processing Conference*, Lisbon, Portugal.

Fan X., Hansen J.H.L. (2011). "Speaker identification within Whispered Speech Audio Stream," *IEEE Transactions on Audio, Speech and Language Processing*, 19(5), pp. 1408-1421.

Georgogiannis A., Digalakis V. (2012). "Speech Emotion Recognition Using Non-Linear Teager Energy Based Features in Noisy Environments", *Proc. of EUSIPCO 2012*, Bucharest, Romania, pp. 2045-2049.

Holms J., Holms W. (2001). "Speech Synthesis and Recognition," Taylor & Francis, London.

Ito T., Takeda K., Itakura F. (2005) "Analysis and Recognition of Whispered speech," *Speech Communication*, 2005, pp. 129-152.

Jovičić S.T. (1998). "Formant feature differences between whispered and voiced sustained vowels," *ACUSTICA - Acta Acoustica*, 84(4), pp. 739-743.

Jovičić S.T., Kašić Z., Đorđević M., Rajković M. (2004). "Serbian emotional speech database: design, processing and evaluation", *SPECOM-2004*, St. Petersburg, Russia, pp. 77-81.

Jovičić S.T., Punišić S., Šarić Z. (2008). "Time-frequency detection of stridence in fricatives and affricates", *Int. Conf. Acoustics'08,* Paris, pp. 5137-5141.

Jovičić S.T., Šarić Z. M. (2008). "Acoustic analysis of consonants in whispered speech," *Journal of Voice*, 22(3), pp. 263-274.

Marković B., Jovičić S.T., Galić J., Grozdić Đ. (2013). "Whispered speech database: design, processing and application", submitted to *The 16th International Conference TSD 2013*, Pilsen.

Masters T. (1993). "Practical Neural Network Recipes in C++", Academic Press, NY.

Pan S.T., Lai C.C. (2007). "Using genetic algorithm to improve the performance of speech recognition based on artificial neural network." In: M. Grimm, K. Kroschel (Eds.), *Robust Speech Recognition and Understanding*, I-Tech Education and Publishing, Vienna, Austria.

Quatieri T.F. (2002). "Discrete-Time Speech Signal Processing," Prentice Hall, NJ.

Zhang C., Hansen J.H.L. (2007). "Analysis and classification of Speech Mode: Whisper through Shouted," *Interspeech 2007*, pp. 2289-2292.

AUTOMATIC DETECTION OF STRIDENCE IN SPEECH USING THE AUDITORY MODEL

RUŽICA BILIBAJKIĆ[1], ZORAN ŠARIĆ[1], SILVANA PUNIŠIĆ[1], MIŠKO SUBOTIĆ[1], SLOBODAN JOVIČIĆ[1,2]
[1]Life Activities Advancement Centre, Belgrade
[2]School of Electrical Engineering, University of Belgrade, Belgrade
e-mail: r.bilibajkic@add-for-life.com

Abstract: Stridence as a form of disorder in Serbian speech is manifested by the appearance of an intense and sharp whistling. Although various forms of stridence manifestation are successfully diagnosed by speech therapists, there is a need for its automatic detection and evaluation. In this paper, a procedure for stridence detection using the Patterson's auditory model is presented. Detection algorithm consists of two steps. In the first step a potential contours of spectral peaks that can be perceived as stridence are detected. In the second step auditory perception model is used to evaluate the ability of selected spectral peaks contours to be perceived as stridence and to make ternary decision: a) stridence, b) no stridence, and c) unable to make decision. The quality of stridence detection is tested on the speech corpus of 26 subjects with stridence and 27 subjects without stridence, which gave high correspondence of subjective measures and automatic detection.

Keywords: speech pathology detection, stridence detection, time-frequency analysis, gammatone auditory model, auditory image.

1. INTRODUCTION

The atypical voice production affects speech intelligibility, the overall quality of verbal communications and thus the quality of life in general. Although experts in speech and language can successfully monitor all anatomic, physiologic and phonetic irregularities related to speech and voice production, there is the problem in establishing the interdependence of these factors and their impact on the development of voice disorders.

Stridence is one of the forms of atypical realization of voice. It is a distortion that is recognized as a special form of sigmatism, and mainly affects the fricatives and affricates. Strident (high-pitched) sigmatism is a phenomenon that is generated in the oral cavity caused by a too deep groove of the tongue. Tip of the tongue is at the proper place, the groove in the middle of the tongue exists, but it is too deep. During the friction this causes production of a whistling sound. Simultaneously it may be accompanied by the appearance of a stronger and longer noise that comes from the notch in the flow of air through a narrow tube. In some pronunciations noise increases with the speed of airflow that causes whistle-like effects.

The traditional form of stridence detection and diagnosis is based on perceptual (audio-visual) assessment of speech quality. Since that kind of assessment is subjective, there is a tendency to objectifies the judgment in order to achieve an objective and of systematic monitoring of course of speech therapy. For this purpose there are varieties of instruments that partly objectify the assessment of pathology. Instrumental measures like aerodynamic test, electromyography, laryngoscopy, radiology and acoustic analysis (Hirschberg et al., 2008) are used as objective indicators of the speech pathologies. Acoustic analysis has proven to be a useful tool in the lung wheezing and stridor evaluation (Earis and Cheetham, 2000; Taplidou and Hadjileontiadis, 2007). Analysis and detection of stridence is currently in the research phase (Punišić et al., 2007; Punišić et al., 2012; Jovičić et al., 2008; Bilibajkić et al., 2012). Advantages of acoustic analysis are its objectivity, reliability and availability of equipment for its performance (standard PC and the appropriate software).

The results of initial research on automatic detection and evaluation of stridence are given in Jovičić et al., 2008. This procedure is based on the FFT spectral analysis and Burg procedure for spectrum assessment using the maximum entropy method (Marple, 1987). Although this procedure is relatively reliable in detection of strong and undeniable stridence, it was noted that in some cases of weak stridence there is a discrepancy between automatic detection and judgment of the trained professionals. This is because the automatic algorithm does not incorporate psychoacoustic effects, primarily masking effect. As a result, the algorithm detects stridence even in cases where, due to the effect of masking, stridence cannot be heard.

In Bilibajkić et al., 2012 a new method based on auditory model is proposed. Model incorporates a bank of gammatone filters which very well models processes of sound perception in the human auditory system (Hohmann, 2002). Selected model allows the use of all major psychoacoustic effects of which the masking effect is most important for the perception of stridence. This allows better compatibility of stridence assessment obtained by stridence detection algorithm and those given by the trained speech therapists.

In this paper we present an improved procedure in respect of the one presented in Bilibajkić et al., 2012. The improvement is achieved implementing two separate phases for analysis and detection of stridence. In the first phase the signal is analyzed and contours of spectral peaks that can be perceived as stridence are extracted. In the second phase, using the auditory model, an assessment is made whether separate spectral peaks can be perceived as stridence or not. On that occasion a ternary decision is delivered: a) stridence exists, b) stridence does not exists c) unspecified. The success of stridence detection is tested on the database of 26 subjects with stridence and 27 subjects without stridence. Tests showed high compatibility of subjective and automatic stridence detection.

2. AUDITORY MODEL

Modern techniques of analysis and speech processing are largely based on the speech production model. Techniques such as Fast Fourier Transform (FFT), and cepstral analysis, are derived taking into account the physical processes that characterize the waveform of the speech signal in the process of transforming acoustic pressure into an electrical signal. Moreover, the technique of linear prediction (LPC), (Markel and Gray, 1987), and their variants are directly derived from the mechanism of human speech production. Unfortunately, these techniques have limited (relatively small) performance in the field of speech analysis, speech recognition and extraction, particularly in cases of strong ambient noise. The fact is that, currently, there is no algorithmic procedure for speech signal processing that could match performances of human auditory system, especially in the cases where different types of degradations are present such as noise and reverberation. Based on the fact that the human auditory system is undoubtedly the most successful system for speech processing, nowadays algorithmic methods are improved using psychoacoustic effects of human speech perception. Linear prediction on the so-called warped frequency scale (Strube, 1980), auditory model derived from the short time Fourier transform (STFT) (Blomberg et al., 1983), the LPC analysis based on speech perception (Hermansky et al., 1984) are just some examples of the use of knowledge about human speech perception in designing a speech signal representation. The most significant example of efforts to use knowledge in the area of auditory perception to improve speech processing is a mel-cepstral analysis of speech (MFCC) (Davis and Mermelstein, 1980), which is now widely used for automatic speech recognition (ASR).

All these approaches use the principle of "short time" speech analysis. A short speech segments are extracted and processed independently supposing that they are stationary part of the process. In order to improve the monitoring of dynamic changes in the speech signal parameters, the segments overlap. Reason for this approach is the assumption that the articulatory features of speech signal change relatively slowly in time. However, despite the use of overlapping segments (windows) in analysis, fine dynamic characteristics of speech signals are often lost.

Similar to STFT, the auditory model based on a filter bank decomposes speech signal into corresponding frequency components (Hohmann, 2002; Slaney and Lyon, 1993; Slaney et al., 1994; Seneff, 1988; Patterson and Holdsworth, 1996). However, unlike the STFT which has a linear frequency scale, filter bank uses nonlinear (usually logarithmic) frequency scale that provides a different resolution of low and high frequency components similar to the human auditory system. In addition, a filter bank continuously decompose speech signal, sample by sample, allowing fine tracking of dynamic characteristics of speech signal similar to the processes that occur during the speech perception on the basilar membrane. A number of different auditory models (Hohmann, 2002; Slaney and Lyon, 1993; Seneff, 1988; Patterson and Allerhand, 1995; Patterson and Holdsworth, 1996) are in use. Figure 1 shows the auditory model proposed by Patterson (Patterson and Holdsworth, 1996). Common feature of all auditory models is that the signal processing is carried out in three steps, Figure 1. The first step is frequency analysis of the signal using the appropriate filter bank, which simulates the transmission of acoustic signals to receptors on the basilar membrane. The second step is modeling of synaptic connections of hair cell receptors (Seneff, 1988). In a functional model, this step is implemented by a half-wave rectifier (HWR), the compressor module and time and frequency adaptation (automatic gain control) AGC. Result of the joined action of AGC, compressor and HWR modules are masking effects present in normal hearing. The third step is the creation of auditory images that can be modeled as a correlogram (Slaney and Lyon, 1993) or auditory images obtained using the quantized time integration (QTI), (Patterson and Allerhand, 1995; Patterson and Holdsworth 1996).

Auditory models have a large number of parameters that give them great flexibility in designing transfer functions and signal processing. On the other hand, large degree of freedom demands a more training and test samples as well as the extra effort invested by the researchers in the selection of processing elements and their fine-tuning. Various applications of auditory models in speech coding (Feldbauer et al., 2005), noise suppression and speech recognition (Wang and Brown, 2006) require certain modifications of auditory models and their adaptation to the specific needs of the application. In this paper, the basic Patterson model is modified primarily in terms of HWR modules and omission of temporal adaptation (AGC in time).

3. ALGORYTHM FOR STRIDENCE DETECTION

Block diagram of stridence detection process is shown in Figure 2. The speech signal undergoes preprocessing using the Patterson's model where spectral analysis, modeling of the basilar membrane receptors activities and neural encoding are performed. The result is time-frequency (TF) representation of the signal. Detection of stridence is carried out in two steps. First, in the time-frequency domain, the identification of the spectral peak contours that could subjectively be classified as stridence is performed. In the second step of the process the intensity of subjective assessment of stridence for each contour are evaluated, based on which the decision about the presence of stridence is delivered.

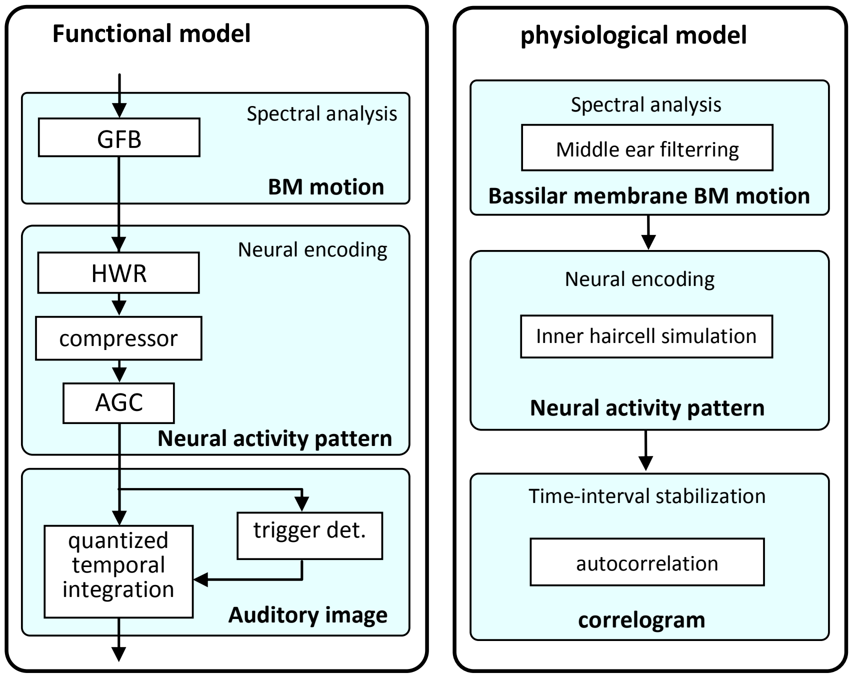


Fig.1. Patterson auditory model (Patterson and Allerhand, 1995)

3.1. Spectral analysis and neural encoding

The signal processing procedure is shown in Figure 3. Single-channel speech signal $s(t)$ is processed using the gammatone filter bank (GFB). Number of channels in filter bank is chosen to achieve the required frequency resolution with reasonable amount of CPU load. Depending on the available computing resources filter bank can contain from a few tens to several hundred channels. Central frequency and the channels' bandwidths are calculated by the ERB (equivalent rectangular bandwidth) scale that models acoustic transfer to certain points of the basilar membrane. In this paper gammatone filter bank is implemented using fourth order complex filters (Hohmann, 2002). Using the complex filter it is easier and more accurate to determinate envelopes of channel signals in comparison with the cases where real filters are used.

In the majority of cases, second module (ii) in auditory model is half-wave rectifier (HWR), as it properly models processes occurring at hair cells receptors. In our work instead of HWR, we calculated module of complex envelope of channel signal, because in that case the output is a smooth function which allows precise monitoring of the dynamics of the signal. Replacing HWR with the module of complex number does not introduce substantial changes in the model, because in both cases the initial information carried by the signal is fully preserved (Slaney et al., 1994).

As well as in the Patterson's model (Feldbauer et al., 2005), the third module (iii) is the power-law compressor, with transfer function

$$f(x) = x^{\beta}, \quad (1)$$

where β is a real positive constant that defines the degree of compression. It typically has a value of 0.4 (Feldbauer et al., 2005). This stage is similar to logarithmic amplitude compression schemes in ordinary waveform coders (e.g., μ-law).

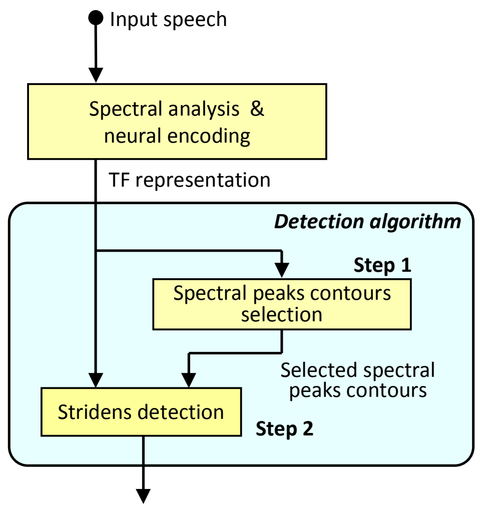


Fig.2. Stridence detection model.

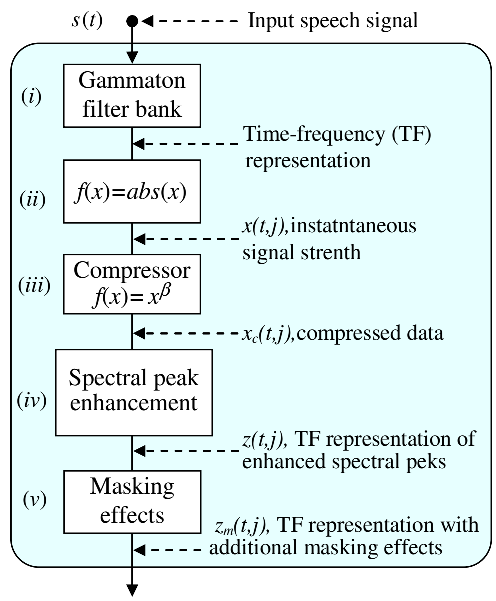


Fig.3. Spectral analysis and neural encoding.

Information whether stridence exists or not is contained in the spectral peaks. For this reason, enhancement of spectral peaks is applied in the module (*iv*). Emphasis of spectral peaks is realized by the subtraction of moving average (MA) filtered spectrum from the original spectrum (Taplidou and Hadjileontiadis, 2007; Patterson and Holdsworth, 1996). Output of the module (*iv*) is TF matrix with elements $z(t, j)$, where t is discrete time index, and j is filter channel with central frequency f_j.

Resonant tone that is perceptually identified as stridence may be masked by other spectral components, especially when strong friction is present in cases of fricatives. Modeling of the masking effect is implemented in the module (*v*) in such a manner that for each element of the input TF matrix, $z(t, j)$, two different power levels are calculated. First is a power level of the spectral components within a narrow frequency band (in band power), $P_{inBand}(t, j)$ that reinforces the stridence perception, and second, power levels outside this range (out band power), $P_{outBand}(t, j)$ which masks the stridence. Element of the output TF matrix, $z_m(t, j)$, is obtained by multiplying the input by weighted coefficient $z_m(t, j) = w(t, j)z(t, j)$, where weighted coefficient $w(t,j)$ is calculated like $w(t, j) = \min(P_{inBand} / P_{outBand}, 1)$. The output matrix of the module (v), is passed to modules for spectral peak contours and stridence detection.

3.2. Spectral peaks contours selection module

Module for spectral peaks contours selection, as shown in Figure 5, analyses the matrix $z_m(t, j)$ and detects the contours of spectral peaks that can be perceived as stridence. This is implemented through three steps. In the first step (*i*) for each time index t all local maxima in the spectrum are notified. In the next module, (*ii*) the individual spectral peaks form contours that connect neighboring spectral peaks. If peak exist in the time instant t in the spectral channel j, the contour is extended to the instant t+1 if there is a spectral peak at a position of j-1, j, j+1. Otherwise, the contour is terminated.

All contours cannot be a stridence. Quasi-periodic signal that is perceived as stridence has to fulfill two conditions:

(c_a) To have certain duration. Experiments showed that the duration should be longer than: T_{min}=9ms,

(c_b) Quasi-periodic signal should have a stable central frequency. The measure of stability is the deviation of the spectral peak compared to the value of mean frequency of contour and it should be less than a given threshold.

The contours which meet the requirements (c_a) and (c_b) are potential sources of stridence. Selected contours are tested in the next module to find out which one is actually producing stridence. For this purpose, a subjective measure of stridence is defined to be used for stridence detection.

3.3. Stridence detection module

Block diagram of the stridence detection process is shown in Figure 6. Two input values are used for detection. The first one is a time-frequency matrix $z_m(t,j)$, which contains elements of Patterson's auditory model. The second input is a set of spectral peaks contour p_i that can be perceived as stridence.

Processing and stridence detection is implemented in three steps. The first step (*i*) is instant expansion in order to further enhance spectral peaks. Expansion function has the inverse characteristic with respect to the compressor defined by (1). In next step, module (*ii*), calculation of stridence measures is carried out. Our intention was to define stridence measure that is in accordance with subjective evaluation of stridence. Proposed procedure for stridence measure calculation is as follows. Using TF matrix $z_{me}(t,j)$, for each of the spectral peak contours $p_i(t)$, a series of spectral intensities are formed

$$S_i(t) = z_{me}(t,\, p_i(t)),\;\; t = t_{min}, \dots, t_{max}, \tag{10}$$

where t_{min} is the first, and t_{max} last time index of the contour p_i. Element $p_i(t)$ of contour p_i is channel index. According to the constraint (c_a) length of the sequence $S_i(t)$ is greater than T_{min}. The intensity of stridence is calculated assuming a sliding window that is L=T_{min} long using the relation:

$$Str_i(t) = \begin{cases} \sum_{j=t}^{t+L-1} S_i(j), & for\ std\big(p_i(t), \dots, p_i(t+L-1)\big) < devMin(i) \\ 0\,, & otherwise \end{cases} \tag{11}$$

where the $Str_i(t)$ is partial sum of intensity on contour p_i at time index t. The requirement that the standard deviation of the spectral peaks frequency std(.) on the part of the contour from time index t to index t+L-1 must not exceed threshold $devMin(i)$ is a result of request that the frequency of the spectral peaks should be stable over time. Otherwise, these spectral peaks will not be perceived as whistle but as a noise. Standard deviation threshold $devMin(i)$ is frequency dependent. For the lowest frequency threshold

$devMin(1)$ is 1, and for the highest frequency it is 1.1. Thresholds for other filter channels are linearly interpolated.

Optimal contour p_i is one along which the maximum value $Str_i(t)$ is the largest, e.g.

$$i_{opt} = \arg\max_i \left(\max_t \left(Str_i(t) \right) \right) \qquad (12)$$

Stridence measure of the optimal contour is calculated by

$$d = \sum_{t=tmin}^{tmax-L+1} Str_{iopt}(t) \qquad (13)$$

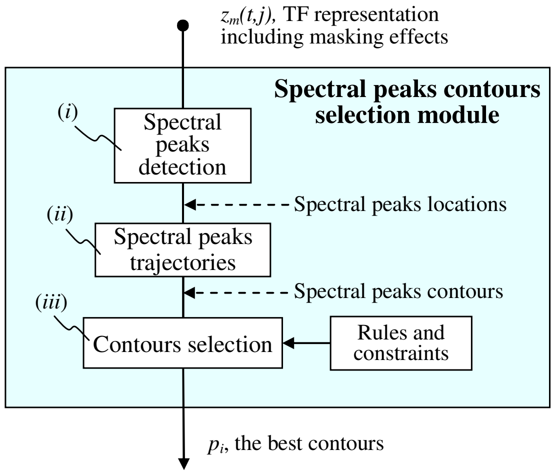


Fig. 5. Module for detection of "the best" spectral peak trajectories based on possibility of stridence.

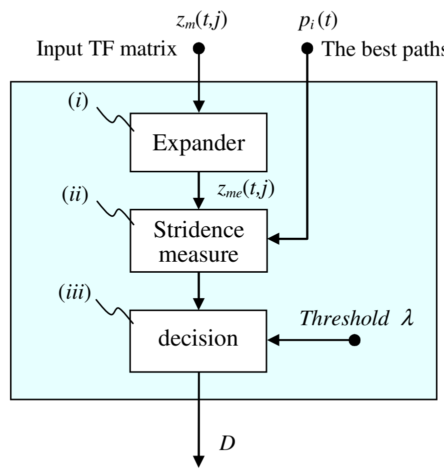


Fig. 6. Module for stridence detection.

The decision about the presence of stridence is made comparing the measure of stridence with three threshold measures

$$D = \begin{cases} D_0 \ \ without\ stridence, & for\ d < \lambda_1 \\ D_1 \ \ without\ decision, & for\ \lambda_1 \le d \le \lambda_2 \\ D_2 \ \ strong\ stridence, & for\ \lambda_2 < d \end{cases}$$

Decision D_0 means that stridence does not exist in speech signal, decision D_2 means that there is a stridence in speech signal, while decision D_1 means that the decision function d is an area where we cannot surely say whether stridence exists or not.

4. EXPERIMENTAL RESULTS

The algorithm was tested on a database of 53 subjects, school-age children. Testing was performed on the word „šuma" (eng. "forest"), where the initial phoneme /š/ is observed. Assessments obtained by trained professionals - speech therapist, are used as a reference. In 26 subjects, speech therapists determined existence of various degrees of stridence from weak to very expressive. Remaining 27 subjects were assessed without stridence.

Speech of each subject was recorded and digitized with sampling frequency f_s=22050Hz to be processed with proposed stridence detection algorithm. Gammatone filter bank contained 111 channels with central frequencies allocated by the ERB scale in the range from 900 Hz to 7940 Hz. In Figures 7a - 7f a typical pronunciation of phoneme /š/ with stridence are showed. Figures 7a, 7b and 7c show the time domain representation, the FFT spectrogram and TF representation using the filter bank, respectively. TF representation of the signal with emphasized spectral peaks $z(t,j)$ is displayed In Figure 7d. The positions of the spectral peaks are shown in Figure 7e. Figure 7f shows the contours that satisfy conditions (c_a) and (c_b), while the most prominent contour is shown in thick red line.

Figure 8 graphically shows the distribution of subjects with and without stridence in one-dimensional space of the stridence measure d. Thresholds λ_1=1.1 and λ_2=1.5 form three areas with decisions D0 - without stridence, D2 - with strong stridence, and D1 - without decision. According to the thresholds λ_1 and λ_2 (Fig. 8) we have one error of type D0/D2 (decision no stridence when really there is a stridence) and one error of type D2/D0 (stridence is detected even if there is no stridence). In the zone $\lambda_1 < d < \lambda_2$, where we cannot surely say if there is or there is no stridence, we have 3 subjects with stridence and 2 without stridence. In terms of percentages error D0/D2 is 3.8%, error D2/D0 is 3.7%, while 9.4% of all subjects are in the area without decision.

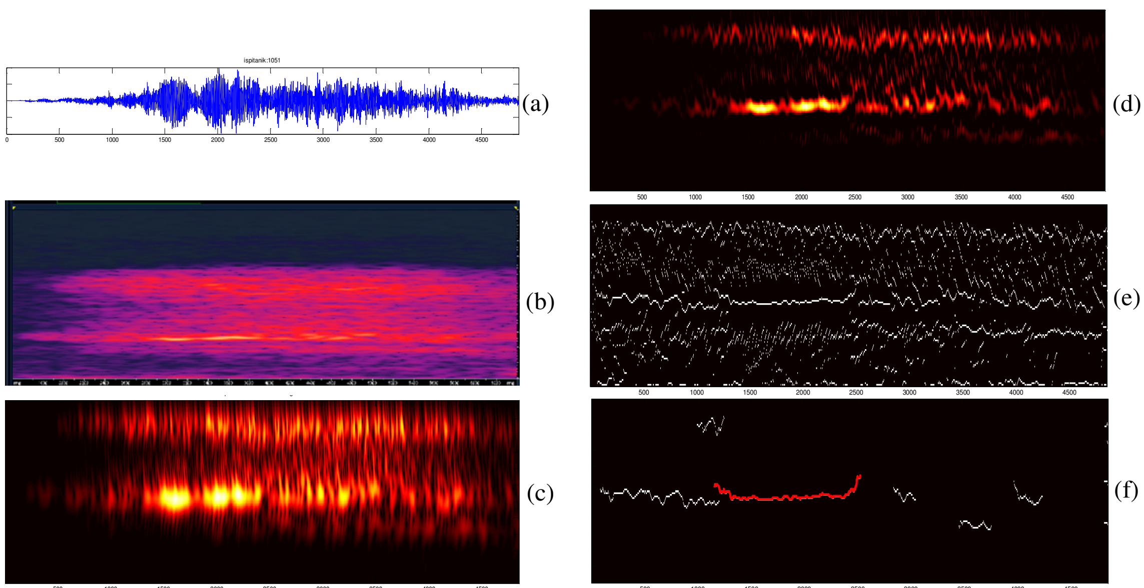
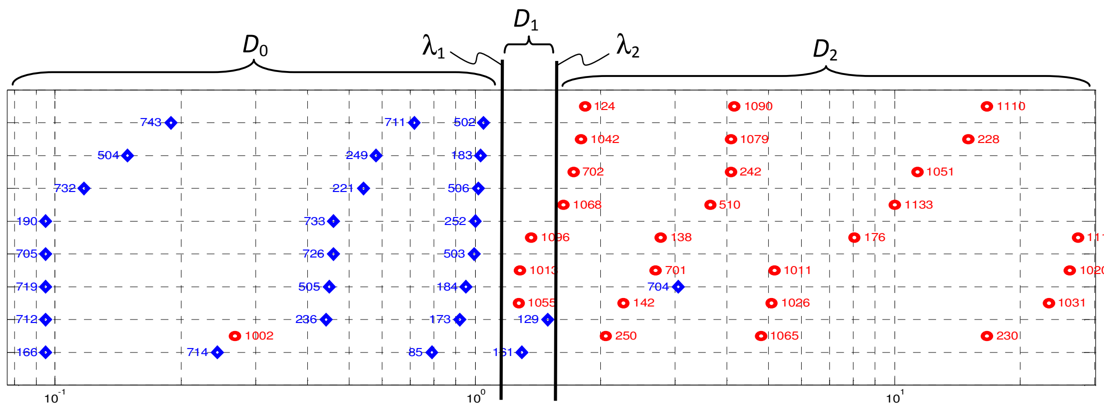


Fig.7. Typical subject with stridence: (a) time domain representation of phoneme „š“ in the word „šuma“, (b) FFT spectrogram, (c) cohleagram, (d) cohleagram with enhanced peaks , (e) spectral peaks, (f) the most prominent spectral peak contour (thick red line).



x-axis: calculated measure of stridence d

Fig. 8. Scatter diagram in the 1-D space of stridence measure. Subjects without stridence are marked with blue rhomboids, while subjects with stridence are marked with red circles. Because of clarity the position of the subjects were disturbed cyclically along the y-axis.

5. CONCLUSSION

In this paper a procedure for stridence detection based on Patterson's auditory model with a complex filter bank is presented. The procedure for stridence detection contains module for spectral peak contour extraction and the module for stridence assessment on the extracted contours. According to introduced multi-criterion function which represents stridence existence, one of three decisions is made: D0 - stridence is not present, D2 – stridence is present and D1 – unable to make decision. Proposed stridence detection algorithm includes psychoacoustic effects, masking effects, which provide similar subjective and objective speech assessment. Tests on small data base of 27 subjects with normal speech and 26 subjects with strident in speech showed high compliance of algorithmic stridence detection with assessment of experienced professionals - speech therapists.

Proposed stridence detection algorithm is optimized and tested on Serbian fricative “Š”. Stridence detection in other consonants had to be further tested and optimized particularly for voiced fricatives and affricates. Studies have shown that in the case of pronunciations of some affricates, a stridence with very unstable "chirp" resonance may occur (Jovičić et al. 2008). Therefore, in further researches it is necessary to properly adjust the constraint of resonant frequency trajectory change according to the analyzed phoneme.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Education, Science and Technological Development of Republic of Serbia through the projects TR32032 and 178027.

REFERENCES

Bilibajkić, R., Šarić, Z., Punišić, S., Subotić, M., Jovičić, S. (2012). Detekcija stridensa u patološkom izgovoru primenom auditornog modela, zbornik radova sa simpozijuma Digitalna obrada govora i slike*, DOGS 2012*, Kovačica.

Blomberg, M. , Carlson, R. , Elenius, K., Granstrom, B. (1983). Auditory Models and Isolated Word Recognition, *STL-QPSR* Vol. 4, 1-15.

Computational Auditory Scene Analysis: Principles, Algorithms and Applications (D. Wang and G. J. Brown, Eds.,)Wiley-IEEE Press, 2006.

Davis, S. B., Mermelstein, P.(1980). Comparison of Parametric Representation of Monosyllabic Word Recognition in Continuously Spoken Sentences", *IEEE Trans. on Acoustics, Speech and Signal Processing,* ASSP Vol. 28(4), 357-366.

Earis, J. E. , Cheetham, B. M. G. (2000).Current methods used for computerized respiratory sound analysis, *Eur. Respir.* Rev.77(10), 586-590

Feldbauer, C., Kubin, G., Kleijn, W. B. (2005). Anthropomorphic Coding of Speech and Audio: A Model Inversion Approach, *EURASIP Journal on Applied Signal Processing* 9, 1334-1349.

Hermansky, H., Hanson, B. A., Wakita, H. (1984). Perceptually Based Linear Predictive Analysis of Speech, In *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing* (ICASSP-84), 509-512

Hirschberg, J. , Szende, T., Koltai, P., Illenyi, A. (2008). *Cry, Stridor And Cough: Acoustic Imaging Analysis of the Pediatric Airway,* Plural Publishing

Hohmann, V. (2002) . Frequency analysis and synthesis using a Gammatone filterbank, *Acta Acustica United with Acustica,* Vol. 88 433 – 442.

Jovičić, S., Punišić, S., Šarić, Z. (2008). Time-frequency detection of stridence in fricatives and affricates, *Proceedings of Acoustics'08*, Paris,

Marple, S. L. (1987). *Digital Spectral Analysis*, Englewood Cliffs, NJ, Prentice-Hall, Chapter7.

Markel, J. D., Gray, A. H. (1976). *Linear Prediction of Speech*, Springer-Verlag, Berlin, Heidelberg, New York.

Patterson, R. D., Allerhand, M. H. (1995). Time-domain modeling of peripheral auditory processing: A modular architecture and software platform, *Journal of Acoustical Society of America*, JASA, Vol. 98, No. 4, 1890-1894.

Patterson, R. D., Holdsworth, J. (1996). A functional model of neural activity patterns and auditory images, *Advances in Speech, Hearing and Language Processing,* Volume 3, Part B, 547-563.

Punišić, S., Jovičić, S., Šarić Z. (2007). Speech distortion assessment: methodological and system approach, *Proc. of Int. Conf. SPECOM'07*, St. Petersburg, 355-360

Punišić, S., Jovičić, S., Subotić, M. , Šarić, Z. , Bilibajkić, R. (2012). Stridens – spektralna distorzija glasova: auditivna i akustička analiza, *DOGS 2012*, Kovačica

Seneff, S. (1988). A joint synchrony/mean-rate model of auditory speech processing, *Journal of Phonetics, Special Issue,* Vol. 16(1), 55-76.

Slaney, M., Lyon, R. F. (1993). On the importance of time – a temporal representation of sound. In *Visual Representation of Speech Signals* (M. Cooke, S. Beet and M. Crawford, eds.), John Wiley & Sons Ltd, 95-116.

Slaney, M., Naar, D. Lyon, R. F. (1994). Auditory model inversion for sound separation. *In proc. IEEE Int. Conf. Acoustics, Speech, Signal Processing* (ICASSP '94), vol. 2, 77–80.

Strube, H. W. (1980). Linear prediction on a warped frequency scale, *Journal of Acoustical Society of America, JASA* Vol. 68(4), 1071-1076.

Taplidou, S. A., Hadjileontiadis, L. J. (2007). Wheeze detection based on time-frequency analysis of breath sounds*, Computers in Biology and Medicine* 37, 1073–1083

THE STATE OF VERBAL ASSOCIATIONS IN PRE-SCHOOL AGED CHILDREN (NEUROPSYCHOLOGICAL ANALYSIS)

NELI VASILEVA
Sofia University "St. Kliment Ohridski"
vasnel@abv.bg

Abstract. Neuropsychological researches in pre-school children indicate a possible development of dyslexia, affiliated with phonological awareness and rapid automatized naming disorders. The naming of verbal associations could be a prognostic feature for learning difficulties itself, since it is similar to the rapid naming. The probation 'Associative continuum' as a component of the neuropsychological battery is used for testing the ability for rapid naming in 365 normal children from three age categories and different settlements. The probation includes three associative tasks, sensitive to the functioning of the posterior and frontal left hemisphere cortex areas. The testing for independent associations exhibit best performance, unlike the associations for actions, where the completion is poor. Research data in the age period 4 – 6 suggest rapid structural and functional development of the posterior brain areas, contrasting with the slow maturation of the frontal lobes.

Key words: neuropsychological profiles, pre-school age, independent verbal associations, actions associations, associations for fruit and vegetables.

1. DISLEXIA, RAPID AUTOMATIZED NAMING AND VERBAL ASSOCIATIONS 1

1.1.2. Dislexia, phonological awareness and rapid automatized naming

In the last decades the children's neuropsychology marks a rapid development in the western, likewise in the eastern schools. Most frequently the objects of neuropsychological researches are the different categories of children with learning difficulties, and the aim of the studies is the composition of their neuropsychological profiles. The last mentioned require various combinations of basic and additive deficits in groups of primary neuropsychological functions. One of the best investigated categories is the dyslexic syndrome.

Data, focusing upon predictors for developmental dyslexia, broadly discuss the difficulties in phonological awareness and rapid automatized naming (or rapid naming). The same are as well, identified as underlying indicators for future difficulties for mastering of reading. After the first articles of Denkla and Rudel (1976) concerning this problem, a number of authors (Ackerman, Dykman, 1993; Fawcett, Nicolson, 1994; Korhonen, 1995) come to the conclusion, that the phonologic difficulties are not the only concern when it comes to dyslexia, since many of the children represent persisting obstacles in tasks for visual naming. According to Araujo, Faisca et al. (2011), the reading and rapid visual naming, because of their inclusion of similar cognitive processing, are, consequently, both affected. The authors mark, that the detailed characterization of the processes responsible for the disorders in rapid naming, direct the path towards strengthening of the knowledge for the reading difficulties and the phenomenon of dyslexia. All the same, the exact nature of the deficits in the rapid naming, which outline the developmental dyslexia, is yet not fully understood.

According to the double-deficit hypothesis (Bowers, Wolf, 1993) dyslexic children can be placed under three categories: (1) with an isolated deficit in rapid naming; (2) with an isolated deficit in the phonological processing; (3) with both deficits. In the children from the first group, a non-phonological problem, which has no reflection on the rapid naming and reading disorders, is speculated (Wolf, Bowers, 1999). However, this cannot deny the role phonological factors when it comes to naming difficulties. After Araujo, Faisca et al. (2011) the access and reproduction of phonological codes are important aspects of the rapid naming, but the phonological component is not solitary responsible for the restrictions in rapid naming in cases of dyslexia. Research data from Wolf and Bowers' (1999) research of children with severe dyslexia show that in 50% of the cases a double-deficit is evident, in 29% there are difficulties in rapid naming and only in 14% deficits in the phonological processing are present.

The evidence that dyslexia could be found in cases of rapid naming deficit, contrasting with normal (preserved) phonological processing mean, that dyslexia cannot be absolutely bind to phonological processes in the act of naming. In agreement to the quoted authors, the rapid naming consists of: 1) stimulated attention; 2) perceptive processes, corresponding to the primary identification of features, visual discrimination, letter and letter-element recognition; 3) integration of the visual information with the orthographic and phonological aspects of the long-term memory; 4) lexical processes, including access and retrieve of phonological patterns, followed by articulation production.

Researches concerning rapid visual naming have been performed for adults with brain lesions (Hamberger, Siedel, 2009). Alongside with a visual naming test, the authors implement probation for descriptive auditory naming, where the individual is to name quickly an object only by its verbal description. According to the authors, the naming in any case correlates with the sinister hemisphere, but represents a non-special localization. However, the deficits in both types of naming derive from left hemispheric temporal lesions, where much modally associated dissociation is being detected. Consequently, patients with anterior lesions have disorders in naming of auditory stimuli, but a preserved ability for labeling visual ones. This means that the anterior temporal areas are thoroughly responsible for auditory stimuli. Lesions in the posterior temporal and temporal-parietal areas consequent in disordered visual and auditory naming (Hamberger et al., 2001). Clinical data speculate that some naming aspects are modally specific and those cortical regions, connected with this concrete modal specific, are topographically distinct. On the whole, the posterior temporal cortex is being reviewed as the basic mediator for the labeling of visual stimuli.

1.2.2. Verbal associations

Contemporary literature review reveals a lack of information concerning the state of verbal associations in dyslexic children. All the same, the associative naming of words is similar to the naming of auditory or visual stimuli. The explanation is that in the associative tasks the child at first actualizes in their memory the image of the object or action and only after that the image is connected with the phonological conception and is being performed in the frameworks of the phonological pattern. When it comes to probing of the rapid automatized naming it is the time needed for the naming of a defined number of visual stimuli that is enquired into, whereas in associative tasks time is limited and the investigation lies in the total of the performed verbal associations. On the whole, the verbal associations' task is with a higher difficulty to the one for rapid naming of visual stimuli, since it is strictly connected with the programming and executive functions of the cortex and the frontal lobes. Researches (Kirkwood, Weiler et al., 2001) reveal the correlation between these functions and the successful school education. According to Semenova et al. (2007), the substantial qualitative alterations in the executive functions are evident in upper pre-school and early school age, consequent from the accelerated growth tempo of the associative layers and the neuronal density in different frontal cortex areas. EEG neurophysiologic researches (Machinskaya et al., 1997) show in the age period from 5 to 8 some significant modifications of the bioelectric activity of the brain, which stand as a predictor for functional maturation of the frontal-thalamic regulatory system and implies the influence of the frontal cortex upon other cortex areas.

It is to be marked, that the up to date the children's neuropsychology mainly focuses upon the problems of the school age period. Least researched is the pre-school age in the frameworks of which are formed the neuropsychological predictors for literacy readiness. For this reason the diagnostic and prognosis abilities of the children's neuropsychology are to be adjusted to this period of the children's development. According to the author, the status of the verbal associative abilities is an outstanding prognostic feature for the future school education, and the implementation of those skills could be enrolled in the diagnostic arsenal for dyslexia predisposition probes.

2. DESCRIPTION AND METHODOLOGY OF RESEARCH 1

2.1.2. Aim, methodology and procedure

The neuropsychological research goal is to probe the pre-school aged children's (4 -6) abilities for rapid actualization of independent and stimulated verbal associations. The probation used is called 'associative continuum', subdivision of the test 'Programming, regulation and control of conscious actions', part of the Neuropsychological diagnostic battery for children (Akchutina, Polonskaya et al., 2008). The method investigates the ability for active extraction of words from the long-term memory, likewise the 'switching' from one word to the other and from certain verbal group to another. The probation includes three separated tasks: 1) independent associations; 2) grammar allied associations (naming of actions); 3) topic-related associations (naming of fruit and vegetables). The accomplishment time is fixed on 1 minute. The completion results of the first task depend on the rapid and active generating of random words and on the ability for switching form one word to another. The second probation requires differentiation and selection of word from a certain grammar category. The third test is about exact election of words from a particular lexical-semantic category, which limits the spontaneous answers and enquires analysis and control.

The independent associations and those for fruit and vegetables are sensitive towards the functions of the posterior temporal cortex of the left hemisphere, and the associations for actions are related mainly to the operations of the frontal and anterior temporal areas. Since the probation allows an assessment of the programming and executive functions related with the frontal lobes, it can be summarized that the functional system of the verbal associations is based on the relations between the frontal and temporal cortex areas of the sinister hemisphere.

2.2.2. Specifics of the verbal associations' functioning in pre-school children

The results have been operated with a tri-factor dispersion analysis, which have been performed separately for each type of associative continuum. The statistical significance of the factors 'age', 'gender' and 'settlement' have been put on trial, as well as the hypothesis of their influence on the raw score on the independent and topic-related associations. If this hypothesis affirms, the raw score is to react with different values for each of the categories 'age', 'gender' and 'settlement'. The disperse analysis represents differences in the statistical value of each factor upon the naming of various types of verbal associations.

The analysis of the results from the independent associations testing, represents a statistically significant effect of the factors 'age' ($F=5.8$; $p<0.0033$) and 'settlement'

($F=11.211$; $p<0.000$), and the influence of the 'settlement' factor is outstanding. From a statistical importance is also the correlation between the factors age*settlement ($F=3.697$; $p<0.005$). The profile of the 'age' factor reveals a moderate increase in the total of named associations from the children of 4 years of age, corresponding to this of the 6 year old ones. The average associations' number of the four year olds is 9,4 words, of the five year olds – 10,5 words and of the six year olds ones – 11,5 words. The data confirm the influence of the age upon the ability for derivation of words from the semantic memory and the rapid switching from one word to another. A combined verification of the importance of the 'age' factor and of the significance of the discrepancies between the average scores of each two groups have been performed with the Duncan's new multiple range test (MRT). The MRT establish the statics significance of each two groups, which reveals a distinguished dynamics in the development of the independent verbal-associative abilities and regulation functions of the children aged 4 – 6 (table 1). This allows the assumption for the growth of the functioning capacity of the frontal divisions and the temporal cortex of the left hemisphere.

Table 1. Significance of the discrepancies of the average scores between each age group for the probation of independent associations

	Age	**{1} - 9.5304**	**{2} - 11.016**	**{3} - 12.164**
1	4		**0.009543**	**0.000017**
2	5	**0.009543**		**0.045075**
3	6	**0.000017**	**0.045075**	

A drawback feature of the generating of independent associations is illustrated by the cases of few produced words as well as the words' equivalency – usage of nouns only for animals or people, naming of objects from the surrounding environment, collocations instead of words. The following strategy corresponds with insufficient effectiveness of the process of seeking words, weak regulation processes, difficulties in the course of the speech act, demonstration of inertia. Common specifics have been proved mainly in four year old children and rarely in six year olds.

The profile of the 'settlement' factor reveals that best performance with highest number of independent associations is given by the children living in the capital, followed by those from the city and the small town. The 'age' factor relates strongly to the number of associations made, and a better performance of the children from the capital is evident. Only the 'age' factor has statistical influences in associations for actions. Associations for fruit and vegetables exhibit the same correlation tendency. The contrast between the means concerning the city and the small towns according to MRT is irrelevant, whereas the adverse of the other two means (capital and city, capital and small town) is statistically significant (table 2). The derived data point out the interesting influence of the socio-cultural and demographic factors upon the dynamics of maturation of the left hemispheric cortex areas.

Table 2. Significance of the discrepancies of the average scores between children from different settlements for the probation of independent associations

	Settlement	**{1} - 12.031**	**{2} - 9.9778**	**{3} - 9.3375**
1	Capital		**0.000889**	**0.000029**
2	City	**0.000889**		0.299775
3	Small town	**0.000029**	0.299775	

Concerning the associations for actions, the F-criteria are statistically significant only when it comes to their influence upon the conditional probability of the 'age' factor (F=13.198; p<0.000) and upon the interaction between the factors age*settlement (F=3.30; p<0.011). The profile of the 'age' factor once more expresses an increase of the number of actions being associated by the children, enhancing from 4 to 6 years of age. The difference between the means of the children of 4 and 5 years of age according to the MRT lack statistical value, which corresponds to the slower dynamics of the linguistic competence for abundant usage of grammatical associations in this age period. The distinct advance of linguistic abilities is demonstrated by the six year olds, which is supported by statistically significant contrast between the means, when paralleled with the other two means (table 3). The mean for the associations of the four-year olds is 6,7 words, of the five-year olds is 7,0 words and for the age of six is 8,5 words. The results allow the speculation that significant changes in the functional activity of the structures of the frontal lobe could be expected not earlier than six years of age.

Table 3. Significance of the discrepancies of the average scores between each age group of children from different settlements for the probation of action associations

	Age	**{1} - 6.1304**	**{2} - 6.6220**	**{3} - 8.1393**
1	4		0.139030	**0.000011**
2	5	0.139030		**0.000013**
3	6	**0.000011**	**0.000013**	

Alerts for fault concerning the verb associations are the cases, representing the naming of single root words or of words from another grammatical category – nouns, for instance. In many occasions the children respond with a whole sentence, neglecting the instructions for single word use only. The explanation of such performance could root in difficulties in grammatical selection, inability for deriving verbs from collocations, as well as deficits in the executive functions. The entire aforementioned are considered norm for the age period 4 – 6.

Analogical to the independent associations, for the topic associations for naming fruit and vegetables the F-criteria demonstrate a statistically significant influence of the factors 'age' (F=12.82; p<0.000) and 'settlement' (F=5.91 p<0.003) upon the conditional probability, with prevail of the 'age' factor. Statistically noteworthy is also the interaction between the factors age*settlement (F=5.04; p<0.000) and age*gender (F=4.123; p<0.017).

The profile of the 'age' factor represents a progress in the number of total associations for fruit and vegetables generated from the children aged 4, compared to the answers of the children aged 5 and 6. The average sum of topic associations made by the 4 year olds is 7,0 words, 8,0 words by the 5 year olds and 9,0 by the 6 year olds. The MRT outlines a statistically important difference between the means of the three age categories (table 4). It could be speculated, that the structures of the posterior temporal cortex, responsible for naming of concrete patterns, undergo an equable and dynamic development in the period 4 – 6 years of age, parallel to the structures in the frontal lobe.

Table 4. Significance of the discrepancies of the average scores between each age group of children for the probation of topic associations for fruit and vegetables

	Age	**{1} - 6.8957**	**{2} - 8.3543**	**{3} - 9.2377**
1	4		**0.000053**	**0.000011**
2	5	**0.000053**		**0.013520**
3	6	**0.000011**	**0.013520**	

The profile of the 'settlement' factor draws a tendency equivalent to the one, outlined by the results of the probation for independent associations. The considerable mean for naming of fruit and vegetables is exhibited by the children from the capital – 8,7 words, followed by the children from the small town – 7,8 words and the children from the city – 7,5 words. The average amount of all the named words by the children from the capital distinguishes significantly from the total of words named by the children from city and the small town. However, there is a lack of statistical significance between the means of the children from these settlements (table 5).

Table 5. Significance of the discrepancies of the average scores between the children from different settlements for the probation of topic associations for fruit and vegetables

	Settlement	**{1} - 8.7113**	**{2} - 7.3444**	**{3} - 7.8750**
1	Capital		**0.000574**	**0.030022**
2	City	**0.000574**		0.168666
3	Small town	**0.030022**	0.168666	

Consequently, an influence from the socio-cultural and demographic factors reflecting on the maturation of the structures of the left temporal cortex and its connections with structures from the frontal lobe is clearly evident when it comes to topic associations. On the results' basis, one could speculate, that the neuropsychological fundament of the semantically orientated associations and the related programming and executive functions allow a rapid development for the children from the capital.

From a qualitative point of view some typical mistakes, made by the children from the three age categories, are to be marked: naming of other type of food, apart from fruit and vegetables, repetition of aforementioned words, etc. according to Polonskaya (2007), the registered difficulties in this associations-related probation correlates with the deficient development of the word treasure, weakness of the nominative functions and inaccurate visual perceptions in the frameworks of a single semantic group. The predicaments could be explained with the more graduate formation of the language operations, connected with the development and the functional maturity of the left temporal posterior cortex. After the author, precisely the task for semantic topic-related associations allows a differentiation concerning different mechanisms of irregular development among the children – concerning presumably the speech and regulatory processes.

Worth mentioning is the fact, that the 'gender' factor, correlating with the 'age' one ($F=4.123$; $p<0.017$), has a role only when it comes to topic-related associations. Results demonstrate, that the rate of the average word count for the females from the three age categories differ significantly (6,7 words for the 4 year olds; 8,2 words for the 5 year olds and 9,8 words for the age of 6), whereas for the males the mean scores are quite similar (7,3 words for the 4 year olds; 7,8 words for the age of five and 8,2 words for the age of 6). The MRT reveals statistically significant discrepancies between the means of all groups of females and between males aged 4 and 5, and 4 and 6 (table 6). Statistically important differences are evident only in the comparison of the average results for females and males aged 6. The data illustrating the variations in the completion of the task for naming fruit and vegetables from both genders confirms the thesis for gender differences in the maturation tempo of the brain areas. Moreover, there is an accelerated formation of the connections between structures of the frontal lobe and the temporal cortex in females for the age period 4 – 6.

Table 6. Significance of the discrepancies of the average scores between the females and males from all age categories for the probation of topic associations for fruit and vegetables

	Age	Gender	**{1} - 6.6724**	**{2} - 7.1228**	**{3} - 8.4912**	**{4} - 8.2429**	**{5} - 9.9516**	**{6} - 8.5000**
1	4	Female		0.374	0.001	0.003	0.000	0.001
2	4	Male	0.374		0.010	0.027	0.000	0.011
3	5	Female	**0.001**	**0.010**		0.624	0.006	0.986
4	5	Male	**0.003**	**0.027**	0.624		0.001	0.636
5	6	Female	**0.000**	**0.000**	**0.006**	**0.001**		0.004
6	6	Male	**0.001**	**0.011**	0.986	0.636	**0.004**	

3. CONCLUSIONS

The data analysis represents that in all age categories the substantial total of named words correlates with the probation for independent associations, and the minor amount is for the tasks for topic associations for fruit and vegetables. Similar tendency is underlined by other authors, who have run the 'Associative continuum' probation among primary school students (Polonskaya, 2007). In a contrast to the independent naming of words, the actualization of verbs and nouns for fruit and vegetables requires a higher level of performance and perception of the operations. All the same, these tasks presume abilities for operations with words from various grammatical and topic categories, enquiring their good knowing. The research results outline a progressive improvement of the skills for operating with various linguistic patterns in pre-school aged children, which correlates with the influence of the 'age' factor upon the associative competence. Paralleled is the effect of the 'settlement' factor upon the children's accomplishment with the tendency for better developed associative skills of the children from the capital. However in the frameworks of the probation for topic-orientated associations, the interaction between the factors 'age' and 'gender' incline the results and stress upon the gender differences in the dynamics of maturation and functioning of the neurophysiologic basis of the verbal associations.

In conclusion, it is to be emphasized that the neuropsychological probation 'Associative continuum' for independent and topic-related associations represents high sensitivity towards the maturation tempo and functioning of the frontal and posterior areas of the left hemisphere and emerges to be a good diagnostic tool for assessment of the lingual and executive functions of the children. On one hand, this demands the implementation of the verbal associations' tasks for testing students with dyslexia, taking into consideration the diagnostic value, as well. On the other hand, the inclusion of the associative probations in the diagnostics of the literacy readiness of pre-school aged children is of a great advantage, since the importance of the prognostic effect.

REFERENCES

Ackerman, P. T., Dykman, R. A. (1993). Phonological processes, confrontational naming, and immediate memory in dyslexia. *Journal of Learning Disabilities,* 26(9), 597-609.

Akhutina, T. V., Polonskaya, N. N. et al. (2008). Ахутина, Т. В., Полонская, Н. Н., Пылаева Н. М., Максименко М. Ю. Методики нейропсихологического исследования детей. *Нейропсихологическая диагностика, обследование письма и чтения младших школьников,* 11-34.

Araújo, S., Faiska, L., Petersson, K., Reis, A. (2011). What does rapid naming tell us about dyslexia? *Avances en Psycologia Latinoamericana* Vol. 29(2), 199-213.

Bowers, P. G. & Wolf, M. (1993) Theoretical links among naming speed, precise timing mechanisms and orthographic skills in dyslexia. *Reading and Writing: An Interdisciplinary Journal,* 5, 69-85.

Denckla, M. B., Rudel, R. G. (1976). Rapid "automatized" naming (R. A. N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia,* 14, 471-479.

Fawcett, A. J., Nicolson, R. I. (1994). Naming speed in children with dyslexia. *Journal of Learning Disabilities,* 27, 641-646.

Hamberger M. J, Goodman R. R., Perrine K, Tammy T. (2001). Anatomical dissociation of auditory and visual naming in the lateral temporal cortex. *Neurology,* 56, 56–61.

Hamberger, M. J., Siedel, W. T. (2009). Localization of cortical dysfunction based on auditory and visual naming performance. *Journal Int. Neuropsychol. Soc.* 15(4): 529–535. doi: 10.1017/S1355617709090754.

Kirkwood M.W., Weiler M.D., Holmes-Bernstein J. et al. (2001). Sources of Poor Performance on the Rey-Osterrieth Complex Figure Test among Children With Learning Difficulties: A Dynamic Assessment Approach. *The Clinical Neuropsychologia,* vol. 15, 3, 345-56.

Korhonen, T. T. (1995). The persistence of rapid naming problems in children with peading development. *Canadian Psychology,* 49(2), 103-110.

Machinskaya, R. I., Lukashevich, I. P., Fishman, M. N. (1997). Мачинская, Р. И., Лукашевич, И. П., Фишман, М. Н. Динамика электрической активности мозга у детей 5-8-летнего возраста в норме и при трудностях обучения. *Физиология человека,* Т. 23, 5, 5-11.

Polonskaya, N. N. (2007). Полонская, Н. Н. *Нейропсихологическая диагностика детей младшего школьного возраста*. М., Академия.

ACQUISITION OF APPROXIMANTS IN CROATIAN

DIANA TOMIĆ
Department of Phonetics, Faculty of Humanities and Social Sciences University of Zagreb
dtomic@ffzg.hr

Abstract: This paper reports a study on the speech sound development of Croatian children aged 3;0-7;0. Speech samples of 600 children (300M and 300F) were analyzed to obtain normative data for the acquisition of approximants. Liquids and trill are considered to be the last sounds appearing in children's phonologies and according to the published Croatian norms, these sounds should be developed by the age of 4;0 - /l/ or 4;6 - /lj/ and /r/. However, the results from this study show that the age of acquisition is higher and it is 4;6 years for /l/, 5;6 for /lj/ and 6;0 for /r/. The paper discusses the dynamics of the development of liquids and the trill in Croatian considering phonological processes (i.e. error patterns or substitutions) and developmental distortions, the age of their suppression and the proportion of their occurrence in the speech of typically developing children. The results show no gender differences in the phonological development within the same age group.

Keywords : speech sound development, approximants, normative study, Croatian

1. INTRODUCTION

Normative data in language acquisition are important for both clinical assessment and research. Speech sound acquisition or acquisition of expressive phonology has received considerable attention in language acquisition research. Although English is the language with numerous normative studies (see Sander, 1972; Smit, 1986 for a review) there are numerous descriptions for speech sound acquisition in other languages with or without normative studies (see McLeod, 2007 for a review). Croatian norms were published over two decades ago (Vuletić, 1990) and we can find other published orientation norms which are not based on a normative study but on long professional experience of Croatian SLPs (Andrešić et al., 2009; Ivičević-Desnica, 1988; Posokhova, 2008). Liquids are among the last sounds in development. According to the existing normative data /j/ and /v/, but also /l/ are developed by the age of three (3;0-3;6) and /lj/ and /r/ between 4;0 and 4;6. Liquids are also highly affected by articulation disorders (Vuletić, 1987, 1990) therefore the course of their development and the age of acquisition has important clinical implications. Comparison of the Croatian norm with normative data in other languages (Acevedo, 1993; Amayreh & Dyson, 1998; Dodd, Holm, Hua, & Crosbie, 2003; Kunnari & Savinainen-Makkonen, 2007; Punišić & Čabarkapa, 2002; Smit, Hand, Freilinger, Bernthal, & Bird, 1990) showed that the Croatian norms for speech sound acquisition are significantly lower i.e. in Spanish, Arabic, English or Serbian approximants seem to be acquired later.

Important characteristics of normative studies are sample size, instrument and scoring procedure. The sample ranges from more than 100 participants to about 1000 (Acevedo, 1993; Amayreh & Dyson, 1998; Amayreh, 2003; Dodd et al., 2003; Smit et al., 1990; Smit, 1993a, 1993b; Vuletić, 1990). Most studies tested acquisition of speech sounds in initial, medial and final postion (Acevedo, 1993; Amayreh & Dyson, 1998; Amayreh, 2003; Smit et al., 1990) while some did not include medial position (Dodd et al., 2003; Vuletić, 1990). Usual procedure is picture naming or word repetition but Croatian norms were determined by a combination of narrative (participants describes pictures) in combination with repetition of target sounds which were not produced spontaneously. Scoring procedure is also different in different studies (for more detailed discussion see Amayreh, 2003; Sander, 1972; Smit, 1986) and some authors use different criteria for the number of developed renditions (i.e. one out of two or three; two out of three depending on the testing material), the degree of development (distortions are part of a wider category labeled acceptable) and the percentage of children indicating the age of acquisition for a certain sound.

2. AIM AND HYPOTHESIS

2.1. 2 Aim

The aim of this research was to provide normative data for the acquisition of approximants in Croatian. Croatian normative data published in *Articulation test* (Test artikulacije, (Vuletić, 1990)) is not explicit about certain methodological issues such as the number of words that are produced nor the number of occurrences required. It also uses 70% of participants as a criterion to determine age at which certain speech sound is developed, while normative studies for other languages use 75% or 90% depending on the applied methodology (Acevedo, 1993; Amayreh & Dyson, 1998; Amayreh, 2003; Dodd et al., 2003; Smit et al., 1990).

2.2. 2 Hypotheses

It is hypothesized that liquids in Croatian are acquired later than suggested by Croatian developmental norms.

3. MATERIAL AND METHOD

3.1. Participants

This research included 600 Croatian children (300M and 300F) aged between 3;0 and 6;11. Demographic details are summarized in Tables 1 and 2. Croatian normative study (Vuletić, 1990) reports the age of acquisition for six-months age bands, therefore this sample is also divided according to that criterion so that the results from the two studies can be compared. Table 2 shows that the results can be interpreted in six-months age bands for all groups except for the oldest group (6b) because of the smaller number of participants. The sample was collected in kindergartens in wider Zagreb area. Only those participants whose parents have signed a written consent after reading an explanatory letter were included in the study.

Table 1. Croatian normative sample by age (age range: one year)

Male					Female				
Group	**Mean age (year;month)**	**Age range**	**s. d.**	**N**	**Group**	**Mean age (year;month)**	**Age range**	**s. d.**	**N**
M3	3;6	3;0-3;11	0;3	75	**F3**	3;6	3;0-3;11	0;3	75
M4	4;6	4;0-4;11	0;3	75	**F4**	4;5	4;0-4;11	0;3	75
M5	5;6	5;0-5;11	0;4	75	**F5**	5;5	5;0-5;11	0;3	75
M6	6;3	6;0-6;11	0;3	75	**F6**	6;3	6;0-6;11	0;3	75
			Total:	**300**				**Total:**	**300**
									TOTAL: 600

Table 2. Croatian normative sample by age (age range: six months)

Male			Female			Total		
Group	**Age range (year;month:day)**	**N**	**Group**	**Age range (year;month:day)**	**N**	**Group**	**Age range (year;month:day)**	**N**
M3a	2;11:16-3;5:15	31	**F3a**	2;11:16-3;5:15	28	**3a**	2;11:16-3;5:15	59
M3b	3;5:16-3;11:15	44	**F3b**	3;5:16-3;11:15	47	**3b**	3;5:16-3;11:15	91
M4a	3;11:16-4;5:15	36	**F4a**	3;11:16-4;5:15	36	**4a**	3;11:16-4;5:15	72
M4b	4;5:16-4;11:15	39	**F4b**	4;5:16-4;11:15	39	**4b**	4;5:16-4;11:15	78
M5a	4;11:16-5;5:15	29	**F5a**	4;11:16-5;5:15	38	**5a**	4;11:16-5;5:15	67
M5b	5;5:16-5;11:15	46	**F5b**	5;5:16-5;11:15	37	**5b**	5;5:16-5;11:15	83
M6a	5;11:16-6;5:15	61	**F6a**	5;11:16-6;5:15	64	**6a**	5;11:16-6;5:15	125
M6b	6;5:16-6;11:15	14	**F6b**	6;5:16-6;11:15	11	**6b**	6;5:16-6;11:15	25
	Total:	**300**		**Total:**	**300**		**Total:**	**300**

3.2. Task

Speech sound development was assessed by picture-naming task. The child was asked to name 17 photos. The material was prepared in PowerPoint presentation and the test was administered as a simple computer game which is becoming more usual testing procedure for children (Mildner & Tomić, 2010, 2011; Puolakanaho, Poikkeus, Ahonen, Tolvanen, & Lyytinen, 2003). The task covered all Croatian approximants at syllable-initial, medial and final positions. For the selection of stimuli the published material for speech sound assessment were consulted (Bjelica, & Posokhova, 2001; Vuletić, 1990) but the stimuli were not identical because today children are not familiar with some words used in those tests. List of words is available in Appendix 1.

3.3. Procedure

Each child was tested individually. The testers were three females trained to ensure the consistency of testing. Children's productions were recorded on digital recorder Marantz PMD 660 with stationary microphone AKG SE 300 B. The tester established rapport with the child prior to testing in a quiet room. The computer screen was clearly visible to both. All testers used similar cues to elicit the word ('What colour is the square?').

3.4. Scoring

Speech sounds productions were assessed in four categories following Croatian normative studies and some recent studies (Munson, Edwards, Schellinger, Beckman, & Meyer, 2010; Vuletić, 1990): omissions, substitutions, distortions and developed speech sounds. Auditory assessment included preliminary assessment during which categories and planned procedures were validated for two children from each gender and age group, the second part was the main assessment during which all participants were assessed and the results were used for data analysis. The main auditory assessment lasted for three months and the groups were assessed in the following order F6, M6, F5, M5 etc. to avoid more stringent criteria for the youngest age groups. The third part of auditory assessment was done four months after the main and included 8% of the speech sample. Intrarater agreement was 93%. Another two assessors participated in the third part of assessment; an experienced kindergarten SLP (F; aged 36 with 9 years of professional experience) and an experienced clinical phonetician working in SUVAG Polyclinic (F; aged 35 with 11 years of professional experience). Intrarater agreement was 83% and 87% respectively.

3.5. Data analysis

SPSS 17 was used for data analysis. Besides descriptive statistics, t-test and ANOVA were used. For *post-hoc* tests Sidak-test was chosen which is considered more reliable than Bonferroni *post-hoc* test.

In order to address methodological issues such as missing responses typical for younger age groups who are often ‘underscored’ and also the developmental variability (i.e. a child may produce certain sound as developed in one position but also show distorted renditions in the other two) the results were calculated according to these formulas and represent the percentage of certain developmental renditions in the sample:

Representation of developed renditions:

$1 - (N_{distortions}+N_{substitutions}+N_{omissions})/\ (N_{distortions}+N_{substitutions}+N_{omissions}+N_{developed\ speech\ sounds})$

Representation of each category of developmental renditions:

$$N_{omissions}\ /(N_{distortions}+N_{substitutions}+\ N_{omissions}\ +N_{developed\ speech\ sounds})$$

$$N_{substitutions}\ /(N_{distortions}+N_{substitutions}+\ N_{omissions}+N_{developed\ speech\ sounds})$$

$$N_{distortions}\ /(N_{distortions}+N_{substitutions}+\ N_{omissions}\ +N_{developed\ speech\ sounds})$$

These formulas followed some of the already devised indices i.e. error consistency index (Stoel-Gammon, 2007; Tyler & Lewis, 2005)

4. RESULTS AND DISCUSSION

4.1. Age of acquisition of approximants

The mean scores and standard deviations of each age group for each approximant are shown in table 3. The results show that /j/ and /v/ are already developed by the age of three with more than 90% of developed renditions in the youngest age groups. Croatian normative study (Vuletić, 1990) used the criterion of 70% to determine the age in which certain speech sound is developed. To make the results of the two Croatian studies comparable, our results will be interpreted in the range between 70% and 75% used in other international studies. Standard deviation indicates decrease in variability of children’s production therefore it can also be considered as one of the factors in determining age of speech sound acquisition. In all age groups for sounds /j/ and /v/ the values of s. d. are low confirming that those sounds are acquired by the age of three. The results show that /l/ is being acquired during the fourth year (69% of developed renditions), but the percentage of the developed renditions shows that the age of acquisition is five years if the 70%+ criteria is applied. Similar is seen for /lj/ and /r/. Both sounds are developed in around 70% of renditions at the age of five but do not reach the 70%. However, the percentage of developed renditions shows higher rise (86% of developed renditions for /lj/ and 80% for /r/ at the age of six) and lower s. d. implying that these speech sounds are developed at the age of six. Also, the comparison of age groups provides another argument to determine age of acquisition for certain speech sound. The differences between both the three-year olds and the other age groups are statistically significant ($p<0.01$) for /l/. The difference between the four-year olds and the other three groups are statistically significant, but when they are compared with five year olds, statistical significance is lower ($p=0.032$). There is no statistically significant difference between five and six year olds. This shows that /l/ is acquired by the age of five. /lj/ is acquired by the age of six when 86% of developed renditions and lower s. d. (0.29) appear. The results show that /r/ and /r̥/ share similar developmental trend. Both sounds are acquired by the age of 6;0 with more than 75% of developed renditions (/r/ - 80% and /r̥/ 77%). The results for /r̥/ show higher standard deviations indicating more intensive development due to higher degree of variability. The differences between age groups for the development of /r/ are statistically significant for all age groups, and for /r̥/ for all age groups except five and six-year olds (p>0.05).

Table 3. Percentage of developed renditions of approximants in Croatian

Speech sound	Age (yrs)	% of developed renditions	s. d.	Speech sound	Age (yrs)	% of developed renditions	s. d.
/j/	3	96%	0,14	/lj/	3	32%	0,42
	4	97%	0,12		4	53%	0,43
	5	98%	0,08		5	69%	0,40
	6	99%	0,07		6	86%	0,29
/v/	3	93%	0,18	/r/	3	14%	0,27
	4	98%	0,10		4	40%	0,39
	5	99%	0,07		5	66%	0,37
	6	99%	0,05		6	80%	0,35
/l/	3	54%	0,37	/r̥/	3	14%	0,34
	4	69%	0,36		4	44%	0,46
	5	80%	0,32		5	69%	0,43
	6	88%	0,28		6	77%	0,37

The narrower 6-month age bands are often used in normative studies since they provide more precise results for the age of acquisition. The results for the development of liquids in Croatian are shown in figure 1.

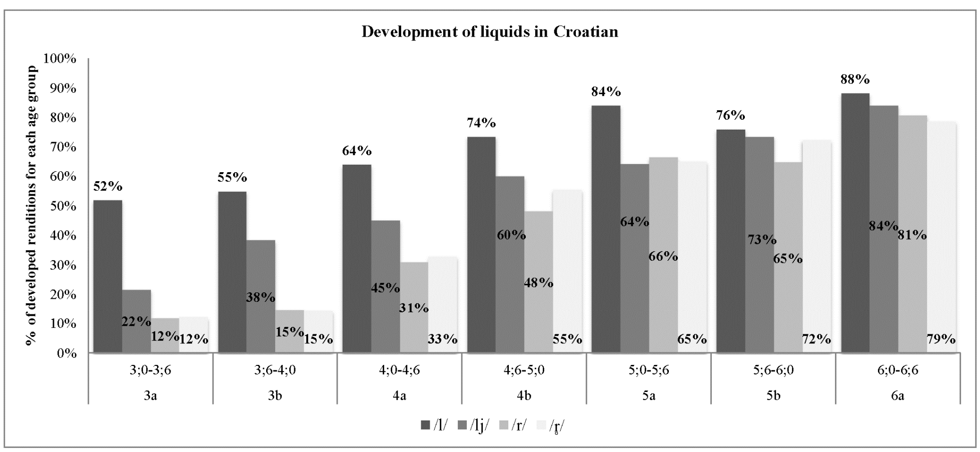


Figure 1. Percentage of developmental renditions of liquids in Croatian (6 months age-bands)

The results show that older group of four-year olds (4b) produce developed /l/ in 74% of renditions, followed by high rise (84%) in group 5a. Therefore we would conclude that the age of acquisition of /l/ in Croatian is 4;6-5;0. Although there is no statistically significant difference between groups 5a and 5b (p>0.05) it should be noted that group 5b showed developmental regression for /l/ (76% as opposed to 84% in younger age group). Regression is a typical feature of phonological development and it was first noted by Prather, Hendrick and Kern (1975) for /s/, /r/, /l/ and /ʤ/ in English. In their sample the regression occurs after the age in which 75% of participants have acquired certain speech sound. Regression was also noted in the most recent American English normative study for /ŋ/, /j/, /l/ and fricatives /θ/,/s/, /z/ and /ʃ/ (Smit et al., 1990). It is interesting to notice that the lower percentage of the developed renditions of /l/ occurs at the age of 5;6 when other two sounds for the group of liquids /lj/ and /r/ start to develop more intensively.

The next sound that is acquired is /lj/. The results show that differences between all age groups are statistically significant and the age of acquisition for /lj/ is 5;0-5;6 because 73% of developed renditions occur. High rise of developed renditions is noted in group 6a which is a common for both /l/ and /lj/. Comparison of different age groups implies continuous development of this speech sound. There are no statistically significant differences between older and younger groups of the same age (3a and 3b, 4a and 4b etc.) nor between groups 3b and 4a, 4b and 5a, 5b and 6a suggesting developmental continuum.

Croatian trill is acquired by the age of six. Younger five-year olds (5a) and older five-year olds produced 66% and 65% of developed renditions respectively, while younger six-year olds (6a) demonstrate higher rise with 80% of developed renditions. The difference between groups 5b and 6a is statistically significant (p=0,032). Syllabic /r̥/ is developed in 65% of all renditions produced by younger five-year olds (5a). The next age group shows has 72% and the rise continues to 79% in group 6a. Statistical significance confirms continuous development of syllabic /r̥/ because there is no significant difference between groups 5a and 5b, nor among those groups and group 6a nor 4b, while the difference between 4b and 6a is statistically significant. In other words, syllabic /r̥/ develops continuously from the age of 4;6 till the age of 6;6.

4.2. Comparison with Croatian and cross-linguistic normative data

The important cross-linguistic comparison of Croatian results is with languages that have trills in their phonological systems i.e. Spanish or Arabic for which normative data are available. Regardless of some methodological differences, cross-linguistic comparisons are useful because they reveal some universal developmental trends but the results should be carefully interpreted bearing in mind phonetic descriptions of both sounds and sound systems.

Acevedo (1993) reports that in Spanish /j/ is in intervocalic position acquired by the age of 3;0. /w/ is also acquired by the age of 3;0 although the regression in initial position appears by the age of 4;0 and at the age of 5;0. Sound /l/ is acquired by the age of 4;6 although it is appears at the age of three but there is some evidence of regression at the age of 3;6 and the development of /l/ stabilizes at the age of 4;0. Trill /r/ in Spanish is acquired by the age of 6 or even later. These results are similar to the results obtained for Croatian. In Arabic /j/ is acquired by the age of 2;6 but the production crystalizes by the age of 6;0, /l/ is acquired by the age of 3;6 and /r/ by the age of 6;0 or even after 6;6 years (Amayreh & Dyson, 1998; Amayreh, 2003).

The results of this study agree with the results of normative studies for languages with trills, they follow the order of speech sound acquisition – trill being the last sound acquired and show similar patterns in results (regression and high rise) typical for large sample speech sound acquisition studies. These results also agree with Kent's motor perspective on developmental speech sound typology (Kent, 1992) it is not unexpected that sound /l/, /lj/ and /r/ are acquired later than described in the existing Croatian norms shown in table 4 since movement of articulators required for the production of liquids is expected by the age of five.

Table 4. Comparison of age of acquisition for liquids in two Croatian studies

Study	/l/	/lj/	/r/	/r̥/
Vuletić (1990)	3;6-4;0	4;0-4;6	4;0-4;6	-
Tomić (2013)	4;6-5;0	5;6-6;0	6;0-6;6	6;0-6;6

The comparison of the results from this study and the older Croatian normative data (Vuletić, 1990) are shown in table 4. The differences in results lie primarily in methodological differences. Vuletić used spontaneous productions and repetitions which can results in lower age of acquisition due to stimulability (Lof, 1996; Miccio, Elbert, & Forrest, 1999; Tyler & Macrae, 2010). Due to methodological issues of normative studies it is extremely important to describe all the procedures in detail (testing, scoring etc.) but also to present the data with more details so that it can be recalculated employing other criteria as it is often case with English normative studies (Sander, 1972; Smit, 1986).
Based on everything said it can be concluded that the existing Croatian norms are too strict.

4.3. Developmental renditions

Developmental renditions are also important part in research of developing phonologies. Vuletić (1990) thinks that more than 30% of participants of certain age producing certain developmental rendition imply it is typical developmental pattern. Smit et al. (1990) use 15-30% of children as a criterion for determining which phonological process is developmentally typical, therefore the results will be interpreted in the 15-30% bands. Omissions are definitely not part of typical speech sound development in children above three years of age, occurring with 5% of less which can be attributed to speech variability. Sounds /j/ and /v/ are developed at the age of three and the occurrence of developmental renditions in the productions of those speech sounds can also be interpreted as part of speech variability. Substitutions of /l/ with /j/ (i.e. gliding) are typical phonological process during third (21%) and fourth year (15%). We also noted certain proportion of distortions (22% at the age of 3) which are also suppressed later (13% of distortions at 4, 12% at 5 and 9% at 6). At the age of three substitutions of /lj/ with either /j/ or /l/ are the most frequent phonological process - 57% followed by 42% at the age of four, but it is still suppressed at the age of five with the occurrence of 27%. Developmental patterns of /r/ show significant proportion of both developmental patterns – substitutions and distortions. At the age of three 34% of /r/- renditions were substituted mostly with /j/ and /l/ and 47% was distorted. At the age four substitutions are suppressed (15%) while distortions remain relatively high 42%. We have to keep in mind that the percentage of developed renditions, which was 14% at the age of three but increased to 40% at the age of four. The trend continues at the age of five with 69% of developed renditions and 29% of distortions and at the age of six, when /r/ has to be acquired, there is still 15% of distortions. Syllabic /r̥/ is primarily substituted in 59% at the age of three of renditions. Typical substitutions are either vowels of vocalic sound /ə/. Children continue to suppress substitutions, so at the age of four there is 29% of that developmental pattern and at the age of five only 14%. When compared to /r/ there is less distortions (27% at the age of three and four, 17% at the age of five and 15% at the age of six) implying the difference between /r/ and syllabic /r̥/ in Croatian.

4.4. Gender differences

Although it is generally accepted that there are gender differences in language acquisition, girls being more advanced, more review papers suggest that this is not the case (Hyde & Linn, 1988). If the speech sound acquisition is compared to the development of motor control gender differences are evident only after the age of four (Smith & Zelaznik, 2004), and there are no gender differences in the development of perception. Recent normative studies also support the claim that there are no clear-cut differences between girls and boys. Older normative studies mentioned certain gender differences and female advantage in language acquisition but Smit et al. (1990) rejects those claims. They did find gender differences for some sounds, but the boys acquired them earlier (/n/, /t/) while the girls were better at those sounds that were acquired later (/ð/, /ɵ/, /ʃ/, /ʧ/ /ʤ/, /l/), i.e. those sounds that require more precise articulatory movement as suggested by Smith and Zelaznik (2004). Smit et al. (1990) did not find any gender differences for /r/ and Dodd et al. (2003) mention that gender differences are evident in the oldest age groups (5;6-7;0) for fricatives and consonants clusters in initial position. They also explain the results with development of motor control. Although there are no proscribed gender differences in older Croatian norm, Vuletić (1990) mentioned significant differences in language acquisition in general saying that at the age of 3;6-4;6 girls perform better on language tasks and she also mentioned gender differences in the production of /r/ by the age of 5;0. If we look for the differences in the acquisition of approximants in this study, there are no statistically significant gender differences for any approximant in any age group except for syllabic /r̥/ among six-year olds (p=0,037). Therefore we can conclude that there are no significant gender differences in the acquisition of approximants in Croatian.

5. CONCLUSION

The results of this study show that liquids in Croatian are acquired later than suggested by the existing norms. The age of acquisition of /l/ in Croatian is 4;6-5;0, /lj/ is 5;0-5;6 and /r/ is 6;0-6;6 for both consonant and syllabic variants. Developmental renditions indicate intensive developmental periods for individual sounds and should be considered part of typical developmental process. For /l/ distortions should be tolerated by the age of 4;0; for /lj/ substitutions with /j/ and /l/ should be tolerated by the age of 5;0, and for /r/ both substitutions with /j/ and /l/ should be tolerated by the age of 5;0 and distortions by the age of 5;6. These results show similar age of acquisition in languages with certain phonological similarities, primarily the presence of trill in the phonological system and there were no significant gender differences in Croatian speech sound acquisition. Since liquids are the group occurring last in the phonological development and are often affected by speech sound disorders, the results of this normative study will have clinical implications.

REFERENCES

Acevedo, M. A. (1993). Development of Spanish Consonants in Preschool Children. *Communication Disorders Quarterly*, *15*(2), 9–15.

Amayreh, M. M. (2003). Completion of the consonant inventory of Arabic. *Journal of Speech, Language and Hearing Research*, *46*(3), 517–529.

Amayreh, M. M., & Dyson, A. T. (1998). The acquisition of Arabic consonants. *Journal of Speech, Language and Hearing Research*, *41*(3), 642–653.

Andrešić, D., Benc Štuka, N., Gugo-Crevar, N., Ivanković, I., Mance, V., Mesec, I., & Tambić, M. (2009). *Najčešći poremećaji jezično-govorne komunikacije djece predškolske dobi*. Zagreb: HLD.

Bjelica,, J., & Posokhova, I. (2001). *Dijagnostički komplet za ispitivanje sposobnosti govora, Jezika, čitanja i pisanja djece.* Lekenik: Ostvarenje.

Dodd, B., Holm, A., Hua, Z., & Crosbie, S. (2003). Phonological development: a normative study of British English-speaking children. *Clinical Linguistics & Phonetics*, *17*(8), 617–643.

Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. *Psychological Bulletin*, *104*(1), 53–69.

Ivičević-Desnica, J. (1988). Razvoj izgovora. In I. Škarić (Ed.), *Govorne poteškoće i njihovo uklanjanje* (pp. 72–73). Zagreb: Mladost.

Kent, R. D. (1992). The biology of Phonological Development. In C. A. Ferguson, L. Menn, & C. Stoel-Gammon (Eds.), *Phonological Development Models, Research, Implications* (pp. 65–90). Timonium, MD: York Press.

Kunnari, S., & Savinainen-Makkonen, T. (2007). Finnish Speech Acquisition. In S. McLeod (Ed.), *The international guide to speech acquisition* (pp. 351–363). Clifton Park, NY: Thomson Delmar Learning.

Lof, G. L. (1996). Factors associated with speech-sound stimulability. *Journal of communication disorders*, *29*(4), 255–278.

McLeod, S. (2007). *The international guide to speech acquisition*. Clifton Park, NY: Thomson Delmar Learning.

Miccio, A. W., Elbert, M., & Forrest, K. (1999). The relationship between stimulability and phonological acquisition in children with normally developing and disordered phonologies. *American Journal of Speech-Language Pathology*, *8*(4), 347–363.

Mildner, V., & Tomić, D. (2010). Acquisition of /s/ clusters in Croatian speaking children with phonological disorders. *Clinical Linguistics & Phonetics*, *24*(3), 224–238.

Mildner, V., & Tomić, D. (2011). Developmental Aspects of Initial sC Clusters in Croatian Children. In W.-S. Lee & E. Zee (Eds.), *Proceedings of the 17th International Congress of Phonetic Sciences* (pp. 1382–1386). Hong Kong: City University of Hong Kong.

Munson, B., Edwards, J., Schellinger, S. K., Beckman, M. E., & Meyer, M. K. (2010). Deconstructing phonetic transcription: covert contrast, perceptual bias, and an extraterrestrial view of Vox Humana. *Clinical linguistics & phonetics*, *24*(4-5), 245–260.

Posokhova, I. (2008). *Razvoj govora i prevencija govornih poremecaja u djece: prirucnik za roditelje*. Busevec: Ostvarenje.

Prather, E. M., Hedrick, D. L., & Kern, C. A. (1975). Articulation development in children aged two to four years. *Journal of Speech and Hearing Disorders*, *40*(2), 179–191.

Punišić, S., & Čabarkapa, N. (2002). Dinamika razvoja fonološke strukture srpskog jezika. In *Acta universitatis Nicola Copernici Studia slavica VII* (pp. 31–38).

Puolakanaho, A., Poikkeus, A.-M., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2003). Assessment of Three-and-a-Half-Year-Old Children's Emerging Phonological Awareness in a Computer Animation Context. *Journal of Learning Disabilities*, *36*(5), 416–423.

Sander, E. K. (1972). When are speech sounds learned? *Journal of Speech and Hearing Disorders*, *37*(1), 55–63.

Smit, A. B. (1986). Ages of speech sound acquisition: Comparisons and critiques of several normative studies. *Language, Speech, and Hearing Services in Schools*, *17*(3), 175–186.

Smit, A. B. (1993a). Phonologic error distributions in the Iowa-Nebraska Articulation Norms Project: consonant singletons. *Journal of Speech, Language and Hearing Research*, *36*(3), 533–547.

Smit, A. B. (1993b). Phonologic error distributions in the Iowa-Nebraska Articulation Norms Project: Word-initial consonant clusters. *Journal of Speech, Language and Hearing Research*, *36*(3), 931–341.

Smit, A. B., Hand, L., Freilinger, J. J., Bernthal, J. E., & Bird, A. (1990). The Iowa articulation norms project and its Nebraska replication. *Journal of Speech and Hearing Disorders*, *55*(4), 779–798.

Smith, A., & Zelaznik, H. N. (2004). Development of functional synergies for speech motor coordination in childhood and adolescence. *Developmental psychobiology*, *45*(1), 22–33.

Stoel-Gammon, C. (2007). Variability in Speech Acquisition. In S. McLeod (Ed.), *The international guide to speech acquisition* (pp. 55–60). Clifton Park, NY: Thomson Delmar Learning.

Tyler, A. A., & Lewis, K. E. (2005). Relationships among consistency/variability and other phonological measures over time. *Topics in Language Disorders*, *25*(3), 243–253.

Tyler, A. A., & Macrae, T. (2010). Stimulability: Relationships to other characteristics of children's phonological systems. *Clinical Linguistics & Phonetics*, *24*(4-5), 300–310. doi:10.3109/02699200903532516

Vuletić, D. (1987). *Govorni poremećaji Izgovor*. Zagreb: Školska knjiga.

Vuletić, D. (1990). Test artikulacije. Fakultet za defektologiju Sveučilišta u Zagrebu.

APPENDIX

Appendix 1. List of words used for the assessment of approximants

Position/speech sound	/j/	/v/	/l/	/r/	/lj/
Initial	Jagoda (*Strawberry*)	Voda (*Water*)	Lav (*Lion*)	Riža (*Rice*)	Ljudi (*People*)
Medial	Boje - bojice (*Coloured pencils*)	Kava (*Coffee*)	Kolica (*Stroller*)	Čarapa (*Socks*)	Ulje (*Oil*)
Final	Čaj (*Tea*)	Lav (*Lion*)	Sol (*Salt*)	Šešir (*Hat*)	Češalj (*Comb*)
Syllabic /r̥/				Crvena (*Red*) Vrt (*Garden*)	

ACKNOWLEDGMENTS

This research was financed in part by grant number 130-0000000-3096 of the Ministry for Science, Education and Sports of the Republic of Croatia. The author wishes to thank the children, parents, speech and language pathologists and headmasters of the kindergartens: Cvrčak, Kolibri, Duga, Travno, Dugo Selo, Hrvatski Leskovec, Remetinec, Siget, Vladimir Nazor, Trnoružica, Sunce. The help of Ms Sara Ferberuš and Marsela Alić with recordings, Marko Štengl with statistical analyses, Ana Generalić and Nataša Klarić Bonacci with auditory assessment is greatly appreciated.

THE INFLUENCE OF FEATURE VECTOR SELECTION ON PERFORMANCE OF AUTOMATIC RECOGNITION OF WHISPERED SPEECH

JOVAN GALIĆ[1,2], SLOBODAN JOVIČIĆ[2,3], ĐORĐE GROZDIĆ[2,3],
BRANKO MARKOVIĆ[4]

[1] Faculty of Electrical Engineering, University of Banja Luka, Banja Luka, Bosnia and Herzegovina
jgalic@etfbl.net
[2] School of Electrical Engineering, University of Belgrade, Belgrade, Serbia
jovicic@rtf.rs
[3] Life Activities Advancement Center, Laboratory for Psychoacoustics and Speech Perception, Belgrade, Serbia
djordjegrozdic@gmail.com
[4] Čačak Technical College, Computing and Information Technology Department, Čačak, Serbia
brankomarko@yahoo.com

Abstract: In this paper the influence of feature vector and frame shift on the performance of a isolated words Automatic Speech Recognition system was analyzed. The part of Whi-Spe corpus with male speakers was used for training and testing. Due to significant degradation of performance in mismatched train/test conditions, four train/test scenarios of normally phonated speech and whispered speech was examined, for two features: Mel Frequency Cepstral Coefficients (MFCC) and Perceptual Linear Prediction Coefficients (PLP). The HTK, toolkit for building Hidden Markov Models created by Cambridge University Engineering Department, was used for training and testing. The percentage correct, as well as optimal set of feature vectors, was determined for all scenarios with modeling of context-independent monophones.

Keywords : whisper, Whi-Spe database, HTK speech recognition, feature vectors.

1. INTRODUCTION

Whispering is a common mode of communication when someone speaks quietly or privately. Nowadays the mobile phone communication is present everywhere and people often uses whisper to speak privately in a public place [1]. It is interesting that this type of speech communication is perfectly understandable.

The whisper has a lot of specific characteristics. Due to the absence of the glottal vibrations, whispering lacks the fundamental frequency of the voice and much prosodic information. In addition, whispered speech has a significantly lower energy as compared to the normal speech [2], the slope of the spectrum being much flatter than in the normal speech [3], and the vowel formants at lower frequencies that are shifted to higher frequencies [4].

There are different approaches, techniques and methods of speech recognition. These techniques are usually based on algorithms of the HMM (Hidden Markov Model), the DTW (Dynamic Time Warping), the ANN (Artificial Neural Network) and their hybrid solutions [5].

This paper presents preliminary results of whispered speech recognition in comparison to normal speech recognition, using a software toolkit HTK (Hidden Markov Model Toolkit). The HTK is a portable toolkit for building and manipulating hidden Markov models that was originally developed at the Machine Intelligence Laboratory of the Cambridge University Engineering Department [6]. HTK tools are designed to run with a traditional command line style interface. As a feature vector, Mel Frequency Cepstral Coefficients (MFCC) and Perceptual Linear Prediction Coefficients (PLP) were used.

This paper is organized as follows. Section 2 gives description of database used for experiment. In Section 3, basic HTK tools used for training and testing are explained. The experimental results, as well as its discussion, are given in Section 4, while concluding remarks and directions for future work are stated in Section 5.

2. DATABASE USED FOR TRAINING AND TESTING

The database is named Whi-Spe (using the first letters of Whispered Speech) and it is designed to contain the two parts: the first one contains the speech patterns of a whispered speech, and the second one contains the speech patterns of the normal speech. Both modes of speech were collected from the five female and five male speakers and each speaker during the session of recording read 50 words. This was repeated 10 times with a pause of a few days between recordings. Finally, the database collection grew to 10.000 utterances, half in the whispered speech and half in the normal speech. The speakers with ages between 20 and 30 years were Serbian native volunteers from the Čačak Technical College. All of them had good articulation in speech and whisper production and correct hearing [7].

The Whi-Spe database was recorded in a quiet laboratory room by using an Optimus omni-directional microphone with good frequency response up to 16 kHz. For normal speech the microphone was at a distance of about 25 cm from the mouth of a speaker, while for whispered speech the distance was about 5 cm. By using these scenarios we tried to obtain the speech patterns, especially for the whisper, as good as possible. The speech was digitized by using the sampling frequency of 22.050 Hz, with 16 bits per sample, and stored in the form of Windows PCM wave files. In this experiment, part of database with male speakers is used.

Due to labeling of database, several factors must be taken into account:

- On plosives *(/ b /, / g /, / d /, / p /, / t /, / k /)* two different parts could be observed in the waveform of speech signal. They are modelled with occlusion and explosion part.
- Although phoneme / *ə* / does not have a letter in Serbian, it is marked separately, if it is next to letter / *r* /.
- *sil* denotes silence in speech signal.

3. THE EXPERIMENT

For match train/test scenarios, recordings marked 1 through 8 were in the part for training (2000 utterances), for all male speakers. Remaining 500 utterances were in the part for testing. For mismatch train/test scenario, all recordings in one mode of speech (2500 utterances) were in the part for training, while remaining 2500 utterances (from another mode of speech) were in the part for testing.

3.1. Training Phase

For training Automatic speech recognition (ASR) system following HTK tools were exploited:

- HCopy,
- HCompv,
- HERest.

Figure 1 algorithmically depicts their usage.

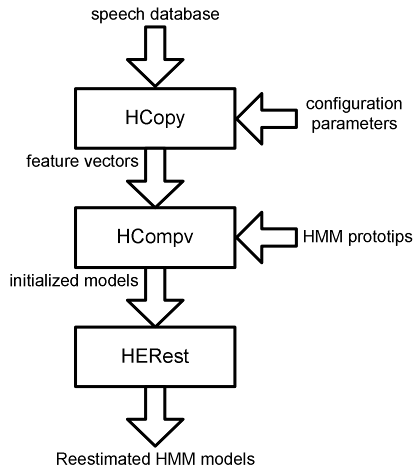


Fig. 1. Scheme for algorithm used in training phase.

3.1. 1 *HCopy*

The HCopy command performs the conversion from audio file format to acoustic feature vector. A configuration file (config), which specifies all the needed conversion parameters, is required for this operation. In this analysis, Hamming window with pre-emphasis coefficient of 0.97 is used. The window size was 24ms, and frame shift was changing as a parameter for three values – 8ms, 12ms and 16ms. For both MFCC and PLP parameters, three parameters were examined:

- with cepstral coefficient C_0 (_0),
- with cepstral coefficient C_0 and delta coefficients (_0_D),
- with cepstral coefficient C_0, delta coefficients and acceleration coefficients (_0_D _A).

Number of filterbank channels was set to 26, and number of output cepstral coefficients per frame was set to 12. We used this program for generation of acoustic feature files in PLP and MFCC formats, which are required by HTK for model building, from recorded WAV files.

3.1. 2 *HCompv*

This program calculates the global mean and covariance of a set of training data [8]. It is primarily used to initialize the parameters of a HMM such that all component means and all covariances are set equal to the global data mean and covariance. Alternatively, the covariances may be used as the basis for Fixed Variance and Grand Variance training schemes. These can sometimes be beneficial in adverse conditions where a fixed covariance matrix can give increased robustness. When training large model sets from limited data, setting a floor is often necessary to prevent variances being badly underestimated through lack of data. Another application of HCompv is the estimation of mean and variance vectors for use in cluster-based mean and variance normalization schemes. We used this tool to create central mean and variance from each segment in the training data.

3.1. 3 *HERest*

This program is used to perform a single reestimation of the parameters of a set of HMMs, or linear transforms, using an embedded training version of the Baum-Welch algorithm [8]. HERest is intended to operate on HMMs with initial parameter values.

HERest supports multiple mixture Gaussians, discrete and tied-mixture HMMs, multiple data streams, parameter tying within and between models, and full or diagonal covariance matrices. We used HERest to retrain the model in the retrain step.

3.2 Testing Phase

For testing ASR system the following HTK tools were used:

- Hparse,
- HVite,
- HResult.

Figure 2 algorithmically depicts their usage.

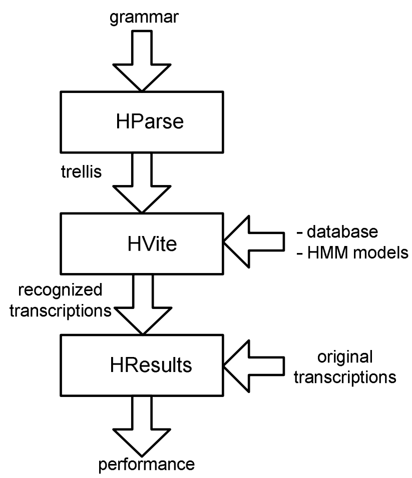


Fig. 2. Scheme for algorithm used in testing phase.

3.2. 1 *HParse*

The HParse program generates word level lattice files from a text file syntax description containing a set of rewrite rules based on extended Backus-Naur Form (EBNF) [6]. The EBNF rules are used to generate an internal representation of the corresponding finite-state network where HPARSE network nodes represent the words in the network, and are connected via sets of links. HParse format grammar consists of an extended form of regular expression enclosed within parentheses. Expressions are constructed from sequences of words and the metacharacters, which are shown in Table 1.

TABLE I: METACHARACTERS USED FOR CREATING A TRELLIS.

metacharacter	description
|	denotes alternatives
[ ]	encloses options
{ }	denotes zero or more repetitions
< >	denotes one or more repetitions

3.2. 2 *HVite*

HVite is a general-purpose Viterbi word recogniser. It will match a speech file against a network of HMMs and output a transcription for each. When performing N-best recognition a word level lattice containing multiple hypotheses can also be produced. HVite supports shared parameters and appropriately pre-computes output probabilities. It can also perform alignment by load a label file and create an alignment network for each test file.

3.2. 3 *HResults*

HResults is the HTK performance analysis tool. It reads in a set of label files (typically output from a recognition tool HVite) and compares them with the corresponding reference transcription files. The optimal string match works by calculating a score for the match with respect to the reference, such that identical labels match with score 0, a deletion carries a score of 7 and a substitution carries a score of 10. The optimal string match is the label alignment which has the lowest possible score**.** Once the optimal alignment has been found, the number of substitution errors (*S*) and deletion errors (*D*) can be calculated. The percentage correct is then [6]:

$$Percent\,Correct = \frac{N-D-S}{N}\cdot 100[\%] \tag{1}$$

In equation 1, *N* denotes total number of labels in reference transcription file.

4. THE RESULTS AND DISCUSSION

In Table 2 are given results for four types of modality train/test, three values of frame shift and three types of MFCC and PLP feature vectors. The results with optimal values are highlighted.

TABLE II: PERCENT CORRECT DEPENDING ON SCENARIO, FRAME SHIFT AND FEATURE VECTOR.

Scenario				Frame shift [ms]	Feature vector
normal / normal	normal / whisper	whisper / whisper	whisper / normal		
92.00	23.20	89.80	21.72	8	MFCC_0
93.60	35.52	93.60	33.08	8	MFCC_0_D
95.80	41.16	94.20	40.28	8	MFCC_0_D_A
87.20	24.68	88.20	26.68	12	MFCC_0
91.00	36.20	89.40	39.12	12	MFCC_0_D
92.00	45.32	90.80	47.88	12	MFCC_0_D_A
78.00	26.56	79.00	31.80	16	MFCC_0
82.60	41.08	81.20	45.68	16	MFCC_0_D
82.20	48.48	82.80	55.40	16	MFCC_0_D_A
93.20	25.16	91.20	22.40	8	PLP_0
94.00	37.20	94.00	34.92	8	PLP_0_D
96.40	42.52	94.60	42.12	8	PLP_0_D_A
88.00	25.44	87.60	28.08	12	PLP_0
92.00	36.88	90.00	40.92	12	PLP_0_D
92.00	46.52	90.20	49.72	12	PLP_0_D_A
77.60	26.88	80.40	33.04	16	PLP_0
82.60	42.40	80.60	47.60	16	PLP_0_D
82.20	48.76	81.80	57.92	16	PLP_0_D_A

From Table 2, some observations could be made:

- For all scenarios the best result was with PLP_0_D_A feature vector with increased word recognition up to 2.5 percent, compared to MFCC_0_D_A feature vector.

- In match scenarios (normal/ normal and whisper/ whisper) frame shift of 8ms gave the best recognition rate, whereas in mismatch scenarios 16ms frame shift showed the best result.
- In general, the mismatch train/test scenarios, such as normal/whisper and whisper/normal, showed significantly lower recognition scores. Based on the results we can conclude that the system which is trained for the whisper and then tested with normal speech gave better results than vice versa. The relative relations of obtained results are in agreement with the results of the experiments performed on the neural networks [9]. This fact is a point for the further investigation.
- The utilization of dynamic feature vectors contributes to the improvement of recognition rate, especially in mismatch scenarios.

For verification of optimal feature set, for match train/test scenarios, crossvalidation was done. With deterministic selection of 20% recordings for test (disjunctive with previous), four additional experiments was made, all with acceleration feature vector. The mean and standard deviation of recognition rate are given in Table 3.

TABLE III: THE MEAN AND THE STANDARD DEVIATION OBTAINED BY CROSSVALIDATION.

Scenario				Frame shift [ms]	Feature vector
normal / normal		whisper / whisper			
μ	σ	μ	σ		
96.05	0.64	93.15	2.81	8	MFCC_0_D_A
92.70	1.05	91.35	1.37	12	
83.00	0.83	82.75	1.89	16	
96.50	0.62	93.25	2.52	8	PLP_0_D_A
92.85	0.90	91.45	1.19	12	
82.95	0.81	83.10	1.94	16	

The results confirmed advantage of PLP feature compared to MFCC feature, especially in the scenario normal/normal.

5. CONCLUSSION AND FUTURE WORK

In this study we examined the influence of feature vector and frame shift on performance of automatic recognition of whispered speech, using HTK software. Shown results are preliminary and there is need for further research. The motivation for this kind of study and experiments is the fact that whisper is a serious problem for ASR systems despite his perfectly understandability in human face-to-face communication. The future research should include comparative analysis of word recognition efficiency using different algorithms such as DTW, HMM and ANN, using the same feature set. Also, using context-dependent triphones instead of monophones should yield in improvement of word recognition. In high-mismatch train/test conditions, more robust features, e.g. TECC (Teager Energy Cepstrum Coefficients) might obtain improvement in word recognition. All above mentioned are subjects for future research.

ACKNOWLEDGMENT

This paper was supported by the Ministry of Education and Science of the Republic of Serbia under Grant numbers OI-178027 and TR-32032.

REFERENCES

[1] Ito, T., Takeda, K., Itakura, F.: Analysis and Recognition of Whispered speech. Speech Communication 45, 129–152 (2005)

[2] Jovičić, S.T., Šarić, Z.M.: Acoustic analysis of consonants in whispered speech. Journal of Voice 22(3), 263–274 (2008)

[3] Zhang, C., Hansen, J.H.L.: Analysis and classification of Speech Mode: Whisper through Shouted. In: Interspeech 2007, pp. 2289–2292 (2007)

[4] Jovičić, S.T.: Formant feature differences between whispered and voiced sustained vowels. ACUSTICA - Acta Acoustica 84(4), 739–743 (1998)

[5] Holms, J., Holms, W.:Speech Synthesis and Recognition, Taylor & Francis, London, 2001.

[6] http://htk.eng.cam.ac.uk/ , accessed 26.9.2013.

[7] Marković, B., Jovičić, S.T., Galić J., Grozdić, Đ.: Whispered Speech Database: Design, Processing and Application, Proceeding of 16th International Conference, TSD 2013, Pilsen, Czech Republic, 591-598 (2013)

[8] Ruoxun, F.: A Probabilistic Approach to Processing Imperfect Transcription in Real World Speech Recognition, MSc Thesis, http://www.informatics.ed.ac.uk/publications/thesis/online/IM070497.pdf, accessed 26.9.2013.

[9] Grozdić, Đ Marković, B., Galić J., Jovičić, S.T.: Application of Neural Networks in Whispered Speech Recognition, accepted for Telfor Journal, (2013)

THE POWER OF WORD IN EDUCATION AND UPBRINGING

LJILJANA KLAJIĆ
Institute for Experimental Phonetics and Speech Pathology, Belgrade

Abstract. The time of technological expansion that we live in carries great ordeals and brings huge chalanges for the teachers and educators of children and youth.
The children-inapropriate contents, wich can be found almost everywhere, from aggresion-promoting televison programs, which are poorer and poorer in afirmating healty values, atention-grabbing Internet and social networks that are taking away the work and life energy of children and youth, to scandalous headlines of tabloids with even more obscene messages.
This causes the value system, which is basis of healthy and complete education, to lose significance and be replaced with „instant values", leaving little time and motivation for creative engagement of kids that, in fact, do have great potentials.
With parents being bussy with work and becoming more and more absent from the lifes of children, the educators and teatchers are left to face the problems wich will inevitably arise.
The verbaly violent comunication, overruled by dangerous models and paterns of behaviour, often causes fisical violence. There's an old saying in Serbia that goes: "A kind word opens even the iron door". This seems to have become forgotten. Being aware of this problem, we confront it with PROPER SPEECH.
Our approach to PROPER SPEECH certainly doesn't refer only to the ESTETIC VALUES of the speech but and above all to the CONTENT and MESSAGE we send by it. We learn trough reading and describing, listening to the most beautiful poetry…
We interpret and visualize with words…
That is our School of Beautiful Speech

GOALS AND PROGRAM OF THE „WIZARDS OF WORDS'' SCHOOL

The „Wizards of Words" school exists at the Institute for Experimental Phonetics and Speech Pathology „Djordje Kostic" since 2006. The „Wizards of Words" are designed for children ages 4 to 14 in order to master speaking skills, enrich their vocabulary, develop retelling, analyzing, and interpreting skills through interesting and educational work, by using carefully selected children's poems, stories and fairy tales. By cultivating speech, active listening, imagination and thinking, big and small „Wizards of words" become good speakers, convincing recitals, and tolerant and wise listeners.

In „Wizards of Words", every word and emotion has its meaning an responsibility. Children become aware of the beauty of the language. „Wizards of words" school has a goal to direct children towards real and beautiful values, in contrast to modern world of social networking. The need for a good book is, in spite of everything, more and more pronounced. „Wizards of Words" have a goal to make children able to achieve their full potential. Children's literature clearly divides well from evil, and makes a base for moral judgement later on.

In addition, it makes clear the character of the person in the story. Good speech is reinforced by reading out loud in workshops, telling kids to openly express their opinions and feelings to others, related to the subject of the workshop. By becoming self-assured in speaking, they get the necessary knowledge for communication that should qualitatively be different from overall slang and jargon that seriously undermine the core of language and its purpose. By learning new words, children become able to use knowledge in everyday communication. By listening to the teacher, they become active and critical. All of this contribut to better speech, interactively, as this is the purpose. This motivates children to take a part in school activities. This is for motivation and personal growth.

Liberating the uncertainty in the oratorical performance, children gain self-confidence necessary to communicate, to be qualitatively different from the present, and so the current slang and jargon that seriously threaten essence and purpose of language.

Learning new words, their meanings, and getting to know the richness of literary language, children are able to open their knowledge in everyday communication and applications. Listening to the interpretation of teachers, children learn the basic language of legality and are active participants in the stories through speech, the most powerful of human characteristics.

All this contributes to the apparent new and higher voice quality and talented children to obtain, arming the "right words" in creative work.

“Wizards od words” words are creative, interactive story involving all participants, creating a shared story and learning how to use a wealth of linguistic power of speech.

The technological revolution, although useful, and in many aspects crucial in the advancement of the human experience, has made children unmotivated to try hard and read the assigned literature, with more and more children copying their homework from the Internet.

This has a confirmed negative effect on oncoming generations. The children care less and less about the literature, focusing instead on more unimportant things that grab their attention.The speed of everyday life dictated by modern standards and tendencies, have separated children and parents from magical moments when time slows down and turns into a story. The said moments are crucial for children emotional development. Their moments have been mostly neglected with the pace of modern life, leaving the children and parents separated in the most important sense Dedications to the book is a matter of choice, not time. This school assures those moments when word becomes magic, making the mystery of language our power and privilege. The children by judging characters and dividing well from the bad will become later better people.

USE OF WORDS AND SOCIAL LEARNING

In everyday communication, we often disregard the quality of how is something told for the sake of what is told. But words have a limitless potential, if we use them unusually. Speech does not have to be limited by boundaries of casualness. In fact, unusual constructions can help us to see its full potential. Almost the entire human experience can be literately described. Regarding the fact the child is not born with an ability to speak, the process must be slow and careful. Being aware of importance of the language and its sociological value, we have to try to cultivate it.

Social and biological processing of acquired language skills should be carefull approach to the work in a school, teach children at an early age, that might not speaking disseminates through life as incidental and fortuitous gift.

Exchanging observations and impressions of the work, emotionally grading of work experience, the ability to successfully linguistic shaping of thought and feeling, developing skills and knowledge for dialogue and dramatization , the appropriate use of emotional tones in speech - are important stages in the work, the “wizard of words”.

Because speech is a kind of mirror of man's physical and spiritual beings, which are also, reflected his life in a community with other people, you can not avoid the fact of the necessity of its proper development within social institutions.

Explicit goals are important for the advancement of children in study groups. Speech should not be taken for granted, and should always, in kid's minds, be appreciated.

Exchange of impressions, emotional grading, and dialogue and dramatization adequate use of melody in speech are therefore important for us. Since speech is a “mirror of self”, the importance of its good development in social institutions can not be circumvented. Research shows that, evidently, speech is endangered, and on many levels, our role is crucial.

MOTIVATION - OR HOW TO ENTER THE MAGICAL WORLD OF LANGUAGE

The children inhabit magical and imagination-filled empires. To present language to them in the right way and the interesting way, and help them love it forever, we must use age-appropriate tools.

Carefully selected poems, faryitales and stories are certainly what we need to make them realize the power of language and cherish it forever as a gift. Language should be viewed as a form of self-expression. Retelling is another important subject that we often deal with. It can help us practice our speech, especially in young minds, ready to learn the importance of language. It should be not being considered a meaningless necessity. Children should learn to motivate themselves and learn new thing, and achieve these experiences for the porpoise of their own advancement. This should show them that they are not doing it because they have to, but for their own desire.

Interactive work and debating on important themes and concepts make one of our methods in The Wizards of words school. Children's attitude helps them accept new things and be better at their interests. They speak poetry. They learn true values by listening to the story and reflecting upon it. They show of the learned skills. Also, they apply them practically. They learn true values, not the ones imposed by the unhealthy environment.

They draw and listen, tell and reinvent through imagination. They listen to atmospheric music that helps them harmonize their thoughts. The harmony of space authentically makes speech and language beautiful and honest, with the sounds of nature. In this atmosphere magical moments occur. The results that this approach has for speech in children area a real proof of the importance of how crucial it is to properly stare children's attention towards top artistic works in the realm of children's literature and elsewhere, form the earliest age.

This is very important. It is a sure sign of the fact that, from the very early age and constantly we should work with children on the perfecting of the speech. That is, more accurately, on the proper expression.

We should give special importance and attention to culture of listening to the person we are talking to. There is never enough practice. Our role, as teachers, should be to help them focus on language. Proper, clear, purposeful, as well as nice, beautiful and well thought of speech is always practiced and perfected and the kid is always stimulated to work oh their speech. Speech is a very important tool for human interaction, ever since the dawn of the mankind. The skill of speech was, even in ancient times, viewed as art by rhethoricists. This should also be the case with modern times. Unfortunately, this is not stressed enough.

Our school practices this constantly, and teaches students many things. That is a way, among other things; it is important for children to, in their speech, use elements of artistic expression, even at the early age. The traits of the cultivated speech make children able to be good at talking and debating. This is way we must put emphasis on this, as it is very important. The children also, and, perhaps, more importantly, learn to be tolerant listeners, and well mannered people.

The success of speech depends, first and foremost, on understanding the subject matter, the form of expression, design of the sentence, accuracy, appropriateness, clearness of elements that make up the language, beauty, and style. It's been proven that over the years of work in our school, little children showed, after initially showing no interest, signs of sparks in their imaginations regarding language, poetry, etc.

When all of the relevant signs of importance and role of speech in everyday life of an individual in our modern society, our point is clear enough. And when we see the importance of language for the human civilization and its power, it is unnecessary to stress on its role.

Language separates man from other animals in fundamental way, and without it, our civilization would be incomplete. When taking into account all relevant indicators of the importance and role of speech in the life of individuals and society as a whole, and examine the development and progress of humanity through the lens power of language, needless to underline the role. We at ,,Wizards of words" carefully and attentively take care of each thoughts about each conjured up feelings and described in the picture.

Nice and proper speech is on the pedestal that it deserves, and we are worthy and respected speakers about it.

We, at the "Wizards of Words" school carefully and attentively take care of every out-coming thought, about every image that we make and remember, of every described sight. Nice and proper speech is a basis of our culture, and caring about it helps us become better individuals.

The entire society benefits from this. Not only are we helping young individuals to explore their talents, but making the world a better place, by altering, for the better, the state of the young minds we are working with.

REFERENCES

Ivic P. (1994). *Srpski jezik i knjizevnost u nastavnoj teoriji i praksi*, Zmaj, Novi Sad.

Milosavljevic P. (1991). *Teorijska misao o knjizevnosti*, Svetovi, Novi Sad.

Milosavljevic P. (1993). *Teorija beletristike*, Prosveta, Nis.

Pavlovic Z. (2005). *Eksplikacija metodoloskog pristupa*, Institut za srpsku kulturu, Pristina, Leposavic.

ABILITY OF NOMINATION IN CHILDREN WITH PHONOLOGICAL DISORDERS

MARIJANA PANIC, VIVIEN ĐORĐEVIĆ, SELENA TODOROVIĆ
[1]The Institute for the Experimental Phonetics and Speech Pathology, Belgrade

Abstract. In this work we present results which are getting by the examination ability of nomination in children with and without phonological disorders. We exam 60 children with phonological disorders (35 boys and 25 girls, middle ages six years and six months) which are made experimental group, and 74 children without phonological disorders (40 boys and 34 girls, the same middle ages), which are made control group. Groups were unification in relation on sex, growth and educational level of their parents. During the examination we used test "Lexical readiness". We gave table review with quantitative and qualitative analysis. We establish that children without phonological disorders in active lexicon have bigger number of words (3809) then children with phonological disorders *3067). Nomination of the parts body, domestic and wild animals, clothes and foot-weares, foods and drinks, flowers and toys are most frequently. Nomination of travel vehicles, birds, parts of houses and buildings, machines and different between villages and cities (there no statistical differences in relation on answering numbers $p > 0.05$). Children with phonological disorders nominate "jeep" ($p < 0.01$) most often. Children without phonological disorders nominate "water" ($p<0.01$), "wall" ($p<0.001$), "machine for washing dishes" ($p<0.05$), "car" ($p<0.01$), "train" ($p<0.03$), "airplane" ($p<0.01$), "back" ($p<0.05$), "chicken" ($p<0.05$) and "pig" ($p<0.05$).
Key words: nomination ability, children with phonological disorders.

INTRODUCTION

Child must pass through learning process of morphological, syntactical, lexical and semantically rules to adopt language at whole. At last few decades in relation on other language examinations, lexical examinations occupy modestly place. Lexicon of each individual develops, improves, expands and alters until to end of life. Child lexicon develops and expands under the strict linguistic rules. At the end of preschools growth child have in its own lexicon about 3.700 words. On this growth, lexicon has highest growth. Nomination of one object on this growth means its generalization or giving a general meaning which add onto concrete [3].

Developmental phonological disorders comprehends speech disorders observing from birth until 12 years of life, to take it's rise under the development brain immaturity with manifest in no existing phonological awareness, inability of forming phonological rules, impossibility phonemic decoding and encoding, misunderstanding phonological meanings, impossibility of using a phonological rules, inability of verbal memory, understanding wrapping and finding phonological information's in memory with disorders in voices production and selection. Phonological disorders are language disorders, so they have influence on all levels of language system [1] [2].

This dynamic view of how children acquire phonological and lexical representations brings us to our final theme, namely that we need to capture phonological knowledge using much finer-grained representations than we have used previously. Counting errors and analyzing substitution patterns in phonetic transcriptions cannot remain our primary methods for measuring children's generative phonological competence. Spoken words are not simple chains of unidimensional phonetic schema that are equivalent across talkers, styles, and prosodic contexts. Further, children do not progress directly and categorically from incorrect substitutions to correct productions.

AIM AND TASKS OF THE EXAMINATION

The aim of the examination was establishing of develop of lexical ability in preschool children with phonological disorders. Tasks of the examination were establishing nominate ability of body parts, toys and games, food and drinks, clothes and foot-weares, domestic and wild animals, birds, travel vehicles, part of hoses and buildings, trees and flowers, developments between villages and cities, and machines.

METHODOLOGY OF THE EXAMINATIO

Organization of the Examination and Pattern

Examination [4] was done in two preschool gardens in Belgrade. We examined 134 pre-school children ages from six to seven years, in the aim of establishing a phonological disorders. We formed two groups of children: experimental and control. Experimental group constituted by children with phonological disorders in development of speech and language (35 boys and 25 girls). Control group constituted children without phonological disorders (40 boys and 34 girls). Groups were unification in relation on sex, growth and educational level of their parents. Examination was done with each child individual in separate rooms. Before testing, each child got the same instructions.

Measure Instruments and Test Description

During the examination preschool children in the aim of establishing phonological disorders, we used relevant tests for evaluation speech and language development: Global Articulation Test (Dj. Kostic, S. Vladisavljevic, 1983) with using articulation normative (D. Vuletic, 1990), Tests for the examination phonemic analysis words, and words into sentences, as well as word synthesis, which we made for examination needs. In this work we present results which are getting by the examination lexical ability of experimental and control groups using a Test Lexical Readiness (R. Matic, 1980). Using this test we examine lexical readiness at whole using the associative method. Lexical areas constitute nomination of body parts, toys and games, food and drinks, clothes and foot-weares, domestic and wild animals, birds, travel vehicles, parts of houses and buildings, trees and flowers, difference between villages and cities, and machines.

RESULTS OF THE EXAMINATION

Whole numbers of words in children with and without phonological disorders bring out 6.876 words. Children without phonological disorders have bigger number of words (3.809) then children with phonological disorders (3.067). We established that children with phonological disorders nominate domestic and wild animals, body parts, clothes and foot-weares most often and so fort until the most poorly nomination of machines (table 1.). Similarly ordering was present in children without phonological disorders.

Table1. Frequently analysis of words number in children with and without phonological disorders

»E« group			»C« group		suma	
No	nomination	Words No	Nomination	Words No	Nomination	Words No
1.	animals	629	body parts	647	body parts	1248
2.	body parts	601	clothes foot-weares	622	animals	1100
3.	food drinks	469	Animals	471	animals	1080
4.	clothes foot-weares	458	food drinks	445	clothes foot-weares	814
5.	trees flowers	369	toys games	355	food drinks	587
6.	toys games	256	trees flowers	331	trees flowers	585
7.	house building	230	travel vehicle	281	toys games	492
8.	travel vehicle	216	house building	258	travel vehicle	474
9.	birds	211	Birds	162	house building	303
10.	village city	141	village city	156	birds	269
11.	machine	43	Machine	81	village city	124
		3067		3809	mašine	6876

Table 2 Answers of children with and without phonological disorders with statistical difference in percent

»E« group				
words	broj	%	t_p	p
sunflower	16	26.7	-2.566	P<0.01
car	36	60.0	2.673	P<0.01
Barby doll	22	36.7	-6.430	P<0.01
doll	14	23.3	-2.693	P<0.01
bear	10	16.7	-2.693	P<0.01
track	10	16.7	2.928	P<0.001
bus	7	11.7	2.379	P<0.02
football	6	10	2.182	P<0.05
windows	50	83.3	-2.225	P<0.05
sandal	19	31.7	-2.299	P<0.05
skirt	14	23.3	-2.580	P<0.02
slipper	13	21.7	-2.278	P<0.05
dress	13	21.7	-2.913	P<0.01
cardigan	13	21.7	-2.913	P<0.01
ears	28	46.7	2.449	P<0.02
cat	29	48.3	-2.052	P<0.05
dog	28	46.7	-2.275	P<0.05
stomach	37	61.7	-2.469	P<0.02

»C« group				
reč	br	%	t_p	P
Violet	35	47.3	-2.765	P<0.01
Beer	29	39.2	3.500	P<0.01
brandy	21	28.4	2.405	p>0.02
cheese	5	6.8	-2.512	P<0.02
car	40	54.1	3.454	P<0.01
Barby doll	38	51.4	-5.386	p>0.001
doll	31	41.9	-4.613	p>0.001
Ekshen men	21	28.4	3.440	P<0.01
bear	15	20.3	-2.964	p>0.01
track	8	10.8	2.761	P<0.01
sandal	27	36.5	-2.226	P<0.05
trousers	21	28.4	2.923	P<0.05
dress	17	23.0	-3.987	P<0.001
skirt	16	21.6	-3.201	P<0.01
pig	40	54.1	2.049	P<0.05
windows	68	91.9	-2.356	P<0.02
door	57	77.0	-3.222	P<0.01
chimney	17	23.0	2.668	P<0.01
Short coat	9	12.2	-2.758	P<0.02
cap	6	8.1	2.356	P<0.03
airplane	21	28.4	2.405	P<0.03
She-fox	21	28.4	-2.251	P<0.05
leopard	8	10.8	2.761	P<0.05
sparrow	36	48.6	-2.081	P<0.05
gloves	5	6.8	2.135	P<0.05

»E« + »C« grupa				
words	broj	%	t_p	p
water	47	35.1	2.532	p>0.01
wall	52	38.8	-2.953	P<0.01
car	124	92.5	2.960	P<0.01
jeep	5	3.7	2.531	P<0.01
airplane	27	20.1	-2.673	P<0.01
train	33	24.6	-2.329	P<0.03
hands	114	85.1	3.391	P<0.01
back	35	26.1	2.107	P<0.05
chiken	35	26.1	-2.638	p>0.05
pig	15	11.2	2.360	p>0.05
Mach. for wash. dishes	40	29.9	-2.244	P<0.05

In table 2 we show child answers on test “Lexical readiness” with statistical differences I percentage representation. We established that children with phonological disorders nominate sunflower, Barby doll, doll, bear, windows, sandal, skirt, slipper, dress, cardigan, stomach, cat, dog, most often. Boys with phonological disorders most often nominate car, track, bus, football, ears. Boys without phonological disorders most often nominate beer, brandy, Barby doll, doll, bear, window, door, chimney, trousers, cap, gloves, airplane, pig, and leopard. Girls without phonological disorders most often nominate cheese, violet, ekshen men, track, shoos, dress, skirt, short coat, sparrow, she-fox. Children without phonological disorders most often nominate wall, machine for washing dishes, car, train, airplane, hands, back, chicken, and pig. Children with phonological disorders most often nominate jeep.

CONCLUSION

Further to the efforts of a great number of researches who have tried to define a phonological disorder [1, 2] considers that phonological disorder imply the following:

1. phonological disorders are in fact language disorders;
2. the structure of phonological disorders consists of the three main components: lack of phonological conscience-awareness (which implies inability of sound segmentation and not knowing the relationship letter-sound);
3. inability of verbal understanding and inability to pack and find phonological information in the memory.

Non-existence of phonological awareness within developmental phonological disorder, in opinion of the author of this paper, refers to immaturity or absence of functions which contribute to understanding and a precise automated implementation of the language phonetic system, such as: auditive perception, auditive discrimination, auditive non-differentation, inability to make auditory analysis, inability to make auditory combinations, slasiffication, auditory non-recognition of words, inability to make rhymes and alliterations and to use intonation or acentuation [1,2]. In addition to non-existance of/or deffects in pfonological disorder in characterized by:

- one's inability to form phonological ideas
- one's inability or hidrance in phonological decoding an encoding
- one's inability to use phonological rules
- one's inability to use and understand phonological meanings

Children with phonological disorders in active vocabulary have bigger number of words then children without phonological disorder. Children with and without phonological disorder have almost all regular sentences, most often are nouns, then verbs, conjunctions, adverbs, prepositions, and numerals. Children with phonological disorder have deficits in number of regular sentences (50%), and whole number of sentences (41%), then deficits in number of prepositions (38%), verbs (35%), conjunctions (31%), nouns (31%), pronouns (23%), and adverbs (21%).

Words have two essential components, sound and meaning, and the link between the two is arbitrary, varying from one language to another. One of the major tasks facing children learning to talk is figuring out the sound-meaning relationships of the words in their ambient language. Most studies of lexical acquisition assume that the abstract, cognitive demands of word meaning represent the foremost task in acquiring a word, and the physical aspects of articulating that word play a secondary role. Research on speech and language development in young children, however, raises questions about this view, suggesting that, at least in the early period of word learning, factors associated with the production of speech may be as important as the cognitive factors. This presentation will provide information on the interactions between lexical and phonological development in children with typical development and those with disorders. Particular attention will be given to the age-range from birth to four years, with a summary of research on prelinguistic vocal development and the emergence of first words, the role of input, and the notion of "ease of articulation". For older children, and adults, it has been shown that word frequency (a lexical factor) and phonotactic probability (a phonological factor) influence the learning of new words and the accuracy of production of those words. [7, 11]

The development of speech and language competence is directly connected with the level of inteligence, emotional and social development, as well as with the quality of enviromental encouraging. The children suffering from phonological disorders have difficulties with production, understanding and correct use of grammar structures. The level and degrees of language deficitiences are manifested throught that sort of organisation. Some children fail to master the entire hierarchical structures throught spontaneous developmen. The children with phonological dosirders always manifest cognitive and language deficits as an important cause or factor which contributes to the existing disorder. Considering the hierarchical language structure, it's obvious why there is connection between term acceptance and lexeme pronounciation [9]

Development of lexicon doesn't growth simultaneous but successive, because child develop and use first these word which are easily and which have most frequency use in speech of child environment, then words which have less frequency representation. Speech and language examinations were establish that number and percentage using words in speech (functional words, such as propositions, conjunctions, numbers, exclamations and particles) have less number then conception words (nouns, verbs, pronouns) [3]. Language disorders on phonological level have influence on disorders in others language levels. Children with phonological disorders have poorly lexicon on all examination levels. Also, we notice that children without speech and language disorders have no adequate development of lexicon [5]. We thought that exaggerated using of television and computer has influence on these phenomena.

LITERATURE

[1] *Golubovic S.*: Phonological Deficits, Deficits of Nominations, Repetitions and Verbal Memory in Dyslexias. Belgrade Defectology School, Belgrade, 1999, pp 59-69

[2] *Golubovic S.*: Diferential Diagnosis Specifity of Developmental Verbal Apraxia, Dysarthria and Phonological Deficits. Belgrade Defectology School 1-2, Defectology Society of Serbia and Montenegro 1-2, 2003, pp-111-123

[3] *Kovacevic Gavrilovic V, Mitic M.:* Specificy of Lexical Development Pree School Children. Pedagogy. Journal of Pedagogical Forum from Szerbia and Montenegro, ISSN 0031-3807, LIX, Belgrade, 204, No.4, pp. 59-68

[4] *Mitic M.*: Specifics of Development Perceptive, Speech and Language and Graph Motor Abilities in Relation on Symptomathology of Dysgraphia.Doctoral Dissertation. Faculty of Defect logy. University of Belgrade. Belgrade. 2004.

[5] *Mitic M., Kovacevic Gavrilovic* V.: Development of Active Lexicon in Pre School children. Teaching and Education. Journal for Pedagogical Theory and Practice. ISSN 0547-3330. Belgrade, 2005, pp. 295-302

[6]Schwartz, R., & Leonard, L. (1982). Do children pick and choose? An examination of phonological selection and avoidance in early lexical acquisition. *Journal of Child Language* 9, 319-336.

[7] Sosa, A. & Stoel-Gammon, C. (in press). Lexical and phonological effects in early word production. *Journal of Speech, Language, and Hearing Research*.

[8] Stoel-Gammon, C. (2011). Relationships between lexical and phonological development inn young children. *Journal of Child Language, 38,* 1-34.

[9] Stoel-Gammon, C. (1998). Sounds and words in early language acquisition: The relationship between lexical and phonological development. In R. Paul (ed) *Exploring the speechlanguageconnection*, 25-52. Baltimore: Paul H. Brookes Publishing Co.

[10] Storkel, H. (2004). Do children acquire dense neighbourhoods? An investigation of similarity neighbourhoods in lexical acquisition. *Applied Psycholinguistics* 25, 210-221.

[11] Storkel, H.L., & Morrisette, M.L. (2002). The lexicon and phonology: Interactions in language acquisition. *Language, Speech, and Hearing Services in Schools, 33,* 24-37.

CHANGE OF PULSATILITY INDEX OF MIDDLE CEREBRAL ARTERY AFTER PRENATAL SOUND STIMULATION IN NO RISK TERM PREGNANCIES

SVETLANA JANKOVIC-RAZNATOVIC[AB], SNEZANA PLESINAC[AC], MIRJANA SOVILJ[DE], TATJANA ADAMOVIC[DE], DARKO PLECAS[AC], DJURDJICA CECEZ[A], LJILJANA DOBRIJEVIC[DE], DJURO KORUGA[F]

[a]Department of Obstetrics and Gynecology "Narodni front", Belgrade, Serbia
[b]Belgrade University Medical School, Belgrade, Serbia
[c]Institute for Obstetrics and Gynecology, Clinical Center of Serbia, Belgrade, Serbia
[d]Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia
[e]Life Activities Advancement Center, Belgrade, Serbia
[f]Biomedical engineering, Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract.
Background. Our experimental study evaluated variations of fetal middle cerebral artery (MCA) circulation after the defined prenatal acoustical stimulation (PAS). Prenatal auditory stimulation (PAS) is a method of early detection of development of fetal auditory and behavioral function.
Methods. Study included 119 healthy pregnant women with no risk pregnancies, without complications of any kind, with the delivery at time. Our examination was performed in period from 37 to 41 weeks of gestational age. Gestational age was determined in relation to last menstruation and estimated by ultrasound examination. Experimental study has been organized as a part of multicentric prospective clinical trial under the supervision of Ministry of Health and Education of Republic of Serbia, (2011-2014). Project included Belgrade University Medical School, Belgrade, Serbia (Department of Obstetrics and Gynecology "Narodni front" and Institute for Gynecology and Obstetrics, Clinical Center of Serbia) and Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia. We analyzed fetal midlle cerebral artery (MCA) circulation using Toshiba Nemio with Doppler and color-Doppler convex sector-probe 3.5 MHz, before and after PAS.
Results. Analysis of the Pulsatility index basic (PIB 1), before PAS and Pulsatility index reactive after (PIR 2), show high statistical difference ($p<0.01$), representing high influence on the fetal brain circulation.
Conclusion. Our results have shown influence of sound stimulation on fetal brain circulation. They also introduce the second stage of investigation correlated to the newborn and adequate postnatal hearing and neurology tests and help us detecting of various hearing and verbal problems in an early childhood and start with exact therapy as soon as it is possible to earn better results.

Key words: fetus, sound stimulation, prenatal acoustical screening, fetal cerebral circulation

INTRODUCTION

The development of audile tract in fetus begins at 20th week, but the peak function reaches between 30th and 32nd week of pregnancy (1).Tomatis (1981) developed an idea that fetus can hear in the 4thmonth of gestation and not only hear by auditory system but with somatosensory cortex and vestibular system (2). Birnholz (1983) and Benacerraf detected the first fetal response to external auditory stimulus by ultrasound (2).

Congenital hearing impairment, if it is not noticed soon after the delivery, can cause difficult auditory, verbal and behavioral problems in the childhood. Most researchers wanted to define sensitive and specific screening prenatal test. An aim of the first phase of our prospective clinical trial was to determine the degree and the mode of variation of middle cerebral artery circulation in low risk pregnancies after the constant sound stimuli.

Prenatal auditory stimulation (PAS) is a method of early detection of development of fetal auditory and behavioral function. It is based on a method of detecting fetal reactions on the defined sound stimulation (3), proposed twenty years ago (4). Our experimental study evaluated variations of fetal middle cerebral artery (MCA) circulation after the defined PAS.

MATERIALS AND METHODS

Study included 119 healthy pregnant women with no risk pregnancies, without complications of any kind, with the delivery at time. Our examination was performed in period from 37 to 41 weeks of gestational age. Gestational age was determined in relation to last menstruation and estimated by ultrasound examination. Experimental study has been organized as a part of multicentric prospective clinical trial under the supervision of Ministry of Health and Education of Republic of Serbia, (2011-2014). Project included Belgrade University Medical School, Belgrade, Serbia (Department of Obstetrics and Gynecology "Narodni front" and Institute for Gynecology and Obstetrics, Clinical Center of Serbia) and Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia. Protocol established in 1992. (Ljubic, Sovilj), included following procedures:

- Creation of medical documentation by trained perinatologist
- Standard procedure for ultrasonic inspection
- Set the antiphons lice on pregnant women, to turn off the sound effect of stimulus auditory system through the mother
- Determination of fetal head position
- Positioning of median fetal cerebral artery (MCA)
- Reading the basic values of Doppler parameters PI 1
- Generation of a defined digitized sound stimulus
- Reading the peak values of Doppler parameters PI 2.

Fetal examination starts with standard ultrasound examination. Noise-canceling headphones types EP-107 are put on women's head. After we determinate the position of the fetal head and ear we put the speaker 5 cm from abdominal wall, to the direction of fetal ear. We identify the circle of Willis is easy with B-scan and blood flow using color Doppler. Using data of blood flow through fetal middle cerebral artery (MCA), Pulsatility index before sound stimulation (PIB 1) is measured.

The fetus is exposed to the digitalized generated sound stimulus performed by loudspeaker sets 5 cm away from abdominal wall. The sound is characterized by 90dB of intensity, frequency range of 1500-4500Hz and 0,2s of duration. Color Doppler ultrasound is used to identify middle cerebral artery flow after sound stimulation and identify the PI index after it. We also measure the values of Pulsatility index after stimulation (PIR 2) and identify reactivity. Doppler analysis of blood flow is performed on the Toshiba Nemio with the possibility of Doppler and color Doppler and convex sector probe with the frequency of 3.5 MHz. We examined blood flow, which is registered in the first third of middle cerebral artery from branching. For the analysis of the wave, we used Pulsatility index (PI):

$$PI = (S-D) / M,$$

one of the major Doppler-parameter (5).Pulsatility index (PI) is equal to systolic (S) minus diastolic (D) amplitude value of arterial waveform, divided by the mean (M) value of the area under the waveform. This parameter is considered as an indicator of the size of the peripheral resistance and belongs to one of the Doppler-indexes of peripheral vascular resistance.

Statistical analysis of Two-way comparisons was done using 2-tailed Student's t-tests. P values of less than 0.05 were considered significant.

RESULTS AND DISCUSSION

Our study included 119 healthy pregnant women with no risk pregnancies, without complications. Our examination was performed in period from 37 to 41 weeks of gestational age. The mean gestational age is 39.01 gestational weeks. Nearly 70% of women are at the age between 25 and 34 yeas old, so they can be a representative part of the population.

The analysis of the Pulsatility index basic (PIB 1) of fetal middle cerebral artery (MCA), before PAS, has shown that the mean value is 1.47. Pulsatility index reactive after the sound stimulation (PIR 2) of fetalMCA, has shown that the mean PIR 2 value is 1.36. Comparation of the Pulsatility index basic (PIB 1) and Pulsatility index reactive after the first sound stimulation (PIR 2), using T-test ($p<0.01$) shown that there is high statistical difference. It means that there is a high influence of first sound stimulation on the fetal brain circulation.

Measured values of PI before (PIB 1) and few seconds after exposure to define digitalized generated sound stimulation (PIR 2) indicate changes in the fetal cerebral circulation. If the PI values after acoustical stimulation (PIR) are lower compared to the basic values of this index before stimulation (PIB), there is an increase in blood flow of fetal middle cerebral, while in the case of higher values of PIR compared to basic ones (PIB) signify reduction in blood flow in examined middle cerebral artery (3).

Jelicic (3) reported different modes and changes of PI of median cerebral artery after defined sound stimulus in low risk and in high-risk pregnancies. Fetuses from pregnancies with diagnosis of diabetes demonstrated significantly higher absolute and relative changes of Pi values compared to other groups of examined fetuses (3).Plesinac (4) concluded that the percentage of fetuses with increase of cerebral blood flow after the defined sound stimulus was slightly higher in the pregnancies with hypertension. An average change of PI of median cerebral artery, before and after the sound stimulus was also higher in this group, so fetuses of mothers with gestational hypertension had better reactivity and faster response to external stimulus, although not statistically significant (4). Many authors were investigated the sound influence on fetus. Kisilevsky (1998) studied complete physical activation or relaxation of fetuses after different sound stimulation (6).

CONCLUSION

The PAS method is important for early detection of fetal auditory function during its development. It is represented by high statistical difference in changes of fetal cerebral circulation after first defined acoustical stimulation ($p<0.01$). Better understanding of information processing could give us more information about fetal hearing (3,4), behavior, adaptation and memory (7), learning and left-right side development.

Our investigation is opening new area of fetal behavior explanation and probably in the near future we will establish reliable hearing screening test.

Acknowledgement: The research was financed in part by the Ministry of Education and Science of the Republic of Serbia, within the projects No. 178027 and III 45009.

References

1. Hill M. Development of the Organs of Audition and Equilibrium (2010). Stage 22 Embryo (selected). UNSW Embryology ISBN: 978 0 7334 2609 4.

2. Plesinac S, Jankovic S, Plecas D, Antonovic O, Adamovic T, Sovilj M. Change of Pulsatility Index of the Fetal Middle Cerebral Artery after Auditory Stimulation in No Risk Pregnancies and in Pregnancies with Gestational Hypertension. ClinExpHypertens. In press.
3. DobrijevicLj, Ljubic A, Sovilj M, Ribaric-Jankes K, Mikovic Z, CerovicN.Changes in Doppler blood velocity in middle cerebral artery in response to airbone sound in low-and high-risk human fetuses. Int J PediatrOtorhinolaryngol. 2009;73(10):1381-1384.
4. Sovilj M, Ljubic A, Milenkovic V, Djokovic S. Possibilities of prenatal examination of fetal reactions on acoustical stimulation of fetuses with congenital infections. Proceedings of X Symposium of Perinatal Medicine SLD, Belgrade, 1992; 17-18.
5. Gosling R, King DH. Ultrasonic angiography. In: Marcus A. Adamson L: Arteries and veins. Churchill Livingstone, Edinburgh, 1975: 61-98.
6. Kisilevsky BS, Fearon I, Muir DW. Fetuses differentiate vibroa- custic stimuli. Infant BehavDev 1998; 21(1):25–46.
7. Janković-Ražnatović S, Dragojević-Dikić S, KorugaDj. The role of cilia in signal transduction from acoustical to electrical under sound influence on fetus. In: Jovičic TS, Subotic M. Verbal communication quality interdisciplinary research I. Belgrade, Serbia: LAAC & IEPSP Belgrade; 2011: 361-377.

PALATAL LATERAL APPROXIMANT /ʎ/ AS ONE OF THE MAIN TROUBLEMAKERS IN LEARNING CROATIAN AS L2

ARNALDA DOBRIĆ[1], JORDAN BIĆANIĆ[2]
Faculty of Humanities and Social Sciences, University of Zagreb[1]
adobric@ffzg.hr[1]

Abstract: According to the Verbotonal theory, speakers of L1 choose the closest sound from their own phonological system instead of the correct sound when learning L2 in adult age and the errors are consistent regarding their common L1 as well as targeted L2. This phenomenon is referred to as the system of errors. Most of adult speakers of different L1 learning Croatian as L2 often have major problems pronuncing palatal lateral approximant /ʎ/ substituting it with several sounds. The palatal lateral approximant /ʎ/ was corrected in eight native speaker of South American varieties of Spanish. The tested subjects were recorded before and after ten sessions of speech correction. Acoustic analysis in Praat showed statistically significant higher F2 in /ʎ/ in second recording and as well as significant difference in duration. Application of this sort of work can be seen in foreign language acquisition but also in research of speech-hearing pathology.
Keywords : Verbotonal theory, speech correction, system of errors, palatal lateral approximant / ʎ /, acoustic analysis

1. INTRODUCTION

Although the traditional translation method of foreign language acquisition has been abandoned for some time, pronunciation, as one of the key elements of good verbal communication has often been neglected, especially when it comes to adult learners. Even the latest methods of teaching do not stress enough the importance of good pronunciation and the reason might be looked for partly in methods of learning that the teachers themselves experienced as learners or the fact that foreign languages are commonly taught in groups so it is impossible to pay required attention to individual pronunication errors (Mildner and Tomić, 2007). It is well known that, when it comes to pronunciation, a person looks for the “closest solutions” in his or her native language. Therefore, if the phonological systems of a person’s L1 and L2 (especially when acquired in an adult age) have been compared, it would be clear that a person, instead of pronouncing a sound from L2 that does not exist in his or her native language, pronunces the colosest sound from L1, closeness being defined on the basis of place of articulation, manner of articulation etc. These sound changes can be predictable up to a certain degree when the two phonological systems are compared. It is also understood that speakers of the same L1 tend do the whole range of same mistakes while pronuncing the same L2. Guberina (2003a) defines this practice as the *system of errors.* The reason is in the perception of a speaker that has been shaped on the basis of the phonological system of his or her native language. Therefore the sounds of the L2 phonological system are perceived through already “shaped” perception which consequently causes distortion in pronunciation. Guberina came across this very problem while teaching French to Croatian high school learners. He suggested organizing classes of speech correction that would be based on listening and repeating speech material organized according to the specific error and with individualized approach to the student. While preparing material for correction of a particular sound, attention should be paid to five elements: sound context with respect to optimal frequency band and coarticulation, position of the targeted sound within the word or sentence, intonation, tenseness of articulation as well as movement and body posture accompanying speech production. Optimal frequency bands are defined as the minimal frequency bands necessary and sufficient to ensure full intelligibility of the particular sound to native speaker

(Mildner, 1999; Mildner and Bakran, 2001). Movement should not be mixed with articulatory movements which are very sophisticated movements of small range but understood as movements on macromotorics plan that should eventually lead to adequate micromotoric movement. Appropriate speech material should be constantly used. The material ranges from the words and sentences that seem to be easiest to pronounce to the ones that are hardest to pronounce so that a speaker could have a good reference point to rely on when the pronunciation deteriorates. The method is based on auditory-phonetic approach (Mildner and Bakran, 2001) that aims toward better auditory perception in trainees. Every session of correction begins and ends with the sentence and in the beginning the words and sentences should have only one targeted sound, respectively. During the sessions optimal speech material (Mildner, 1999) was used and the signal was manipulated (Guberina, 2003b) in order to facilitate perception of the targeted sound. Global structure (sentence rhythm and intonation) is practiced in the beginning of the sessions using low pass filters. It is commonly accepted that improvements on the sound level bring along improvements in pronunciation in general (Tomić et al., 2011). Among other sounds, palatal lateral approximant /ʎ/ was found to be one of the most difficult sounds to pronounce although the same sound (or identically transcribed sound) exist in other languages such as Spanish (Céldran et al., 2009), Portugues (Cruz-Ferreira, 1999), etc. Palatal lateral approximant /ʎ/ is usually pronounced by learners of Croatian as L2 as two separate sounds, alveolar lateral approximant /l/ and alveolar lateral approximant /j/, or substituted by only one of them. This susbstitution was also observed in native speakers of Spanish who learn Croatian as L2. Possible explanation is that this sound is pronounced in different ways by Spanish speakers coming from different regions of Spain and South America no matter only one symbol is used to describe them all. Moreover, it is well known that IPA sometimes uses same symbols for different sounds within different languages and that symbols should be considered within languages respectively. In terms of articulation, possible explanation based on palatography and X-ray examination of the languages containing the same sound (Catalan, Italian, Portuguese and French) might be that the sound exhibits alveopalatal closure, and less often (in Spanish and Italian), the sound is produced with a very front closure at the alveolar zone (Recansens and Espinosa, 2006). Electropalatographic and X-ray examination of Croatian /ʎ/ are to be done.

2. AIM AND HYPOTHESES

The aim of the research is was to examine acoustically changes in pronunciation after session of speech correction. It is presumed that duration of the targeted sound will be shorter after the correction (1), that differences in F2 of the sound pronounced before and after correction will show greatest change and the difference will be significantly different (2), that the greater differences will be achieved when the targeted sound is in initial position or when it follows a plosive consonant than when it is in a medial or final position (3).

3. MATERIALS AND METHODS

3.1. Subjects

Four male and four female native Spanish speakers from Latin America, aged 22 to 24 (mean age 22.8), were recorded before and after ten sessions of speech training (correction). The recordings of participants (pre-correction and post-correction) were done approximately one month apart with 10 individual sessions between recordings. Each session lasted approximately

40 minutes. All subjects attended lessons of Croatian as L2 in Croaticum, Center for Croatian as a Second and Foreign Language on the Faculty of Humanities and Social Sciences in Zagreb. At the time of the speech training they learnt Croatian for at least one and not more than three semesters, starting at beginners level. All of them spoke at least basic English.

3.2. Material

Lists of words containing palatal lateral approximant /ʎ/ in initinal, plosive+/ʎ/, medial and final positions were recorded before and after the session of speech correction. Material was composed taking into consideration sound surrounding, place in the word or sentence, tension and intonation. During the sessions students were exhibiting body movements so some of them used movements of smaller range during their postcorrection recording. Consisted of words *ljeto, ljubav, Ljuba, ljekar, ljepota, ljetopis, pljuska, bljesak, pljesak, kljun, gljiva, pljuvati, ključ, pljeskati, pljusak, pljuskati, pljeskač, voljeti, buljiti, poljubac, soljenica, puljanin, patuljak, čeljade, pelješac, daljinski, boljitak, Miljenko, ciljano, daljina, dolje, tuljan, kradiljivac, spaljeno, okupljanje, poljubac, rukoljub, kraljica, okupljanje, kašalj, moljac, topljiv, koljeno, daljinski, moljakati, muljati, ciljati, bosiljak, buljiti, polje, smilje, zaljubiti, učiteljica, boljitak, naljutiti, maljati.*

3.3. Method

The recordings of the read material were made in the studio of the Department of Phonetics. Acoustic analysis in Praat was used to objectively confirm the differences in pronunciation of words containing /ʎ/ before and after correction. Duration of /ʎ/, as well as of /l/ and /j/ respectively were measured. Furthermore, F1, F2 and F3 were also measured and compared before and after sessions of correction. Excell software was used for statistical analysis.

4. RESULTS AND DISCUSSION

Results mostly confirmed hypotheses of the paper but also opened some still unanswered questions about palatal lateral approximant /ʎ/. Overall change can be seen in duration and F2. Furthermore the position of the targeted sound within the word proved to be of great importance. Figure 1 shows the overall change in one of the best trainees.

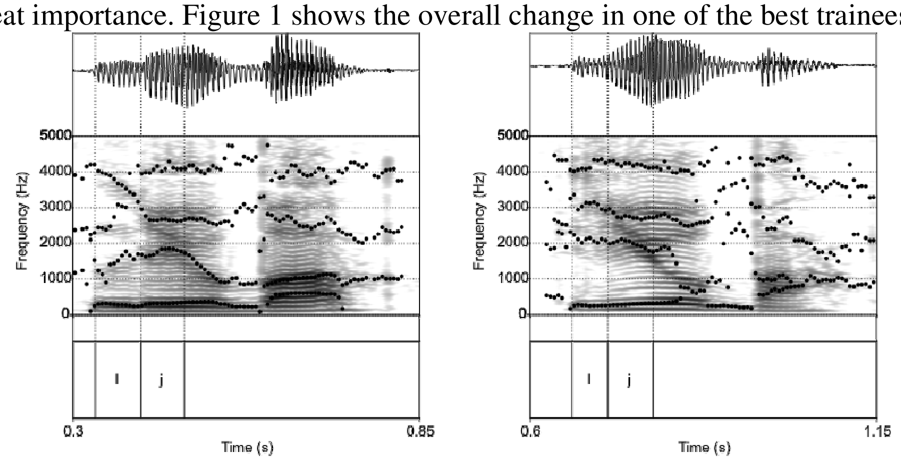


Figure 1. Pronounciation of word *Ljuba* /ʎuba / before (left) and after (right) sessions of correction

In Table 1. shows changes in time and F1, F2 and F3 in total of 103 words measured before and after correction, respectively, with targeted sound in all four tested positions.

Table 1. Changes in time and F1, F2 and F3 in total of 103 words measured before and after correction, respectively, with /ʎ/ in all four tested positions

		Duration	F1	F2	F3
Before correction	M	0,128	304	1979	2885
	SD	0,075	61	408	379
After correction	M	0,101	316	2159	2945
	SD	0,030	116	324	465
	P	**0,001**	0,362	**0,001**	0,307

As expected duration of /ʎ/ was significantly shorter ($p < .01$) after ten sessions of correction for both male and female trainees, being 128 ms and 101 ms after correction. Still, the pronunciation was longer than in standard Croatian measured in intervocalic position (59 ms) (Bakran, 1996). During the correction most of the trainees proved to have better accomplishment while accompanying the pronunciation with firmer body posture and movement such as a clap with hands, so it can be concluded that more strength in pronunciation should be also included. Although the overall rise in all three measured formants can be seen, only F2 was significantly higer ($p < .01$) after correction (2159 Hz) compared to the F2 before correction (1979 Hz). Depending on the vocalic context, F2 of /ʎ/ in intervocalic position varied from 2070 Hz (when surrounded by /i/) to 1740 Hz (when surrounded by /u/). In Table 2 differences in duration and all three measured formants are given for male and female trainees respectively.

Table 2. Changes in time and F1, F2 and F3 in all words for male and female trainees, respectively

		Male trainees				Female trainees			
		Duration	**F1**	**F2**	**F3**	**Duration**	**F1**	**F2**	**F3**
Before correction	M	0,128	282	1714	2643	0,129	328	2260	3141
	SD	0,098	40	300	298	0,037	71	307	273
After correction	M	0,094	272	2020	2689	0,109	363	2306	3217
	SD	0,027	34	265	376	0,031	150	317	390
	p	**0,018**	0,142	**0,000**	0,490	**0,005**	0,132	0,463	0,262

Duration of /ʎ/ was found to be significantly shorter for both male ($p < 0.1$) and female ($p < .01$) trainees but was still longer than the values obtained for standard Croatian. In male trainees F2 was found to be significantly higher after correction, bandwidth of F2 being approximately 400 Hz. Difference was not significant in female trainees. Being automatically calculated by Praat, it might have occurred that F2 merged with F3 which inquires further investigation. In the female trainee with the poorest results of correction the F2 bandwidth was 1000 Hz. Taking into consideration position of /ʎ/ within the word, it is understood that initial consonants are longer and involve more linguopalatal contact than their final correlates (Recasens et al., 2006). In Table 3 duration of /ʎ/ in different positions within the word has been compared.

Table 3. Duration of /ʎ/ as well as F1, F2 and F3 in different positions within the word

			Duration	F1	F2	F3
Initial position	**Before correction**	M	0,141	290	2057	2896
		SD	0,022	46	306	332
	After correction	M	0,118	353	2278	3017
		SD	0,033	272	297	370
		P	**0,040**	0,401	0,063	0,373
After a plosive consonant	**Before correction**	M	0,107	309	2003	2855
		SD	0,028	54	409	371
	After correction	M	0,085	315	2207	2895
		SD	0,021	67	299	460
		P	**0,000**	0,668	**0,014**	0,675
Medial position	**Before correction**	M	0,147	286	2021	2897
		SD	0,126	53	399	404
	After correction	M	0,103	298	2160	2942
		SD	0,029	68	309	489
		P	0,058	0,435	0,125	0,691
Final position	**Before correction**	M	0,130	337	1792	2918
		SD	0,024	84	465	412
	After correction	M	0,121	322	1959	3004
		SD	0,029	59	357	516
		P	0,318	0,517	0,236	0,584

The obtained results showed some inconsistency with some previous investigations (Recasens et al., 2006) because the longest duration obtained before correction was for /ʎ/ in medial position since it was surrounded by vowels. Possible explanation is that since the trainees could not pronounce /ʎ/ but rather as /l/+/j/ in the beginning of the correction, the duration was closer to the duration of two single sounds. Duration for intervocalic /l/ measured by Bakran (1996:260) was 35 ms in connected speech and 34 ms in a cluster in intervocalic position (Bakran, 1996:267). Duration of /j/ was measured on the basis of minimal pairs and in isolated two-syllable words was counted to be 105 ms (Bakran, 1996). The results for /l/ and /j/, respectively, confirmed the presumption that the trainees pronounce /ʎ/ as two separate sounds. The shortest duration was observed for C+/ʎ/ cluster in intial position which can be explained with the tenseness needed for production of plosives. The best improvement in duration was acquired for /ʎ/ in initial position and C+/ʎ/ and the difference in duration before and after sessions of correction was significantly different ($p < .01$). The difference of duration of /ʎ/ in medial position is questionable. It might become significantly different with greater number of trials. On the other hand, the result can also be explained by the disadvantages of establishing clear boundaries between /ʎ/ and surrounding vowels. Results obtained for final /ʎ/ can be explained in the light of articulatory weakening and unclear final boundary. Change in F2 was significant only in C+/ʎ/ ($p < .01$). The difference p=.06 of F2 of /ʎ/ in initial position before and after correction shows tendency to become significant but the measurements should be done on a greater number of trials. Due to the duration of /ʎ/ obtained in medial position, it is, as already said, probable that the trainees understood the single grapheme *lj* as two separate sounds, /l/+/j/. Therefore the measurements for the separate parts of the single sound /ʎ/ should be made on a larger number of native Croatian speakers. In Table 4 the measurements (duration as well as F1, F2 and F3) of the initial part (sound /l/) of the sound /ʎ/ before and after correction are shown.

Table 4. Duration as well as F1, F2 and F3 of /l/ as the initial part of /ʎ/ measured in all positions within the words

		Duration	F1	F2	F3
Before correction	M	0,076	301	1904	2853
	SD	0,064	62	431	463
After correction	M	0,054	328	2094	2916
	SD	0,020	186	371	568
	p	**0,002**	0,151	**0,001**	0,383

The duration of sound /l/ was significantly shorter ($p < .01$) after sessions of correction, but still not as short as single sound /l/ in standard Croatian (Bakran, 1996:260, 267). As expected, F2 proved to be significantly higher ($p < .01$) after the correction. In Table 5 the measurements (duration as well as F1, F2 and F3) of the final part (sound /j/) of the sound /ʎ/ before and after correction are shown.

Table 5. Duration as well as F1, F2 and F3 of /j/ as the final part of /ʎ/ measured in all positions within the words

		Duration	F1	F2	F3
Before correction	M	0,065	318	2182	2988
	SD	0,022	82	401	431
After correction	M	0,050	313	2181	2960
	SD	0,019	75	327	478
	p	**0,000**	0,723	0,986	0,699

The duration of /j/ as the final part of sound /ʎ/ was statistically different before and after sessions of correction. According to the obtained measures it can be seen that F2 in /l/ is higher than in standard Croatian both in before and after correction (Bakran, 1996:140), but this is the part of the targeted sound that was more changed over the process of correction. Oppositely, the values of F2 of the final part of the targeted sound are closer to the values of F2 in /ʎ/. Therefore it can be concluded that it is possible that after correction more attention is paid to merging of two sounds during pronunciation and planning of speech production goes in the same direction. In Table 6 comparison of the initial /l/ and final /j/ segment of /ʎ/ before and after sessions of correction is given. The measurements are made on the basis of 169 trials where both sounds were pronunced. In 37 trials the targeted sound /ʎ/ was pronunced as /l/ so there were no two parts of the sound to be compared. Sound /j/ was pronunced in 74 words before and 95 words after correction. The same sound was not pronunced in 29 words before and 8 words after correction.

Table 6. Comparison of the initial /l/ and final /j/ segment of /ʎ/ before and after sessions of correction

			Duration	F1	F2	F3
Before correction	L	M	0,076	301	1904	2853
		SD	0,064	62	431	463
	J	M	0,065	318	2182	2988
		SD	0,022	82	401	431
	p		0,107	0,135	**0,000**	0,048
After correction	L	M	0,054	328	2094	2916
		SD	0,020	186	371	568
	J	M	0,050	313	2181	2960
		SD	0,019	75	327	478
	p		0,089	0,449	0,081	0,554

In both sounds higher F2 was confirmed after the correction, /j/ having higer F2 than /l/ although the results were significantly different ($p < .01$) only for comparison of F2 before correction.

5. CONCLUSION

Although many times neglected, pronunciation plays an important role both in the process of foreign language learning and the final aim. Some errors in pronunciation may cause some misunderstandings, such as mispronunciation of the palatal lateral approximant /ʎ/sound. Having a distinctive role in Croatian, sound /ʎ/ pronounced as /l/ will, for example, turn *people (ljudi)* into *insane people (ludi)*. In this paper several hypotheses (on duration, formants and partly on position of the sound within the word) have been confirmed, but raised also some question for investigation, such as position of the sound, planning of production, appropriate measurements, coarticulation etc. Duration of /ʎ/ was shorter after correction and best results were seen for /ʎ/ pronounced after a plosive consonant. F2 before and after correction was significantly different in the same position as well in all positions for male and female trainees, respectively. Application of this sort of work can be seen not only for laboratory investigation but also in practical work on the field of foreign language acquisition and in speech and hearing pathology treatment.

ACKNOWLEDGEMENTS

This research was financed in part by grant 130-0000000-3096 of Croatian Ministry of Science, Education and Sports.

REFERENCES

Bakran, J. (1996). Zvučna slika hrvatskoga govora. Zagreb: IBIS grafika.

Celdrán, E.M., Fernández-Planas, A.M., Carrera-Sabaté, J. (2009). Spanish. In *Handbook of the International Phonetic Association.* http://www.ipds.uni-kiel.de/kjk/pub_exx/kk2009_4/spanish/spa.html. (4. veljače 2013.)

Cruz-Ferreira, M. (1999). Portuguese. In *The Handbook of the International phonetics association: a guide to the use of the international phonetic alphabet.* New York: Cambridge University Press.

Guberina, P. (2003a). Philosophie, principes et dévelopements de la Méthode Verbo-tonale. In: C. Robèrge (Ed.) *Rétrospection*. Zagreb: ArTresor.

Guberina, P. (2003b). Les appareils SUVAG et SUVAG Lingua. In: C. Robèrge (Ed.) *Rétrospection*. Zagreb: ArTresor.

Landau, E., Horga, D., Škarić, I. (1999). Croatian. In *The Handbook of the International phonetics association: a guide to the use of the international phonetic alphabet.* New York: Cambridge University Press.

Mildner, V. (1999). Odpravljanje izgovornih napak v materinem in tujem jeziku. Skripta 3: *Zbornik za učitelje slovenščine kot drugega/tujega jezika* (ur. M. Bešter), 13-21.

Mildner, V., Bakran, J. (2001). Acoustic correlates of phonetic correction. Clinical Linguistics and Phonetics, 15 (1-2), 151-155.

Mildner, V., Tomić, D. (2007). Effect of phonetic speech training on the pronunciation of vowels in a foreign lanugage. In J. Trouvain and W. Barry (Eds.) *Proceedings of the 16th International Congress of Phonetic Sciences.* (Eds.) Saarbruecken. 1665-1668.

Recasens, D., Espionosa, A. (2006). Articulatory, positional and contextual characteristics of palatal consonants: Evidence from Majorcan Catalan. *Journal of Phonetics*, 34, 295-318.

Tomić, D., Kiš, A., Mildner, V. (2011). Chinese L1- Croatian L2 – Difficulties and Success. In W.-S. Lee and E. Zee (Eds.) *Proceedings of the 17th International Congress of honetic Sciences.* Hong Kong: City University of Hong Kong, 2006-2010.

ARTICULATION-ACOUSTIC CHARACTERISTICS OF FRICATIVES

MIŠKO SUBOTIĆ[1], SILVANA PUNIŠIĆ[1], NATAŠA ČABARKAPA[1], MILAN VOJNOVIĆ[2]

[1]Institute for Experimental Phonetics and Speech Pathology

[2]Life Activities Advancement Center, Belgrade, Serbia

Abstract. The study consists of a review of current research in fricative analysis. Articulation, acoustic and perceptive characteristics of fricatives have been discussed respectively. Review of correlation of specific acoustic and perceptive characteristics is given. This relation is not simple. A single perceptive feature can correlate with more acoustic parameters. Also, one acoustic parameter can be added to a number of perceptive features. Voice gropus of fricatives of different languages have their articulation-acoustic similarities and differences so generalisation should be carried out carefully for different languages, as well as in selection of acoustic paarameters for description of other phenomena tied to fricatives.

1. INTRODUCTION

Speech researchers tend to assume that the primary unit involved in speech production and perception is the phonetic segment or the distinctive feature, where a word is made up of segments, and the segments themselves are decomposed into a restricted set of phonetic features. Any given feature organizes the segments of a language into natural classes, which in turn play a significant role in the phonology. Along with articulatory attributes, a feature is ultimately assumed to be associated with some specific property of the acoustic signal. The precise nature of the relation between such features and these alleged "acoustic correlates" is as yet not straightforward.

Many such studies investigated the properties of the acoustic signal through which sound is transmitted from speaker to hearer. However, the task is complicated by the problem of variability in the acoustic signal, resulting in a defective match between a signal and its percept (Liberman, et al. 1967). The production mechanism of speech sounds, particularly fricatives, involves intrinsic sources of variability arising from changes in the shape of the vocal tract and the rate of air flow (Strevens 1960; Tjaden and Turner 1997). Variability in the speech signal also arises from extrinsic sources including speaker age (Pentz, et al. 1979), vocal tract size (Hughes and Halle 1956), speaking rate (Nittrouer 1995), and linguistic context (Tabain 2001). Variability in speech is also often a result of a combination of these factors. However, it appeared much easier to generalize about the acoustic distinctions between fricatives within a given speaker than across speakers. To quote from Hughes and Halle article (Hughes and Halle 1956p. 305), "The discrepancies among the spectra of a given fricative as spoken by different speakers in different contexts are so great as to make the procedure of plotting these spectra on one set of axes a not very illuminating one. On the other hand, the differences among the three classes of fricatives (labial, dental, and palatal) are quite consistent, *particularly for sounds spoken by a single speaker*".

Fricative consonants are distinguished from other speech sounds by their manner of production. Fricatives are produced by forming a narrow constriction in some region along the length of the vocal tract. Air blown through this constriction becomes turbulent in flow, typically near an obstacle in the airstream or at the walls of the vocal tract. The acoustic result of this turbulence is the generation of noise. This noise is then filtered by the vocal tract, with the acoustic cavity in front of the constriction contributing the greatest influence on the filtering. In addition, the vocal folds may vibrate simultaneously, generating a periodic sound at the glottis and modulating the airflow through the constriction.

Due to their profound acoustic effect, these two articulatory parameters, constriction location and presence of voicing, are the primary means of classifying fricatives. These features specify the articulators, such as the tongue, lips and larynx, that are used in producing the sounds, and describe how these articulators are adjusted in forming constrictions in the vocal tract (Jakobson et al., Chomsky and Halle, 1968; Halle and Stevens, 1991; Stevens and Keyser, 1989).An additional feature sometimes used is that of stridency (Jakobson et al. 1965) or sibilancy (Lindblad 1980). This feature identifies the fricatives in which the airstream is directed towards an obstacle such as the teeth downstream of the constricted region, at which, presumably, additional sound is generated.

Several studies have attempted to delineate stable acoustic correlates of the fricative place of articulation and voicing. Parameters that seem to influence identification include gross spectral shapes and peak frequencies (Behrens and Blumstein, 1988; Hughes and Halle, 1956; Jongman *et al,* 2000; Strevens, 1960). The first four moments of the spectral energy distribution (Forrest *et al,* 1988; Jongman *et al.,* 2000; Nissen and Fox, 2005; Nittrouer, 1995; Nittrouer *et al,* 1989; Shadle and Mair, 1996), the slopes of lines fitted to spectra in lower and higher frequency regions (Evers *et al,* 1998; Jesus and Shadle, 2002), formant transition information (Jongman *et al,* 2000; McGowan and Nittrouer, 1988; Nittrouer *et al,* 1989; Soli, 1981), overall amplitude (Behrens and Blumstein, 1988; Jongman *et al.,* 2000; Stevens, 1971; Strevens, 1960), amplitude relative to the neighboring vowel in specific frequency regions (Hedrick and Ohde, 1993; Jongman *et al,* 2000; Stevens, 1985), and duration (Baum and Blumstein, 1987; Crystal and House. 1988; Jongman. 1989; Jongman *et al,* 2000). Briefly, alveolar fricatives (/s/, *ITJ)* are characterized by spectral energy [above 4 kHz, Hughes and Halle (1956)] and major peaks [3.5-5 kHz, Behrens and Blumstein (1988); 6-8 kHz, Jongman *et al.* (2000)] at higher frequencies compared to palato-alveolars *(iy, fy* 2-4 kHz; [Hughes and Halle (1956), Behrens and Blumstein (1988)], which display larger overall relative amplitudes. Dental *(/&, lot)* and labio-dental *{Iii, NI)* fricatives show relatively flat spectra below 10 kHz with no dominating peaks, while alveolar and palato-alveolar fricatives have well-defined peaks. Nonsibilants show higher standard deviations (SDs), lower overall amplitudes, and shorter durations than sibilants. Thus, these parameters clearly distinguish sibilants from nonsibilants and from each other but are less effective at determining the place of articulation for nonsibilants. However, it was observed that the onset of F2 at the fricative-vowel boundary was significantly higher for dental fricatives than for labiodental fricatives (Jongman *et al,* 2000; Nittrouer, 2002) and higher for palato-alveolar fricatives than for alveolar fricatives (Jongman *et al,* 2000; McGowan and Nittrouer, 1988; Nittrouer *et al,* 1989). Fewer studies have reported on the voicing distinction in fricatives (Baum and Blumstein. 1987; Crystal and House, 1988; Jesus and Shadle, 2002; Jongman *et al* 2000). These studies suggest that voiceless fricatives are characterized by higher spectral mean and peak values, more defined peaks, less variance, negative skewness, larger overall amplitude, and longer duration compared to their voiced counterparts.

Many issues are unclear; for instance, should acoustic correlates be thought of as invariant, or as variable according to phonetic context? Should they generalize across all segment classes? To what extent can the correlates be thought of as language specific? And finally, do the acoustic attributes differ according to their phonological distinctiveness in different languages?

2. ARTICULATION CHARACTERISTICS

The basic mechanism for fricative production is that a turbulence forms in the air flow at a point in the oral cavity. To generate such turbulence, a steady air flow with velocity greater than a critical number (Reynold's Number) passes through a narrow constriction in the oral cavity and forms a jet that mixes with surrounding air in the vicinity of a constriction to generate eddies. These eddies, which are random velocity fluctuations in the air flow, act as the source for frication noise (Stevens, 1971). Depending on the nature of the constriction, frication noise can also be generated at either an obstacle or a wall (Shadle, 1990). According to Shadle, obstacle source refers to fricatives in which sound is generated primarily at a rigid body perpendicular to the air flow. An example is the production of voiceless alveolar and voiceless post-alveolar fricatives (/s, ʃ/): the upper and lower teeth, respectively, act as the spoiler for the airflow. Such sources are characterized by maximum source amplitude for a given velocity.

In addition, the vocal folds may vibrate simultaneously, generating a periodic sound at the glottis and modulating the airflow through the constriction.

It is well known that voicing and frication demand different control strategies concerning the intraoral and subglottal pressure conditions in the vocal tract. Theoretically, voicing requires an adducted glottis and a transglottal pressure difference, with the pressure below the glottis (subglottal pressure) higher than the pressure in the oral cavity (intraoral pressure). This transglottal pressure difference is observed in an open vocal tract configuration, such as occurs during open vowel production. However, during the production of obstruents, the intraoral pressure rises before full articulatory closure or constriction is reached (Müller & Brown, 1980). The intraoral pressure may rise to such an extent that the transglottal pressure difference necessary for voicing cannot be maintained, thus, the phonologically voiced obstruents become devoiced or partly devoiced. This is true unless other mechanisms such as cavity enlargement are realised, which aim to maintain the transglottal pressure difference. Experimental evidence for its involvement in fricatives production has not been reported (except Narayanan, Alwan, & Haker, 1995). It is possible to employ the strategy of cavity enlargement to maintain voicing during the production of obstruents by shifting the place of closure or constriction further to the front. The production of frication requires an abducted glottis, a significant pressure drop across the oral constriction, and a high amount of airflow. An abducted glottis leads to a high amount of airflow. The pressure drop is created with a higher intraoral than atmospheric pressure by means of a small constriction and a larger cross-sectional area of the glottal constriction than the supraglottal constriction (Stevens, 1971). Airflow usually becomes turbulent when leaving the narrow channel and/or hitting an obstacle in the vicinity of the air stream. The teeth are the obstacle during the production of alveolar and postalveolar fricatives (Shadle, 1990; 1991).

When producing voiced fricatives, a very precise laryngeal-oral adjustment is assumed in order to balance the two contradictory mechanisms: a higher intraoral than atmospheric pressure for frication and a lower intraoral than subglottal pressure for voicing. Mawass (1997) studied the area of the supraglottal and glottal constriction for a given subglottal pressure by means of a model. He discussed about the region where both voicing and frication can be realised and this region is indeed very narrow. If the pressure balance between frication and voicing is not achieved, voicing is more likely to disappear than frication, resulting in devoicing of phonologically voiced fricatives rather than the loss of frication (Smith, 1997).

According to Maddieson (1984:44) about 83% of the 317 languages in his survey have some kind of 's-sound', which is either dental or alveolar. If a language contains another sibilant it is mostly ʃ/ʒ. Only in a small number of languages there is a three-way place contrast among fricatives (sibilants). The most common inventories include a dental/alveolar fricative which contrasts either with (i) a postalveolar and retroflex sibilant (ii) a postalveolar and alveolo-palatal one. A sibilant inventory of the latter type is assumed to exist for several Slavic languages, e.g., Croatian (Kordic, 1997), Polish (Rubach, 1984), Serbian (Kordic, 1997), and Upper Sorbian (Sewc, 1968). Although there are opinions in literature that retroflexive fricatives exist in Serbian language (Keating (1991) Stankiewicz (1986:107) authpors of this paper will hodl on to Miletic's classification of fricatives (Miletić, 1933, 1960; Miletić, 1952; Kostić, 1971).

In Serbian language, consonants are divided into sonants and real consonants, based on wether speech organs creat complete or partial constriction. Fricatives /f, s, z, š, ž, h/ are a part of the real consonant group based on articulation. Based on localisation of constricion, they can be labiodentals /f/; dentals /s, z/; palatals /š, ž/; and velars /h/. Based on role of vocal cords in production, they can be voiced /z, š/ and vocieless /f, s, š, h/.

Beside presence of laringeal sound, discriminative characteristics of fricatives, can be found in different spectral characteristics of friction found in narrow constrictions along the vocal tract This is why, as aphonetic group, they are dispresed across the whole articulation area, from the mouth to the soft palate (Vladisavljević, 1981).

In fricative /f/ articulation, a constriction is formed between the lower lip and upper teeth. Because this constriction is not full, the phonation air flow creates a consonant sound.

In articulation of fricatives /s/ and /z/, the edges of the middle and the back glottis are pressed together along the edges of the hard and soft palate, leaving a wide groove in the middle. The frontal glottis creates a narrow area with the alveolae and upper teeth, while the supraglottal area is bent behind the lower teeth, creating pressure. A small resonator is created between the frontal glottis and the upper jaw. This resonator has a narrow opening , because the lips are widened. Passing through the middle groove, the air flow is comprimed in the narrow opening between the front glottis and the alveolae, where it strongly hits the edge of lower teeth, creating a sharp sound.

In articulation of /š/ and /ž/ edges of the glottis are pressed against the sides of the frontal and back palate while the tip of the glottis rises towards the frontal palate, making contact right behind the alveolae where the air flow is moving through the narrow constriction. In the frontal part of the cavity, under the tip of the tongue and the front teeth, a marginal resonator is created and is prolonged by a protrusion and minimal circling of the lips, creating a rustling sound.

During articulation of these voices, the lower jaw doesn't move forward or down. In articulation of /š/ the vocal cords are not moving because this consonant is vocieless unlike its pair, the vocied /ž/. In articulation of /h/, edges of the glottis ar pressed along the edges of the palate, while the tip of the glottis contacts the lower teeth. The middle line of the mouth cavity is left with an opening for the air flow.

According to most authors, the system of automatic articlation in the mother tongue is formed by seven years of ages age needs to have automatic articulation for the mother tongue, in all types of phonetic positions (the initial, medial, final in coarticulation and consonant slusters), in monosyllable and multisyllable words as well as automatic use of intonation schemes and other elements of suprasegmental structure. (Kašić, 2000b).

Coordination of developmental articulation norms for the group of fricatives, created by a number of authors (Vasić,1971; Vuletić, 1990; Vladisavljević, 1981; Golubović, 1997; Kašić, 2003a) resulted in the following dynamics: children aged from 3 years and 6 months have correct articulation of fricatives /f, h/ in each position. A mild deviation is tolerated for fricatives /s, z/, while articulation of /š, ž/ can be tolerated even in the form of severe distortion, in connection with area and way of articulation (softening); children aged 5 years and 6 months have correct articulation of all fricatives in all positions, with tolerance from some authors for discrete distortion of fricatives /š, ž/. In thepriod from 5 to 7 years of age, there is a stabilisation of phoneme articulation in all phoneme-sound positions in all lexical positions.

Variations in pronuntiation, caused by factors of linguistic and paralinguistic origin have to stay in the articulation filed of the sound representing realisation of a specific phoneme, or, in other words, within the limited field (typical realisation). If phoneme realisation in any of its dimensions, exceeds the limits preordained by linguistic standards, this can be called the atypical realisation, with deviation registered for one or a group of articulation and/or acoustic characteristics. One sound can deviate from typical quality of articulation in a number of ways. These deviations can be registered as: 1) omission, absence of voice; 2) substitution, replacement of an undeveloped voice with an already existing one; 3) distortion, different typical and atypical voice distortions. Voice distortions examined in this study mark articulation-acoustic deviation from standard norms in reproduction of a voice or a number of voices. This doesn't automatically include change of opposition function of the phoneme (as in omission and substitution) but distortion of the acoustic picture in its phonemic surrounding; the voices are pronounced but with low quality. In fricative articulation of the distortion type and with completed physiological development, there are the so-called typical, consequential deviations known as stygmatism. There are 12 types of stygmatism for voices /s, z, š, ž/.

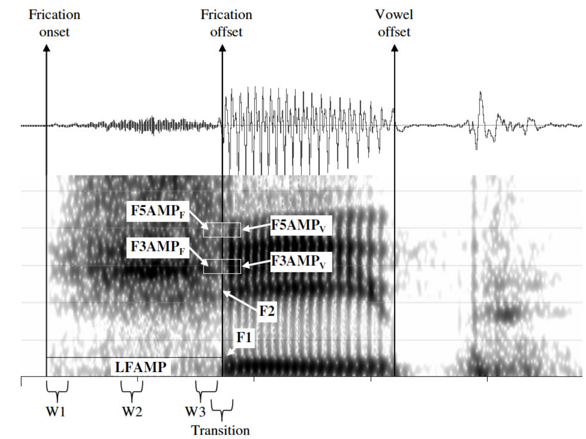
All of the fricatives can have one or more deviation characteristics: vocieless; voiced; disorder of duration such as prolonged or shortened friction; intensity disturbance such as strong or weak friction; pitch disorder; or disorders such as bilabial in case of /f/ and /v/; nasal; stridens; coronal; I, II or III grade interdental; adental; alveolar; palate; left or right lateralisation; production of rounded /s/; too sharp , gutural, frontal /h/.

Complexity of the articulation mechanism in production of fricatives has an effect on the variation field of acoustic representations of voices, which influences objective analysis.

3. ACOUSTIC CHARACTERIZATION

The main body of today's knowledge on fricative recognition is found in the pioneering studies of the acoustic analysis of fricatives conducted about 40-50 years ago (e.g., Fant, 1960; Fletcher, 1953; Harris, 1958; Heinz & Stevens, 1961; Hughes & Halle, 1956; Stevens, 1971; Strevens, 1960).

One approach for characterizing fricatives is to describe them by a set of distinctive features. These features specify the articulators, such as the tongue, lips and larynx, that are used in producing the sounds, and describe how these articulators are adjusted in forming constrictions in the vocal tract (Jakobson, Fant and Halle, 1965; Chomsky and Halle, 1968; Halle and Stevens, 1991; Stevens and Keyser, 1989).



Picture 1. Wave shape and spectar FV at entered critical points.

Voicing and place distinctions in fricatives are cued by multiple acoustic characteristics, some of which can cue both phonological distinctions. For example, the place distinction between alveolar [s] and alveopalatal [ʃ] (and between [z] and [ʒ]) corresponds to differences in formant transitions, spectral mean, and spectral variance (Jongman et al., 2000; McMurray & Jongman, 2011) as well as noise amplitude (Jongman et al., 2000). On the other hand, the voicing distinction between [s] and [z] (or between [ʃ] and [ʒ]) can also be cued by differences in spectral mean and variance, noise amplitude, and duration (Jongman et al., 2000; McMurray & Jongman, 2011; Silbert & de Jong, 2008). The mapping between features and acoustic cues in consonants can be modulated by the position of a consonant within a syllable, as well. Vowel duration is a robust cue to voicing of coda consonants, but plays, at best, a secondary role in cuing onset voicing (e.g., de Jong, 2004; Peterson & Lehiste, 1960). The relationships between place and the spectral properties of frication noise and the relationships between voicing and the acoustic power of frication noise also vary consistently with syllable position (Silbert & de Jong, 2008). Current descriptions of the mapping between multiple acoustic cues and multiple phonological categories remain limited in at least one important respect. Essentially all existing studies of the acoustic cues to phonological distinctions rely on the assumption that patterns of variability of and correlation between acoustic cues are constant across phonological categories. Many statistical analyses rely on the much stronger assumption that separate cues are statistically independent. For example, studies of multiple cues to multiple phonological distinctions in fricatives have either employed univariate statistical tests, which assume equal variance and zero correlation (e.g., Jongman et al., 2000; McMurray & Jongman, 2011), or multivariate tests that assume that variance-covariance patterns are constant across categories (e.g., Silbert & de Jong, 2008).

Shadle (1990) postulates three reasons for current limitations in our characterization of the acoustic mechanism of fricatives: 1) the theory of sound generation due to turbulence is incomplete; 2) the primary sound generation process, unlike vowels, does not include a mechanical vibration that is clearly correlated with the speech signal; and 3) an intrinsically noisy speech signal must be described statistically, rather than analytically. These limitations, which exist even for static vocal-tract configurations, become even more interesting when considered in terms of the kinematics of moving between a consonant and a vowel.

The English language has the richest body of research on acoustic analysis of fricatives. The parameters researched are duration, amp;itude and spectral characteristics. The parametres named have been registered, based on the wave form and fricative spectre (Graph 1) surrounded by vocals.

Table 2: Summary of the cues used in the fricative analysis. The "cue for" column indicates the phonological feature typically associated with each cue (McMurray, Jongman 2011).

Cue	Variable	Description	Cue for
Peak frequency	Max PF	Frequency with highest amplitude	Place
Frication duration	DUR_F	Duration of frication	Voicing
Vowel duration	DUR_V	Duration of vocalic portion	Voicing
Frication RMS	RMS_F	Amplitude of frication	Sibiliance
Vowel RMS	RMS_V	Amplitude of vocalic portion	Normalization
F3 narrow band amplitude	$F3AMP_F$	Amplitude of vowel at F3	Place
F3 barrow band amplitude (vowel)	$F3AMP_V$	Amplitude of frication at F5	Place
F5 narrow band amplitude	$F5AMP_F$	Amplitude of frication at F5	Place
F3 barrow band amplitude (vowel)	$F5AMP_V$	Amplitude of vowel at F5	Place
Low frequency energy	LF	Mean RMS below 500Hz in frication	Voicing
Pitch	F_0	Fundamental frequency at vowel onset	Voicing
First formant	F1	First formant frequency of vowel	Voicing
Second formant	F2	Second formant frequency of vowel	Place
Third formant	F3	Third formant frequency of vowel	Place
Forth formant	F4	Forth formant frequency of vowel	Unknown
Fifth formant	F5	Fifith formant frequency of vowel	Unknown
Spectral mean	M1	Spectral mean at three windows in frication noise (onset, middle, offset)	Place/voicing
Spectral variance	M2	Spectral variance at three windows in frication noise (onset, middle, offset)	Place
Spectral skewness	M3	Spectral skewness at three windows in frication noise (onset, middle, offset)	Place/voicing
Spectral kurtosis	M4	Spectral kurtosis at three windows in frication noise (onset, middle, offset)	Place
Transition mean	M1TRAN	Spectral mean in window including end of frication and vowel onset	Place
Transition variance	M2 TRAN	Spectral variance in window including end of frication and vowel onset	Place
Transition skewness	M3 TRAN	Spectral skewness in window including end of frication and vowel onset	Place
Transition kurtosis	M4 TRAN	Spectral kurtosis in window including end of frication and vowel onset	Place

Following amplitude measures are used in characterizing fricatives: Fricative noise amplitude, Low Frequency Energy, Frequency-specific relative amplitude, Narrow band amplitude, Frication RMS amplitude and Maximum Normalized Spectral Slope.

Fricative noise amplitude- A spectrum over the entire frication noise is computed, and the average amplitude of the components is measured

Low Frequency Energy is used as a potential measure of voicing during the frication. A spectrum over the entire frication noise is computed, and the average amplitude of the components below 500 Hz is measured.

Frequency-specific relative amplitude is computed in two stages. First, the amplitude of F3 at vowel onset for sibilants, and of F5 for non-sibilants is measured using a discrete Fourier transform over a 23.3 ms window. Second, a spectrum is derived over the middle 23.3 ms of the fricative and the amplitude of the frequency component closest to the F3 or F5 values was obtained. Relative amplitude is then the difference between fricative amplitude and vowel amplitude.This cue could artificially distinguish sibilants from non-sibilants.

Narrow band amplitude is calculated using both F3 and F5 amplitude for all fricatives and vocalic portion.

Frication RMS amplitude and *Vowel RMS amplitude* are measured by computing the RMS amplitude in dB for the entire frication as well as three consecutive pitch periods at the point of maximum vowel amplitude, respectively.

Maximum Normalized Spectral Slope (MXSS), relates the spectral slope of the frication noise spectrum to the maximum total energy in the utterance, thus capturing the spectral shape of the fricative and its amplitude in addition to the vowel amplitude features in one quantity.

Most studies of frication noise amplitude have focused on English fricatives. McCasland (1979) studied the role of amplitude as a perceptual cue to fricative place of articulation. Results led McCasland to conclude that the low amplitude of nonsibilant fricatives was used as a perceptual cue to distinguish them from the sibilants.

Behrens and Blumstein (1988a) investigated the role of fricative noise amplitude in distinguishing place of articulation among fricatives. They found, contrary to previous studies, that the overall amplitude of the fricative noise relative to the amplitude of the following vowel does not constitute the primary cue for sibilant/nonsibilants distinction.

Another way to capture classification information found in frication noise amplitude is to measure the Root-Mean-Square (RMS) amplitude of the fricative noise normalized relative to the vowel. Jongman et al. (2000) measured the difference between the average RMS amplitude (in dB) of three consecutive pitch periods at the point of maximum vowel amplitude and the RMS amplitude of the entire frication noise. The authors found that this "normalized RMS amplitude" can differentiate among all four places of fricatives in English with voiced fricatives having a smaller amplitude than their voiceless counterparts.

Abdelatty Ali et al. (2001) used Maximum Normalized Spectral Slope to analyze fircatives. It differs, however, from Jongman and colleagues' normalized amplitude in two ways: first it uses peak amplitude instead of RMS amplitude for the vowel and the fricative; and second, it uses only the strongest peak of the fricative (as opposed to whole frication noise) and normalizes that in relation to the strongest peak of the vowel (as opposed to the average of the strongest three pitch periods).

So far, relative amplitude has been shown only to differentiate between sibilants and nonsibilants as a class, with the exception of Jongman et al. (2000) study, in which they found that relative amplitude, as defined by Hedrick and Ohde (1993), also differentiates among all four places of fricatives articulation in English.

Fricative duration measures were used in previous research mainly to differentiate between sibilants and nonsibilants, and to assess the voicing of fricatives (Behrens and Blumstein 1988b). They found that sibilants were longer than nonsibilants. Also, they found no significant differences between the duration of members of the same class. The vowel effect was found to be minimal and only among the nonsibilant fricatives. Similar results were obtained by Pirello et al (1997). The researchers also found that alveolar fricatives were longer on average than labiodental fricatives in English.

Jongman (1989) questioned the importance of frication noise duration as a cue for fricative identification. When frication noise duration was normalized by taking the ratio of fricative duration over word duration, Jongman et al. (2000) found a significant difference among all places of fricative articulation with the exception of the labiodental and interdental contrast.

Frication noise duration has also been used to assess the voicing distinction between fricatives of the same place of articulation (Cole and Cooper 1975, Manrique and Massone 1981, Baum and Blumstein 1987) examined the role of frication noise duration on the perception of voicing in fricatives. They found that syllable-initial voiceless English fricatives in citation forms are longer than their voiced counterparts. However, they noted considerable overlap in duration distributions of voiced and voiceless fricatives at all places studied.

Using connected speech, Crystal and House (1988) also found that, on average, voiceless fricatives in word-initial position are longer than voiced fricatives. Like Baum and Blumstein's results, there was a considerable amount of overlap between the duration distributions of the voiced and voiceless fricatives in connected speech. Normalized fricative noise duration (defined as the ratio of fricative duration over that of the carrier word) significantly longer for voiceless than for voiced fricatives. They also found that such differences are more apparent in nonsibilant than in sibilant fricatives.

In addition to amplitude and duration, spectral properties of the frication noise have been investigated to find cues that identify fricative place of articulation. Usually used acoustic measures for fricative characterizations are: Peak frequency, spectral slopes below and above peak frequencies, Spectral mean, variance, skewness, kurtosis, Transition moments, Formant Frequencies, Fundamental frequency, and different kinds of band frequencies and their relative relationship.

Peak frequency is measured from a 40 ms window at the center of the frication noise. It is the frequency of the highest-amplitude peak of the FFT spectrum.

Spectral mean, variance, skewness, and *kurtosis* are usually computed from spectra obtained from three 40 ms Hamming windows centered at the onset, midpoint and end of the frication. Spectra can be based on a linear or bark frequency scale. As Jongman et al. (2000) reported there is little difference in results using those two scales.

Transition moments is derived in the same way from a window that included the last 20 ms of the frication and the first 20 ms of the vowel.

Formant Frequencies. The frequency of the first five formants over the first 23.3 ms of vowel onset. Frequencies are automatically extracted using the Burg algorithm method with two different parameter-sets (one selected for men and one for women). *Fundamental frequency is* computed for the first 46.6 ms of each vowel.

One of the early attempts to relate the fricative place of articulation to the frequency location of energy maximum in the frication noise was the study by Hughes and Halle (1956). In this study, gated 50 ms windows of the frication noise were used to produce spectra of English fricatives. They reported that the length of the vocal tract from the point of constriction to the lips was inversely related to the frequency of the peak in the spectrum. Thus, the spectral peak increases as the point of articulation becomes closer to the lips.

Strevens (1960) also looked into the use of spectral prominence to differentiate between fricatives through examining the front, mid and back voiceless fricatives based on average line spectra. Strevens found that the front fricatives were characterized by unpatterned low intensity and smooth spectra, the mid fricatives by high intensity with significant peaks on the spectra around 3.5 kHz and the back fricatives by medium intensity and a marked formant like structure with peaks around 1.5 kHz.

The results reported above for front and mid fricatives were also shown to be perceptually valid (Heinz and Stevens 1961, Manrique and Massone 1981).

Other studies of English fricatives confirmed that spectral peak location can classify sibilants from nonsibilants as a class, and only between sibilants (Behrens and Blumstein 1988b, Pentz et al. 1979). Spectral peak location is found to be age and gender dependent (Nissen 2003), vowel dependent (Mann and Repp 1980; Soli 1981) and highly variable for speakers with neuromotor dysfunction (Chen and Steven 2001) due to their lack of control over articulatorv muscles.

However, in contrast to all the studies mentioned above, Jongman et al. (2000) found that across all (male and female) speakers and vowel contexts, all four places of fricative articulation in English were significantly different from each other in terms of spectral peak location. The researchers justified the use of the larger analysis window they adopted in their study, as compared to other studies, as a way to obtain better resolution in the frequency domain at the expense of temporal domain resolution. They argue that such a compromise is advantageous due to the stationary nature of frication noise.

In summary, spectral peak location for the fricatives increases as the constriction becomes closer to the open end of the vocal tract. Also, spectral peak for back fricatives shows a formant-like structure similar to the following vowel.

Spectral moments analysis is another metric that has been used for fricative identification. Unlike spectral peak location analysis, this statistical approach captures both local (mean frequency and variance) and global (skewness and kurtosis) aspects of fricative spectra. Spectral mean refers to the average energy concentration and variance to its range. Skewness, on the other hand, is a measure of spectral tilt that indicate the frequency of the most energy concentration. Skewness with a positive value indicates a negative spectral tilt with energy concentration at the lower frequencies, while negative skewness is an indication of positive tilt with energy concentration at higher frequencies (Jongman et al. 2000). Kurtosis is an indicator of the distribution's peakedness.

One of the early applications of spectral moments to classify speech sounds was the study by Forrest et al. (1988) on English obstruents. For the fricatives in that study, Forrest et al. generated a series of Fast Fourier Transforms (FFT) using a 20 ms analysis window with a step-size of 10 ms that started at the obstruent onset through three pitch periods into the vowel. The FFT-generated spectra were then treated as a random probability distribution from which the first four moments (mean, variance, skewness, and kurtosis) were calculated. The spectral moments obtained from both linear and Bark scales were entered into a discriminant function analysis in an attempt to classify voiceless fricatives according to their place of articulation. Classification scores, on both scales, were good for the sibilants. The nonsibilants, on the other hand, were not as accurately classified using any moment on either of the two scales. Subsequent implementations of the spectral moment analysis tried to extend or replicate Forrest et al. approach with some modifications. The study by Tomiak (1990) of English voiceless fricatives, for example, used a different analysis window (100 ms) at different locations of the English voiceless frication noise. Like in previous research, spectral moments were successful in classifying sibilants and /h/ data. In the case of nonsibilants, it was found that the most useful spectral information is contained in the transition portion of the frication. Additionally, in contrast to Forrest et al., Tomiak found an advantage for the linearly derived moment profiles over the Bark-scaled ones.

Spectral moments were also used by Shadle et al. (1996) to classify voiced and voiceless English fricatives. The study involved spectral moments measured from discrete Fourier transform (DFT) analyses performed at different locations within the frication noise and at different frequency ranges. They found that spectral moments provided some information about fricative production but did not discriminate reliably between their different places of articulation. Furthermore, their results indicated that spectral moments are sensitive to the frequency range of the analysis. However, the moments were not sensitive to the analysis position within the fricative. Similar results were also obtained for children (Nittrouer et al 1989; Nittrouer 1995). The use of spectral moments as a tool to distinguish between /s/ and /ʃ/ was also extended to atypical speech and found to be reliable Tjaden and Turner (1997).

The studies mentioned so far demonstrate the ability of spectral moments to distinguish sibilants from nonsibilants as a class and that they can reliably distinguish only among sibilants. However, contrary to the studies mentioned above, Jongman et al. (2000) found that spectral moments were successful in capturing the differences between all four places of fricative articulation in English. Jongman et al. study, however, differs from other studies in that it calculated moments from a 40 ms FFT analysis window placed at four different places in the frication noise (onset, mid, end, and transition into vowel) and that it uses a larger and more representative number of speakers and tokens (2880 tokens from 20 speakers) as compared to a smaller population in other studies. Across moments and window locations, variance and skewness at onset and transition were found to be the most robust classifiers of all four places. Also, on average, variance was shown to effectively distinguish between voiced and voiceless fricatives with the former having greater variance.

Early research on formant transition focused on perceptual usefulness of such information in classifying speech sounds (Harris 1958, Heinz and Stevens 1961). Harris suggested that the perception of fricatives occurs at two consecutive stages. In the first stage, cues from frication noise alone determine whether the fricative is a sibilant or nonsibilant. If sibilant is the determined class, then cues from the frication noise alone will differentiate among the sibilant fricatives. However, if the class is determined to be nonsibilant at the first stage, then the formant transition information is used for the within-class classification.

The role of formant transition, however, was not found to be as crucial in other studies (LaRiviere et al 1975, Manrique and Massone 1981; Jongman 1989) also found similar results using different methods.

Locus equations provide a method to quantify the role of formant transition in the identification of fricative place of articulation by relating second formant frequency at vowel onset ($F2_{ONSET}$) to that at vowel midpoint ($F2_{VOWEL}$)- Locus equations are straight line regression fits to data points formed by plotting onsets of F2 transitions along the *y* axis and their corresponding vowel nuclei F2 along the *x* axis in order to obtain the value of the slope and ^-intercept. This metric has been used primarily to classify English stops (Lindblom 1963; Sussman et al. 1991). It was only recently that this measure was applied to fricatives. Fowler (1994) investigated the use of locus equations as cues to place of articulation across different manners of articulation including the fricatives. In this study, Fowler found that locus equations (in terms of slope and y-intcreept) of a homorganic stop and fricative were significantly different, while those of a stop and a fricative of different place of articulation were significantly similar. Nevertheless, locus equations were able to differentiate between members that share the same manner of articulation. In another study, Sussman (1994) investigated the use of locus equations to classify consonants across manners of articulation (approximants, fricatives, and nasals). In contrast to Fowler (1994), he found that fricatives were not distinguishable based on the slope of their locus equations.

Results of other studies of English fricatives were similar to those of Sussman (1994). For example, in their large-scale study of English fricatives, Jongman et al. (2000) calculated the slope and y-intercept for all English fricatives in six vowel environments. Specifically, Jongman and colleagues measured $F2_{ONSET}$ and $F2_{VOWEL}$ from a 23.3 ms full Hamming window placed at the onset and midpoint of the vowel respectively. Locus equations are particularly of interest here since they have been shown to work across languages (Sussman et al 1993), gender (Sussman et al. 1991), speaking style (Krull 1989), and speaking rate (Sussman et al 1998).

4. CONCLUSION

Comparison of fricatives of different languages shows that, in addition to similiarities, differences can be found in production and acoustic features. This is why it is difficult to apply results on characterization of fricatives of one language to another. This study is therefore a first step in analyzing acoustic parameters used in describing fricatives in different languages in order to correctly describe the fricatives in Serbian language. Because of many dialects and little results found for Serbian language, one can note the complexity and scope of this field of research aimed at objective description of Serbian language fricatives. This problem is additionally complicated by articulation pathology.

AKNOWLEDGEMENT

This paper is created within the project „E-logoped“ number TR32032 and project of basic research Interdisciplinary Research of Verbal Communication Quality number OI178027, which are financed by the Ministary of Science and Enviromental Protection in the Republic of Serbia.

LITERATURE

Abdelatty Ali, A. M., J. Van der Spiegel, and P. Mueller (2001). Acoustic-phonetic features for the automatic classification of fricatives. *J Acoust Soc Am 109(5* Pt I). 2217-2235.

Baum, S. R., and Blumstein, S. E. (1987). "Preliminary observations on the use of duration as a cue to syllable-initial fricative consonant voicing in English," J. Acoust. Soc. Am. 82, 1073-1077.

Behrens, S. and S. E. Blumstein (1988a). Acoustic characteristics of English voiceless fricativesia descriptive analysis. *J Phonetics 16,* 295-298.

Behrens, S. and S. E. Blumstein (1988b). On the role of the amplitude of the fricative noise in the perception of place of articulation in voiceless fricative consonants. *J Acoust Soc Am 84(3),* 861 867.

Bob McMurray; Allard Jongman, 2011, What information is necessary for speech categorization? Harnessing variability in the speech signal by integrating cues computed relative to expectations. Psychological review 2011;118(2):219-46.

Chen, H. and K. N. Steven (2001). An acoustical study of the fricative /s/ in the speech of individuals with dysarthria. *J Speech Lang Hear Res 44(6).* 1300 1314.

Chomsky, N. and Halle, M. (1968). *The Sound Pattern of English.* (Harper and Row, New York).

Cole, R. A. and W. E. Cooper (1975). Perception of voicing in English affricates and fricaitves. *J Acoust Soc Am 58(6).* 1280 1287.

Crystal, T. and A. House (1988). Segmental durations in connected-speech signals: Current results. *J Acoust Soc Am 83,* 1553-1573.

Crystal, T. H., and House, A. S. (1988). "A note on the durations of fricatives in American English," J. Acoust. Soc. Am. 84, 1932-1935.

de Jong, K. (2004). Stress, lexical focus, and segmental focus in English: patterns of variation in vowel duration. *Journal of Phonetics, 32(4),* 493-516. doi: 10.1016/j. wocn.2004.05.002

Evers. V. Reel/. H. and Lahiri. A. (1998). "Crosslinguistic acoustic categorization of sibilants independent of phonological status," J. Phonetics 26, 345-370.

FANT, G. (1960). *ACOUSTIC THEORY OF SPEECH PRODUCTION.* MOUTON, VGRAVENHAGE: THE NETHERLANDS.

FLETCHER, H. L. (1953). *SPEECH AND HEARING IN COMMUNICATION.* VAN NOSTRAND; NEW YORK.

Forrest. K.. Weismer. G. Milenkovic. P.. and Dougall. R N. (1988) "Statistical analysis of word-initial voiceless obstruents: Preliminary data." J. Acausi Soc Am. 84. 115-121.

Fowler, C. A. (1994). Invariants, specifiers, cues: An investigation of locus equations as information for place of articulation. *Perception Psychophysics 55,* 597-611.

Furundžić, D., Subotić, M., Pantelić, S. (2006). Ocena poremećaja govora na nivou fonema primenom neuronskih mreža. *DOGS. Zbornik radova*, Vršac, str. 10-13.

Furundžić, D., Subotić, M., Pantelić, S. (2007). Primena neuronskih mreža u klasifikaciji poremećaja izgovora frikativa. E*TRAN* - elektronski zbornik, Herceg Novi.

Furundžić, D., Subotić, M., Punišić, S. (2009). Determination of relevant parameters influence in articulation regularity quantification for serbian language phoneme /š/ using neural networks. In the book: S. Jovičić, M. Sovilj (editors). *Speech and Language*, Proceedings, 158-168. Belgrade

Furundžić D., Punišić S., Subotić M. (2011). Acoustic features variability analysis using neural networks. S. Jovičić, M. Sovilj (Eds.). Speech and Lenguage, Interdisciplinary Research III. 188-226.

Golubović, S. (1997). *Klinička logopedija I.* Defektološki fakultet, Beograd.

Halle, M. and Stevens, K. N. (1991). " Knowledge of language and the sounds of speech," in *Music, Language, Speech and Brain,* edited by J. Sundberg, L. Nord, and R. Carlson (MacMillan, Basingstoke, Hampshire, England), pp. 1-19.

Harris, K. S. (1958). "Cues for the discrimination of American English fricatives in spoken syllables," Lang Speech 1, 1-7.

Harris, K. S. (1958). Cues for the discrimination of American English fricatives in spoken syllables. *Language and Speech,* 1,1-7.

Hedrick, M. S., and Onde. R. N. (1993). "Effect of relative amplitude of frication on perception of place of articulation," J. Acoust. Soc. Am. 94, 2005-2026.

Heinz, J. M. and K. N. Stevens (1961). On the properties of voiceless fricative consonants. *J Acoust Soc Am 33,* 589 596.

Hughes, G. W. and M. Halle (1956). Spectral properties of fricative consonants. *J Acoust Soc Am 28,* 303 310.

Jakobson, R., C.G.M. Fant and M. Halle (1965) *Preliminaries to Speech Analysis.* Massachusetts Institute of Technology Press, Cambridge, Mass.

Jesus. L M. T.. and Shadle. C. H. (2002). "A parametric study of the spectral characteristics of European Portuguese fricatives." J. Phonetics 30. 437-464.

Jongman, A. (1989). "Duration of frication noise required for identification of English fricatives," J. Acoust. Soc. Am. 85, 1718-1725.

Jongman, A. (1998). Are locus equations sufficient or necessary for obstruent perception? *Behav Brain Sci 21(2),* 271-272.

Jongman, A., Wayland, R., and Wong, S. (2000). "Acoustic characteristics of English fricatives," J. Acoust. Soc. Am. 108, 1252-1263.

Jovičić S., Kašić Z., Punišić S. (2010). Production and perception of distortion in word-initial friction duration. *Journal of Communication Disorders* 43/5., DOI:10.1016/j. jcomdis.2010.04.007.

Kašić, Z. (2000). *Segmentna i suprasegmentna organizovanost govora.* U: S. Golubović i Z. Kašić *Segmentna i suprasegmentna organizovanost govora i poremećaji fluentnosti*. Beograd: Društvo defektologa Jugoslavije.

Kašić, Z. (2003). *Fonetika.* Beograd: Defektološki fakultet.

Keating, P. (1991): Coronal Places of Articulation. In C. Paradis & J.-F. Prunet (eds.): *Phonetics and Phonology. The Special Status of Coronals. Internal and External Evidence,* 29-48. New York: Academic Press.

Kordic, S. (1997): Serbo-Croatian. Munchen, Newcastle: Lincoln Europa.

Kostić, Đ. (1971). *Metodika izgradnje govora u dece oštećenog sluha.* Savez društva defektologa Jugoslavije, IEFPG, Beograd.

Krull D. (1989). Second formant locus pattern and consonant-vowel coarticulation in spontaneous speech. *Perilus 10,* 87 108.

LaRiviere, C, H. Winitz, and F. Herriman (1975). The distribution of perceptual cues in English prevocalic fricatives. *J Speech Hear Res 18,* 613 622.

Liberman, A. M., F. S. Cooper, D. P. Shankweiler, and M. Studdert-Kennedy (1967). Perception of the speech code. *Psychol Review 74(d)-* 431 461.

Lindblad, Per (1980) "Some Swedish Sibilants," Travaux de l'Institut de Linguistique de Lund v. 16.

Lindblom. B. (1963). A spectre-graphic study of vowel reduction. *J Acoust Soc Am 35,* 1773-1781.

Maddieson, I. 1984. *Patterns of Sounds.* Cambridge: Cambridge University Press.

Mann, V. A. and B. H. Repp (1980). Influence of vocalic context on perception of the [s] - [sh] distinction. *Perception & Psychophysics 28,* 213 228.

Manrique, A. M. and M. I. Massone (1981). Acoustic analysis and perception of Spanish fricative consonants. *J Acoust Soc Am 69(4),* 1145-1153.

McCasland, G. P. (1979). Noise intensity and spectrtuirt cues for spoken fricatives. *J Acoust Soc Am Suppl 165.* S78-79.

McGowan. R.. and Nittrouer. S (1988). "Differences in fricative production between children and adults: Evidence from an acoustic analysis of *flj* and *hi.'* J. Acoust. Soc. Am 83. 229-236.

McMurray, B., & Jongman, A. (2011). What information is necessary for speechcategorization? Harnessing variability in the speech signal by integrating cues computed relative to expectations. *Psychological Review, 118(2),* 219-246. doi:10.1037/a0022325

Miletić, B. (1933) *Izgovor srpskohrvatskih glasova,* Beograd, Izdanje zadužbine Milana Kujundžića.

Miletić, B. (1952). *Osnovi fonetike srpskoga jezika.* Znanje, Beograd.

Miletić, B. (1960) *Osnovi fonetike srpskog jezika,* Beograd, Naučna knjiga.

Muller, E. M., & Brown Jr., W. S. (1980). Variations in the supraglottal air pressure waveform and their articulatory interpretation. *Speech and Language: Advances in Basic Research and Practice, 4,* 317-389.

Narayanan, S. S., Alwan, A. A., & Haker, K. (1995). An articulatory study of fricative consonants using magnetic resonance imaging. *Journal of the Acoustical Society of America, 98(3),* 1325-1347.

Nissen, S. (2003). *An accoustic analysis oj and typically developing children.* Ph. D. OH. *voicless obstruents produced by adults* thesis, Ohio State University, Columbus,

Nissen. S. I... and Fox. R. A. (2005). "Acoustic and spectral characteristics ol young children's fricative productions: A developmental perspective." J. Acoust. Soc. Am. IIS. 2570-2578.

Nittrouer. S. (1995). "Children learn separate aspects of speech production at different rates: Evidence from srvciral moments." J. Acoust. Soc. Am. 97. 520-530.

Nittrouer. S. (2002). "Learning to rereeive speech: How fricative perception changes, and how- it stays the same." J. Acoust Soc. Am. 112. 711-719.

Nittrouer. S.. Studdert-Kennedy. M,, and McGowan. R. S. (1989). "The emergence of phonetic segments: Evidence from the spectral structure of fricative-vowel syllables spoken by children and adults." J. Speech Hear. Res. 32. 120-132.

Pentz, A., H. R. Gilbert, and P. Zawadzki (1979). Spectral properties of fricative consonants in children. *J Acoust Soc Am 66(6).* 1891 1893.

Peterson, G. E., & Lehiste, I. (1960). Duration of Syllable Nuclei in English. *The Journal of the Acoustical Society of America,* 32(6), 693-703. doi:10.1121/1.1908183

Pirello, K., S. E. Blumstein, and K. Kurowski (1997). The characteristics of voicing in syllable-initial fricatives in American English. *J Acoust Soc Am 101* (6), 3754-3765.

Rubach, J. (1984): *Cyclic and Lexical Phonology. The Structure of Polish.* Dordrecht: .Foris.Rubach, J. (1993): *The Lexical Phonology of Slovak.* Oxford: Clarendon Press.

Sewc, H. (1968): *Gramatika hornjoserbskeje reče.* Budysin: Ludowe nakladnistwo Domowina.

Shadle, C. H. (1990). Articulatory-acoustic relationships in fricative consonants. In W. J. Hardcastle & A. Marchal (Eds.). *Speech production and speech modelling* (pp. 187-209). Dordrecht: Kluwer Academic Press.

Shadle, C. H. (1991). The effect of geometry on source mechanisms of fricative consonants. *Journal of Phonetics, 19,* 409-424.

Shadle. C. H.. and Mair. S. J. (1996). "Quantifying spectral characteristics of fricatives." Proceedings from the International Conference on Spoken Language Processing (ICSLP). Philadelphia, pp. 1521-1524.

Silbert, N., & de Jong, K. (2008). Focus, prosodic context, and phonological feature specification: Patterns of variation in fricative production. *The Journal of the Acoustical Society of America, 123,* 2769.

Smith, C. L. (1997). The devoicing of *Izl* in American English: Effects of local and prosodic context. *Journal of Phonetics, 25,* 471-500.

Soli, S. D. (1981). Second formants in fricatives: acoustic consequences of fricative-vowel coarticulation. *J Acoust Soc Am 70(4),* 976 984.

Stankiewicz, E. (1986): Polish Mazurzenie and the Serbo-Croatian Palatals. In Stankiewicz (ed.): *The Slavic Languages. Unity in Diversity,* 105-112. Berlin: Mouton de Gruyter,

Stevens, K. N. (1971). Airflow and turbulence noise for fricative and stop consonants: Static considerations. *J Acoust Soc Am 50,* 1182-1192.

Stevens, K. N. (1985). "Evidence for the role of acoustic boundaries in the perception of speech sounds," in *Phonetic Linguistics: Essays in Honor of Peter Ladefoged.* edited by V. Fromkin (Academic. New York), pp. 243-255.

Stevens, K. N. and Keyser, S. J. (1989). "Primary features and their enhancement in consonants," Language 65, (1), 81-106.

Strevens, P. (1960), Spectra of fricative noise in huma speech." *Lang, and Speech* 3, 32-49, 1960.

Sussman, H. M. (1994). The phonological reality of locus equations across manner class distinctions: Preliminary observations. *Phonetica 51,* 119-131.

Sussman, H. M., D. Fruchter, J. Hilbert, and J. Sirosh (1998). Linear correlates in the speech signal: the orderly output constraint. *Behav Brain Sci 21* (2), 241-299.

Sussman, H. M., H. A. McCaffrey, and S. A. Matthews (1991). An investigation of locus equations as a source of relational invariance for stop place categorization. *./ Acoust Soc Am 90,* 1309 1325.

Sussman, H. M., K. A. Hoemeke. and F. S. Ahmed (1993). A cross-linguistic investigation of locus equations as a phonetic descriptor for place of articulation. *J Acoust Soc Am 94(3* Pt 1), 1256-1268.

Tabain, M. (2001). Variability in fricative production and spectra: implications for the hyper- and hypo- and quantal theories of speech production. *Lang Speech U* (Pt 1), 57-94.

Tjaden, K. and G. S. Turner (1997). Spectral properties of fricatives in amyotrophic lateral sclerosis. *J Speech Lang Hear Res 40(6).* 1358 1372.

Tomiak, G. R. (1990). *An acoustic and perceptual analysis of the spectral moments invariant with voiceless fricative obstruents.* Ph. D. thesis, State University of New York. Buffalo, NY.

Vasić, S. (1971). *Razvitak artikulacije kod dece na uzrastu od tri do devet godina.* Naučna knjiga, Beograd

Vladisavljević, S. (1981). *Poremećaji izgovora.* Privredni pregled, Beograd.

Vuletić, D. (1990). *Test artikulacije.* Fakultet za defektologiju Sveučilišta u Zagrebu, Zagreb.

BASIC COMPETENCIES IN GENETICS FOR SPEECH – LANGUAGE PATHOLOGIST

IGOR BUZGANOVIĆ, BOJANA BOBIĆ GECE
Life Activities Advancement Center, Belgrade, Serbia;
Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia

Abstract: The evolution of scientific discoveries in genetics during the last decade has provided information with potential for tremendous influence on health care. Understanding the role genetics plays in health and disease provides the means to integrate such information into prevention, diagnosis and treatment of various communication disorders. Genetic discoveries are already making their way into mainstream healthcare, and patients are asking providers questions about genetic services. The forward motion for developing this list of ideal competencies related to genetics was to support speech-language pathologists to integrate genetics knowledge, skills, and attitudes into routine clinical practice in order to provide effective service delivery to individuals and their families. The goal of preventive activities is early stimulation treatment.

Keywords: genetics, speech and language, prevention, detection, early stimulation treatment

1. INTRODUCTION

There is a current explosion of information on human genetics, yet research suggests that allied health professionals lack the confidence and or knowledge regarding genetics and genetic disorders. It has been suggested that health professionals would benefit from implementing genetic information into their clinical practice (Collins & Guttmacher, 2001). Moreover, as genetics comes into public focus, individuals and families are increasingly asking health professionals for more detailed information about the heritability of disease and the risks to their children, siblings, and other extended family members (Kaiser, 2007). It is generally assumed that speech-language pathologists lack information about genetics, but would benefit from knowing more information. There has been some effort to provide educational opportunities to speech-language pathologists (Garrett, Neils-Strunjas, Steinberg-Warren, Kishman, 2005).

Below are the questions which should be asked by every speech-language pathologist:

1. Does a speech-language pathologist ask questions about genetic family history and siblings' development?
2. Does a speech-language pathologist use case history forms which might include family history information?
3. What does a speech-language pathologist know about genetics and genetic contributions to communication disorders?
4. How does a speech-language pathologist find information about genetics in communication disorders?
5. What knowledge does a speech-language pathologist have regarding the FOXP2 gene?
6. Does a speech-language pathologist need more information and/or education about genetics, and do they know how to find a genetic counselor and/or refer to one?

Genetics is the branch of science concerned with the means and consequences of biologic inheritance. Research within the field of genetics is improving not only our understanding of the patho-physiology of disease, but also improving medical professionals' ability to diagnose, to make a prognosis, to manage, and to prevent morbidity and mortality across all medical and health care realms, (Pennisi,2007) including speech-language pathology. In addition, as genetics comes into public focus, individuals and families are increasingly asking health professionals for more detailed information as to the heritability of disease and risks to their children, siblings, and other extended family members (Kaiser, 2007).

Speech-language pathologists working in hospitals and clinics will often ask if other family members presented with communication disorders during their development. Case history forms may include specific questions regarding when siblings reached developmental milestones or how the milestones of other family members were reached in comparison to the individual being assessed. School speech-language pathologists may also benefit from knowing the family history of a child and whether or not he or she may be predisposed to a communication disorder.

However, whether or not speech-language pathologists are making a connection between the family history (which is inherently genetic information) and its significance to the clinical picture is largely unknown. By possibly knowing more information about the genetic contributions to communication disorders and how the disorder may develop and progress, (as it may have among other family members) will the speech-language pathologist be able to contribute to the professional team. The speech-language pathologist will then be able to determine the best treatment plan for individuals with communication disorders (with or without additional, complicating medical issues).

2. GENETIC SYNDROMES SEEN IN PRACTICE

Scientists have declared several syndromes with a known genetic cause (and many more with both a genetic and environmental etiology) that are seen in many speech-language pathologists' places of practice. Examples include: speech-language impairment, autism, readingimpairment, dyslexia, Down syndrome, fragile-X syndrome, Pierre Robin sequence, and Prader-Willi syndrome. A survey of allied health professionals suggests that speech-language pathologists are not confident in their abilities to talk to patients and or family members about the genetics of these syndromes (Neils-Strunjas, Guerdjikova, Christianson, Nichols, & Holbrook, 2004). The clinical manifestations, the role of the speech-language pathologist in caring for individuals affected by these genetic disorders, and some of what is known about the genetic basis of each disorder are presented briefly in Table 1.

Table 1: Disorders reported seen by speech-language pathologists

Disorder	Incidence/Prevalence/ Genetic Linkage	Speech-Language Involvement/Behavioral Manifestations	Inheritance \pattern
Speech-language impairment	Genetic linkage on chromosomes 2, 6, 15, and 18 (Cardon et al., 1994; Fisher et al, 1999; Gayan et al.,1999; Grigorenko et al., 1997)	Social and language difficulties.	Multifactorial (genetic + environment); positive family history increases risk to relatives
Reading impairment	More often in males compared to females. Genetic linkage to 16 & 19. (Flax, Realpe-Bonilla, Brzustowicz, Bartlett, & Tallal, 2003)	Child's literacy development and exposure to literacy materials (Bishop, 2001).	Multifactorial (genetic + environment); positive family history increases risk to relatives
Dyslexia	Genetic linkage to chromosomes 2, 6, 15, & 18, (Flax, Realpe-Bonilla, Brzustowicz, Bartlett, & Tallal, 2003).	Unexpected difficulty in reading who possess intelligence and motivation for appropriate skills (Shaywitz & Shaywitz, 2005).	Multifactorial (genetic + environment); positive family history increases risk to relatives
Down Syndrome	1/800 newborns Most common cause of mental retardation (Brassington, 2007; Glasson, Sullivan, Hussain, Petterson, , Montgomery,& Bittles, 2002)	Cognitive impairments, muscle hypotonia, speech, language and swallowing treatment	Chromosomal; usually sporadic; advanced maternal age is a risk factor Triplication of chromosome 21 (21q22.2)
Fragile-X Syndrome	1/4000 (males) Number one cause of mental retardation among males (Kogan, Boutet, Cornish, Zangenehpour, Mullen, , Holden, Der Kaloustian, Andermansh, & Chaudhuri,2004)	Difficult temperaments and possible behavior regulation. Language delays and difficulties with social functioning (Antshel, Aneja, Strunge, Peebles, Fremont, Stallone,Abdulsabur, Higgins, Shprintzen, & Kates, 2007)	X-linked recessive; males typically affected; female siblings have 50% chance of being a carrier.
Velo-Cardio Facial Syndrome	22qII.21 in 4,000 live births (Burn & Goodship, 1996)	Learning disorders, psychosis, and speech delays (Carlson, Papolos, Pandita, Faedda, Veit, Goldberg, Shprintzen, Kucherlapati, & Morrow, 1997)	Chromosomal micro deletion; usually occurs sporadically, but affected individuals can have affected children
Pierre Robin Sequence	Interference with the mandible at 9 weeks gestation resulting in micro-retrognathia, glossoptosis, cleft of secondary palate, and upper airway obstruction)- (Kummer, 2001).	Delays in gross motor skills, speech and language milestones, mental retardation. Feeding issues due to hypotonia. Behavioral and emotional problems (Chen, Vistooksak, Dills, & Graham,2007)	Mechanical Interference: Sequence due to crowding in utero; head down and mandible retracted limiting oral cavity space (Kummer, 2001).
Prader Willi Syndrome	1/25,000 individuals Absence of paternally inherited genes on the long arm of chromosome 15 (Chen, Vistooksak, Dills, & Graham, 2007)	Delays in speech and language milestones Feeding difficulties (Chen, Vistooksak, Dills, & Graham,2007)	Chromosomal;imprinting disorder, usually sporadic.

3. GENETIC RESEARCH REGARDING COMMON COMMUNICATION DISORDERS

Each of the aforementioned genetic conditions have been, or are currently, the subject of ongoing genetic research. Genetic research is being conducted on a host of other common genetic conditions that are relevant to speech-language pathologists, which include stuttering, autism, and apraxia of speech.

3.1 Stuttering

Hegde (2001) claimed, "Stuttering is a disorder of fluency with excessive amounts, or excessively long durations of dysfluency, which are combined with tension, struggle, and related behaviors," (p. 23). Research has indicated that some individuals who stutter have a different organization/dominance within their cerebral hemispheres as well (Ambrose & Cox, 1996). Five in 100 preschool-aged children and one in 100 school-aged children stutter(Ambrose & Cox, 1996). A strong genetic predisposition is more likely, however, in children whose stuttering persists beyond elementary school (Felsenfield, 2002). Many genes have been implicated in stuttering, including genes on chromosomes 1, 12 (Riaz, Steinberg, Ahmad, Pluzhnikov, Riazuddin, Cox, & Drayna, 2005), and 18 (Shugart,Mundorff, Kilshaw, Doheny, Doan, Wanyee, Green, & 2004). Additional genes that have implications regarding whether a child will recover from stuttering have also been identified (Ambrose & Cox, 1996). As the underlying etiology of stuttering becomes clearer, it may be possible for speech-language pathologists to make more accurate prognoses for affected children and their families.

3.2 Autism

Autism is a disorder that may be present at birth in a child, but is usually noticed sometime during the first three years of age. As Hegde (2001) observed, a child with autism has a lack of wanting to relate to others in addition to other "peculiar verbal and non-verbal behaviors," (p. 163). Current data indicates for parents with one child affected by autism, the risk of another child with autism is 5%. When more than one sibling of a child with autism is affected, the risk increases to 25%. Males are three times more likely to be affected than females. Immediate relatives of individuals with autism may develop characteristics that also fall within the autism spectrum (Whitelaw, Flett, and Amor, 2007).

A group of researchers at Cold Spring Harbor Laboratory in Long Island, New York looked for genetic mutations associated with autism in 528 families. Some of the families had multiple children diagnosed with autism, and other families had only one child diagnosed with autism. Families with no history of autism comprised the control group. The results from the study showed that genetic mutations were ten times more likely to be present in families with a child with autism, when compared to the control group. The results also indicated autism was five times more likely to occur among the families with multiple affected children. The rate of autism, however, was found to be highest when only one family member was affected with autism (Swaminathan, 2008a). The study mentioned at Cold Spring Harbor Laboratory still leaves many unanswered questions for clinicians and researchers. The clinical significance of this research from Swaminathan (2008a) states, "Although 90% of autism cases are sporadic, heritable/familial forms of autism also occur," By knowing more information regarding genetics, the speech-language pathologist will be more informed when counseling patients in reference to genetic disorders and autism.

Scientists studying autism agree the disorder is influenced by environmental, as well as genetic components. Some studies have linked autism to genes located on chromosomes 16 and 20, among many other possible genes (Swaminathan, 2008b). Various organizations are struggling with the speculations and uncertainties from current research (Swaminathan, 2008b).

Current studies have also examined parents' knowledge of risks regarding autism. A recent study in Canada revealed that a majority of parents of children with autism overestimated the chance of having another child with autism. Fewer than half of these parents reported that the recurrence rate had been explained to them by a professional (Hurley, Losh, Parlier, Reznick, & Piven, 2006).Conversely, a study performed in Tasmania and Australia, indicated a majority of the parents were informed of the recurrence rate of autism among family members and siblings as well as the fact that autism is more common in males than females. The study also discussed fertilization and pre-implantation to select female embryos to reduce the risk of autism (Whitelaw, Flett, & Amor, 2007), which is a controversial topic within the field of genetics. When considering autism, specific aspects of cognitive impairment may be important for genetics research, and may be considered by the speech-language pathologist.

In addition, face recognition, emotion recognition, and theory of mind are frequently impaired among individuals with autism (Iarocci, Yager, & Elfers, 2007). Three-quarters of the autism population have an IQ below 70. Another form of autism contains a profound form of mental retardation (Starr, Berument, Pickles, Tomlins, Bailey, Papanikolaou, & Rutter, 2001).

3.3 Speech Sound Disorder

A speech sound disorder is described as a significant delay in a child's acquisition of articulated speech sounds (Shriberg, Tomblin, & McSweeney, 1999). Speech Sound Disorder (SSD) has been described as having multiple genetic etiologies, and numerous genes contributing to the disorder (Stein, Millard, Kluge, Miscimarra, Cartier, Freebairn, Hansen, Shriberg, Taylor, Lewis, & Iyengar, 2006). Some genes affected may be causing SSD to occur, while other involved genes are impacting an individual's reading and writing (Lewis, Shriberg, Freebairn, Hansen, Stein, Taylor, Iyengar, 2006) SSD is thought to have life long impacts in some cases. By being able to identify SSD early on, intervention is much more successful in a child's overall development with specific regards to speech and language (Fisher, Francks, Marloq, MacPhie, Newbuyry, Cardon, Ishikawa, Brush, Richardson, Talcott, Gayan, Olson, Pennington, Smith, DeFries, Stein, & Monaco, 2002). Research has indicated the prevalence of speech sound disorder, learning impairment, and reading disorder within a family are greater than their prevalence in the overall population (Pennington, 1997). Speech-language pathologists in clinical practice should be aware that a family history of speech sound disorder, learning impairment, and reading disorder increases the risk for these disorders in families where two or more family members in the immediate family are affected (Lewis, Shriberg, Freebairn, Hansen, Stein, Taylor, Iyengar, 2006).

3.4 FOXP2 and Involvement in Speech and Language Development

The FOXP2 gene (on chromosome XX), is a specific gene related to language development. It represents an interesting genetic entry point into the investigation of the different neural and biological processes within areas of speech and language (MacDermot, Bonora, Sykes, Coupe, Lai, Vernes, Vargha-Khadem, McKenzie, Smith, Monaco, &Fisher, 2005).

FOXP2 has been identified with the following language and speech problems: articulation difficulties; language problems, and grammatical impairment (Marcus & Fisher, 2003). The researchers involved with the FOXP2 gene mutation have associated the individuals affected with apraxia. Language difficulties are present among those individuals with the genetic mutation on the FOXP2 gene as well. Researchers have found bilateral grey matter abnormalities in both motor and language-related regions of the brain among individuals affected with the FOXP2 genetic mutation (Belton, Salmond, Watkins, Vargha-Khadem, & Gadian, 2003). Mutations in FOXP2 have also been found in individuals with Autism and Apraxia(Marcus & Fisher, 2003). It should be noted however that the FOXP2 gene does not account for the majority of speech and language problems in the general population (Newbury, Bishop, & Monaco, 2005).

Ninety-six percent of the speech-language pathologists surveyed believe that genetics will influence whether a child develops a speech, language, or reading problem, whereas fourpercent stated “no opinion” as to genetics influencing whether a child will develop a speech, language or reading problem. The four-percent of speech-language pathologists mentioned previously is a relatively low number of professionals who are apparently unaware of recent research findings indicating genetic influences on speech (Lewis, Freebairn, Hansen, Taylor, Iyengar, & Shriberg, 2004), language (Tallal, 2004) and reading (Shaywitz & Shaywitz, 2005). All practicing speech-language pathologists need to be aware of genetic implications for children when providing intervention.

3.5 Dyslexia

Dyslexia is a learning disorder in reading, despite the existence of normal intelligence, good vision and hearing, systematic training, motivation and other appropriate educational favourable psychological and social conditions. Dyslexia is a significant discrepancy between the actual (current) and the expected level of reading in relation to mental age. It is characterized by a marked impairment in the development of reading skills, and affects a large number of people (5–10%). It is recognized that the neurological basis for dyslexia, is caused in large part by genetic factors. Based on twin studies genetic influence is estimated at 60–70% . Linkage studies have successfully identified several regions of the human genome that are likely to harbour susceptibility genes for dyslexia. In the past few years there have been exciting advances with the identification of four candidate genes located within three of these linked chromosome regions: DYX1C1 on chromosome 15, KIAA0319 and DCDC2 on chromosome 6 and ROBO1 on chromosome 3. More importantly, the first genes, where some of them are found by the study of rare families, have indicated specific neurodevelopment processes which are important for the development of dyslexia, including control of neuronal migration for the *DYX1C1*, *KIAA0319 and DCDC2* genes, and a role of axonal and dendrite guidance suggested by the *ROBO1* gene. Functional studies of these genes are offering new insights about the biological mechanisms underlying the development of dyslexia.

4. Conclusion

Speech-language pathologists have varying degrees of knowledge about genetics and are not consistently applying this information to clinical practice. Information and coursework may be considered for up and coming speech-language pathologists' graduate curriculum. Continuing education involving genetics is helpful for all allied health care professionals. Also, a firmer foundation in genetics will assist health care professionals when provide counseling and information to patients and their family members. Some case history forms include genetically related information to a greater degree than others. Every information related to heritage may provide early prevention and detection of any speech-language pathology.

References:

Ambrose, E., & Cox, N. (1996). Genetics of Stuttering: A Critical Review. *Journal of Speech and Hearing Research, 39*, 771-784.

Antshel, K., Aneja, A., Strunge, L., Peebles, J., Fremont, W., Stallone, K., Abdulsabur, N., Higgins, A.,Shprintzen, R. & Kates, W. (2007). Autism spectrum disorders in velo-cardio facial syndrome (22q11.2 Deletion). *Journal of Autism Developmental Disorders, 37*, 1776-1786.

Belton, E., Salmond, C., Watkins, K., Vargha-Khadem, F., Gadian, D. (2003). Bilateral brain abnormalities associated with dominantly inherited verbal and orofacial dyspraxia. *Human Brain mapping, 18*, 194-200.

Bishop, D. (2001). Genetic influences on language impairment and literacy problems in children: same or different? Journal of Child Psychology and Psychiatry, 42, 189-198.

Brassington, C. (2007). What i wish i knew then.. reflections from personal experiences in counseling about down syndrome. *Journal of Genetic Counseling, 16*, 731-734.

Burn, J. & Goodship, J. (1996). Congenital heart disease. *Emery and Rimoin's Principles and Practice of Medical Genetics, 1*, 767-828.

Cardon, L.R., Smith, S. D., Fulker, D. W., Kimberling, W.J., Pennington, B.F., & DeFries, J.C. (1994). Quantitative trait locus for reading disability on Chromosome 6. *Science, 266*, 276-279.

Carlson, C. Papolos, D., Pandita, R., Faedda, G., Veit, S., Goldberg, R., Shprintzen, R., Kucherlapati, R., & Morrow, B. (1997). Molecular analysis of velo-cardio facial Syndrome patients with psychiatric disorders. *American Journal of Human Genetics, 60*, 851-859.

Chen, C., Vistooksak, J., Dills, S., Graham, J. (2007). Prader-willi syndrome: an update and review for the primary pediatrician. *Clinical Pediatrics, 46*, 580-591.

Collins, F. & Guttmacher, A. (2001). Genetics moves into the medical mainstream. *Journal of American Medical Association, 286*, 2322-2324.

Felsenfeld, S. (2002). Finding Susceptibility Genes for Developmental Disorders of Speech: The Long and Winding Road. *Journal of Communication Disorders, 35,* 329-345.

Fisher, S., Marlow, A., Lanb, J., Maestrini, E., Williams, D., Richardson, A., Weeks, D., Stein, J., Monaco, A., (1999). A quantitative-trait locus on Chromosome 6p influences different aspects of developmental dyslexia. *American Journal of Human Genetics, 64*, 146-156.

Fisher, S., Francks, C., Marlow, A., MacPhie, I., Newbury, D., Cardon, L., Ishikawa- Brush, Y., Richardson, A., Talcott, J., Gayan, J., Olson, R., Pennington, B., Smith, S., DeFries, J., Stein, J., & Monaco, A. (2002). Independent genome-

Wide scans identify a chromosome 18 quantitative-trait locus influencing dyslexia. *Nature Genetics, 30*, 86-91.

Flax, J.F., Realpe-Bonilla, T., Brzustowicz, L. M., Bartlett, C.W., & Tallal, P. (2003). Specific language impairments in families: Evidence for co-occurrence with reading impairments. *Journal of Speech, Language, and Hearing Research, 46*, 530-543.

Garrett, J., Neils-Strunjas, J., Steinberg-Warren, N., Kishman, C. (2005). Ohio clinicians to launch a national web resource for genetics education. ASHA Leader, 20.

Grigorenko, E. L., Wood, F.B., Meyer, M., So., Hart, L.A., Speed, W.C., Shuster, A., & Pauls, D.L. (1997). Susceptibility loci for distinct components of developmental dyslexia on Chromosomes 6 and 15. *American Journal of Human Genetics, 60*, 27-39.

Hegde, M. (2001). *Introduction to Communication Disorders*. Austin: Pro-ed Books.

Hurley, R., Losh, M., Parlier, M., Reznick, J., & Piven, J. (2006). The broad autism phenotype questionnaire. *Journal of Autism and Developmental Disorders, 37*, 1679-1690.

Iarocci, G., Yager, J., & Elfers, T. (2007). What gene-environment interactions ca tell us about social competence in typical and atypical populations. Brain and Cognition, 65, 112-127.

Kaiser, J. (2007). It's all about me. Science, 318, 1843. Retrieved February 1, 2008, from ScienceMag database on World Wide Web: http://www.sciencemag.org.

Kogan, C., Boutet, I., Cornish, K., Zangenehpour, S., Mullen, K., Holden, J., Der Kaloustian, V., Andermansh, E., & Chaudhuri, A. (2004) Differential impact of the fmri gene on visual processing in fragile-x syndrome. Brain, 127, 591-601.

Kummer, A. (2001). Cleft-Palate & Cranio-facial Anomalies. San Diego: Singular.

Lewis, B., Freebairn, L., Hansen, A., Taylor, H., Iyengar, S., Shriberg, L. (2004). Family pedigrees of children with suspected apraxia of speech. *Journal of Communication Disorders, 37*, 157-175.

Lewis, B., Shriberg, L., Freebairn, L., Hansen, A., Stein, C., Taylor, H., Iyengar, S. (2006). The genetic bases of speech sound disorders: evidence from spoken and written language. *Journal of Speech, Language, and Hearing Research, 49*, 1294-1312.

MacDermot, K., Bonora, E., Sykes, N., Coupe, A., Lai, C., Vernes, S., Vargha-Khadem, F., McKenzie, F., Smith, R., Monaco, A., Fisher, S. (2005). Identification of FOXP2 truncation as a novel cause ofDevelopmental speech and language deficits. *American Journal of Human Genetics, 76*, 1074-1080.

Marcus, G. & Fisher, S. (2003). FOXP2 in focus: what can genes tell us about speech and language? *TRENDS in Cognitive Science, 6*, 257-262.

Neils-Strunjas, J., Guerdjikova, A., Christianson, C., Nichols, L., & Holbrook, D. (2004).

Genetics internet resources for allied health professionals. *Journal of Allied Health, 33*, 145-149.

Newbury, D., Bishop, D., & Monaco, A. (2005). Genetic influences on language impairment and phonological short-term memory. *TRENDS in Cognitive Science, 9,* 528-534.

Pennisi, E., (2007). Human genetic variation. Science, 318, 1842-1843. Retrieved February 1, 2008, fromScienceMag database on World Wide Web: http://www.sciencemag.org.

Shaywitz S., & Shaywitz, B. (2005). Dyslexia (Specific Reading Disability). *Biological Psychiatry, 57*, 1301-1309.

Shriberg, L., Campbell, T., Karlsson, H., Brown, R., McSweeney, J., & Nadler, C. (2003). A diagnostic marker for childhood apraxia of speech: the lexical stress articulation. *Clinical Linguistics & Phonetics, 17*, 549-574.

Starr, E., Berument, S., Pickles, A., Tomlins, M., Bailey, A., Papanikolaou, K., Rutter,M.(2001).A family genetic study of autism associated with profound mental retardation. *Journal of Autism and Developmental Disorders, 31*, 89-96.

Swaminathan, N. (2008a). Maverick against the mendelians. Scientific American, Retrieved February 18, 2008 from Electric Library database, on the World Wide Web: http://www.sciam.com

Swaminathan, N. (2008b). Navigating the genome for autism. Scientific American, Retrieved, February 18, 2008 from Electric Library database, on the World Wide Web: http://www.sciam.com

Tallal, P. (2004). Improving language and literacy is a matter of time. *Nature Reviews: Neuroscience, 5,* 721-728

Whitelaw, C., Flett, P., & Amor, D. (2007). Recurrence risk in autism spectrum disorder: a study of Parental knowledge. *Journal of Pediatrics and Child Health*

APPLICATION OF DTW METHOD FOR WHISPERED SPEECH RECOGNITION

BRANKO MARKOVIĆ[1], JOVAN GALIĆ[2], ĐORĐE GROZDIĆ[3]
SLOBODAN T. JOVIČIĆ[3,4]
[1] Čačak Technical College, Computing and Information Technology Department, Čačak, Serbia
brankomarko@yahoo.com
[2] Faculty of Electrical Engineering, University of Banja Luka, Department of Electronics and Telecommunications, Banja Luka, Bosnia and Herzegovina
jgalic@etfbl.net
[3] Life Activities Advancement Center, Laboratory for Psychoacoustics and Speech Perception, Belgrade, Serbia
djordjegrozdic@gmail.com
[4] School of Electrical Engineering, University of Belgrade, Telecommunications Department, Belgrade, Serbia
jovicic@etf.rs

Abstract: This paper explains the results of recognition for whisper and normal speech using the DTW method. The patterns for recognition are based on the Whi-Spe database. For these experiments the subset of this database which contains words of colours and numbers is used, and speakers were male and female. The vectors for comparison are based on MFCC coefficients including delta and delta-delta parameters. The DTW algorithm took in consideration two scenarios: the first, when there is no constrains on the global path, and the second, where constrains are of CE2-1 type. The results are given in form of tables and diagrams.

Keywords : Whispered speech, Recognition, Whi-Spe database, MFCC coefficients, DTW algorithm.

1. INTRODUCTION

Whisper as a speech mode is often used nowadays in different situations: when someone wishes to be discrete/private in public place [1], when someone expresses the emotions and sometimes when someone wishes to hide identity during the telephone calls. Especially nowadays in era of the mobile telephone services, whisper is usual when someone has a need for communication surrounded by people where normal speech can disturb others (at work space, shopping malls etc). The research of whisper is still at the beginning, but some researches related to signal/noise ratio, a level of energy [2], vibration of vocal cord [3], the slope of spectrum [4], the vowels formants that shifting to higher frequencies [5] and so on, are done. But the whisper is still a challenge for many researches and one of the major questions is how the whisper has a high intelligibility despite its significantly different compare to the normal speech. Hence, the further research is focused on the brain activity during the whisper processing and also to the different areas of phonetics related to the whisper.

Different techniques for automatic speech recognition (ASR) applied to the normal speech can be applied to the whisper too. The most interesting ASRs are based on standard methods like DTW (Dynamic Time Warping), HMM (Hidden Markov Models) and ANN (Artificial Neuron Networks). This work used standard DTW method. Based on it the research is done using the single words. For the experiment we used database Whi-Spe [6] which is created for the purpose of the whisper research. It contains 10,000 patterns of words which are spoken in normal and whispered mode. The vocabulary has 50 different words of Serbian language and they are divided in three sub corpuses: colours, numbers and balanced words [7].

Five male and five female speakers pronounced this vocabulary ten times in both modes (normal and whisper). The patterns are recorded in special ambient where the ambient noise was suppressed. The sessions of recording are separated with a few days.

For a purpose of this research we used a part of database and we conduct the experiments using two male and two female speakers. Also we used only colours and numbers. We considered different parameters which contain MFCC cepstral coefficients, delta cepstral with cepstral coefficients and delta-delta cepstral with delta cepstral and cepstral coefficients. These vectors are applied in two scenarios: when the global path does not have any constrains and when the global path is constrained with CE2-1 type of global constrains [8]. In both cases the local constrain was Type I proposed by Sakoe and Chiba [9].

The work is structured in the following way: in the second part we explained pre-processing and feature extraction. The third part describes the DTW algorithm and global and local type of constrains. The results of this research are given in the forth part. The ideas for further research and final remarks are given in conclusion.

2. PREPROCESSING AND FEATURES EXTRACTION

2.1. Preprocessing

In order to compare speech patterns it is necessary to convert them into vectors of parameters and this is called preprocessing. The samples in the Whi-Spe database [6] are recorded with sampling rate of 22,050 Hz with 16 bits pre sample and stored in the form of Windows PCM wave files. These samples were inputs in the preproecessing system which is given at Figure 1.

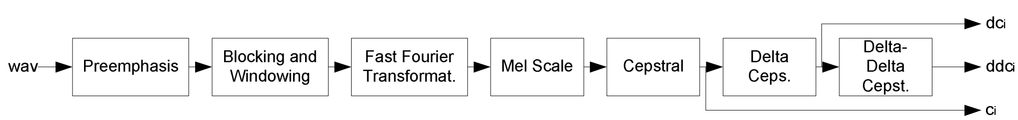


Figure 1: Block diagram for preprocessing.

Firstly, the digitized speech signal comes to the block for pre-emphasis. It produces spectrally flatten signal and makes it less susceptible to finite precision effects later in the signal processing. In the block for framing and windowing the signal is divided in to N frames, overlapped 50% and then weighted with the Hamming windows. This windowing is used to taper the signal to zero at the beginning and end of each frame. Next step is to apply the Fast Fourier Transformation in order to obtain the spectral values at equidistant points. The energy is calculated based on Mel scale which is divided into 30 equidistant filters. Based on a log energy and cosine function we calculated cepstral coefficients (MFCC) as per Equation 1. :

$$c_i = \sum_{j=1}^{Nf} \log(E_j) * \cos\left(\frac{i*(j-0.5)*\pi}{N_f}\right) \qquad (1)$$

where N_f is number of subspaces at Mel scale, and $i = 1,2,...N_c \le N_f - 1$

2.2. Features Extraction

Based on MFCC cepstral coefficients we get temporal (delta) cepstral coefficients and also delta-delta. Delta cepstral coefficients can be obtained using Equation 2:

$$dc_i(l) = \sum_{k=-K}^{K} = \mu * c_i(l-k) \tag{2}$$

where l is a current frame and K is usually 3 or 4 (it means in calculation we used 3 or 4 "neighbour" frames around the *l-th* frame). Parameter μ is an appropriate normalization constant.

On the similar way we calculated delta-delta cepstral coefficients where instead c_i we have used dc_i as per Equation 3:

$$ddc_i(l) = \sum_{k=-K}^{K} = \mu * dc_i(l-k) \tag{3}$$

The next step is to create vectors which are representations of speech patterns. For these experiments we created the following three types of vectors:

- vectors contains 12 cepstral coefficients. The form of this vector is:
  $$Vci = \{c_{i1}, c_{i2}, \ldots c_{i12}\} \tag{4}$$
- vectors contains 12 cepstral and 12 delta cepstral coefficients. The form of this vector is:
  $$Vdci = \{c_{i1}, c_{i2}, \ldots c_{i12}, dc_{i1}, dc_{i2}, \ldots dc_{i12}\} \tag{5}$$
- vectors contains 12 cepstral, 12 delta cepstral and 12 delta-delta cepstral coefficients. The form of this vector is:
  $$Vddci = \{c_{i1}, c_{i2}, \ldots c_{i12}, dc_{i1}, dc_{i2}, \ldots dc_{i12}, ddc_{i1}, ddc_{i2}, \ldots ddc_{i12}\} \tag{6}$$

The research is conducted with all of these vectors using both modes (normal speech and whisper) and two scenarios (without global constrains and with CE2-1 constrains).

3. DTW ALGORITHM

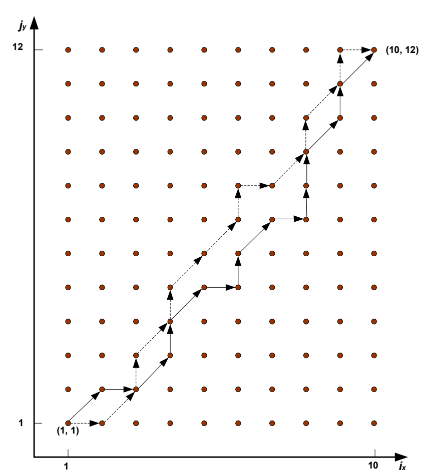


Figure 2: Example of two possible paths.

When two speech patterns are compared in order to obtain their similarity one of the best way is to use DTW algorithm [10]. It allows comparison of two patterns which are represented by feature vectors and beginnings and ends of these patterns should be overlapped. Figure 2 shows two potential paths which guides from the beginning point ***(1,1)*** to the ending point ***(M, N)*** (where ***M***=10, ***N***=12 for this example) by usage of the certain number of steps.

The local constrain of Type I is given at Figure 3. It explains how to reach point ***(i,j)*** form the previous state. With ***k*** we denoted a weight from ***(i-1, j-1)*** to ***(i, j)***.

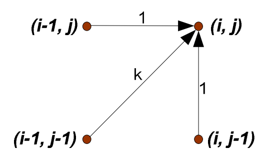


Figure 3: Local constrain of Type I.

The DTW algorithm allows to find an optimal path using the dynamic asynchronous programming from the beginning point ***(1,1)*** to the final ***(M,N)***. The key idea is to use the recursion steps and to find all local paths that reach (i,j) in exactly one step from the previous states (***(i-1,j)*** or ***(i-1,j-1)*** or ***(i, j-1)***). This algorithm can be implemented through the following steps [10]:

1) Initialization:
$$D(1,1) = d(1,1) * m(1) \tag{7}$$
2) Recursion:
$$D(i, j) = \min_{i',j'} \left[D(i', j') + d((i', j'), (i, j)) \right] \tag{8}$$
3) Termination:
$$d(M, N) = \frac{D(M, N)}{M_\Phi} \tag{9}$$

where ***d(i,j)*** is a local distance between vectors ***i*** and ***j***, ***D(i,j)*** is an accumulated distance for the global path up to point ***(i,j)*** and M_Φ is a normalization factor.

It is important to keep information of all steps how to get from ***(1,1)*** point to ***(M,N)*** point and then going backward to find a desirable path. This path should be with the low cost (optimal path).

4. RESULTS

We developed a software package WiseWave 1.5 which is DTW ASR and can compare speech patterns. Changing some parameters it allows to use different vectors: only with cepstral coefficients, with delta cepstral and cepstral coefficients and with delta-delta cepstral, delta cepstral and cepstral coefficients. Also the global path can be without any constrains (Figure 4a) or constrained with CE2-1 endpoints constrains [8] (Figure 4b).

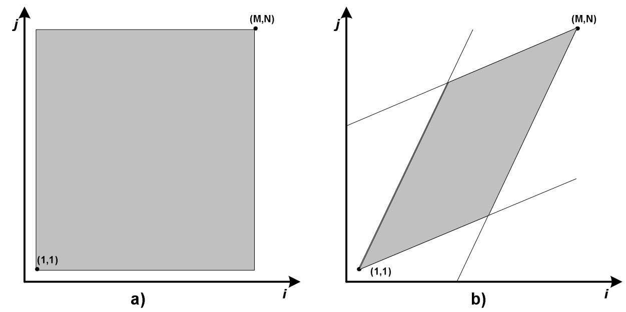


Figure 4: Without global constrains (a) and with CE2-1 constrains (b).

We have used the subset of the Whi-Spe database which contains colours and numbers. The following tables represent these subsets:

Table 1: List of colours.

COLOURS					
colour 1	*colour 2*	*colour 3*	*colour 4*	*colour 5*	*colour 6*
/bela/	**/ʒuta/**	**/tsrna/**	**/tsrvena/**	**/plava/**	**/zelena/**

Table 2: List of numbers.

NUMBERS						
number 1	*number 2*	*number 3*	*number 4*	*number 5*	*number 6*	*number 7*
/nula/	**/jedan/**	**/dva/**	**/tri/**	**/tʃetiri/**	**/pet/**	**/ʃest/**
number 8	*number 9*	*number 10*	*number 11*	*number 12*	*number 13*	*number 14*
/sedam/	**/osam/**	**/devet/**	**/deset/**	**/sto/**	**/hiʎadu/**	**/milion/**

The ASR was not trained. The first pattern is used as a referential, and we compared all others from the appropriate subset.

Two speakers (Speaker1 and Speaker2) were female and two were male (Speaker3 and Speaker4) and we use them for testing. The results of recognition are given ahead.

4.1. Normal speech

The results for normal speech when there is no any global constrains are given in tables 3 and 4 for colours and numbers respectively.

Table 3: Recognition rate for colours (in %).

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	100	100	100
Speaker 3	92,59	90,74	90,74
Speaker 4	100	100	100

Table 4: Recognition rate for numbers (in %).

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	100	100	100
Speaker 3	100	100	100
Speaker 4	100	100	100

The results for normal speech when the global constrain CE2-1 is applied are given in tables 5 and 6 for colours and numbers respectively.

Table 5: Recognition rate for colours (in %) – CE2-1.

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	100	100	100
Speaker 3	90,74	90,74	90,74
Speaker 4	100	100	100

Table 6: Recognition rate for numbers (in %) – CE2-1.

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	99,21	99,21	99,21
Speaker 3	100	100	100
Speaker 4	100	100	100

4.2. Whisper

The results for whisper when there is no any global constrains are given in tables 7 and 8 for colours and numbers respectively.

Table 7: Recognition rate for colours (in %).

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	85,19	83,33	83,3
Speaker 2	98,15	98,15	98,15
Speaker 3	96,29	96,29	98,15
Speaker 4	92,59	92,59	92,59

Table 8: Recognition rate for numbers (in %).

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	96,83	96,03	96,03
Speaker 3	99,21	100	99,21
Speaker 4	92,86	92,86	92,86

The results for whisper when the global constrain CE2-1 is applied are given in tables 9 and 10 for colours and numbers respectively.

Table 9: Recognition rate for colours (in %) – CE2-1.

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	81,48	87,03	79,63
Speaker 2	96,30	96,30	96,30
Speaker 3	96,30	96,30	98,15
Speaker 4	92,59	92,59	92,59

Table 10: Recognition rate for numbers (in %) – CE2-1.

Vectors/Speaker	*Cepstral*	*Delta, Cepstral*	*Delta-Delta, Delta, Cepstral*
Speaker 1	100	100	100
Speaker 2	99,21	98,41	98,41
Speaker 3	99,21	99,21	97,62
Speaker 4	94,44	94,44	93,65

5. CONCLUSION

Based on the results we can conclude the recognition for normal speech is higher then for whisper, what was expected. When the global constrains are no applied average recognition for colours in normal speech mode is 97.84%, while for whisper is 92.90. Similarly for numbers, in normal speech mode average recognition is 100% while for whisper it is 97,15%.

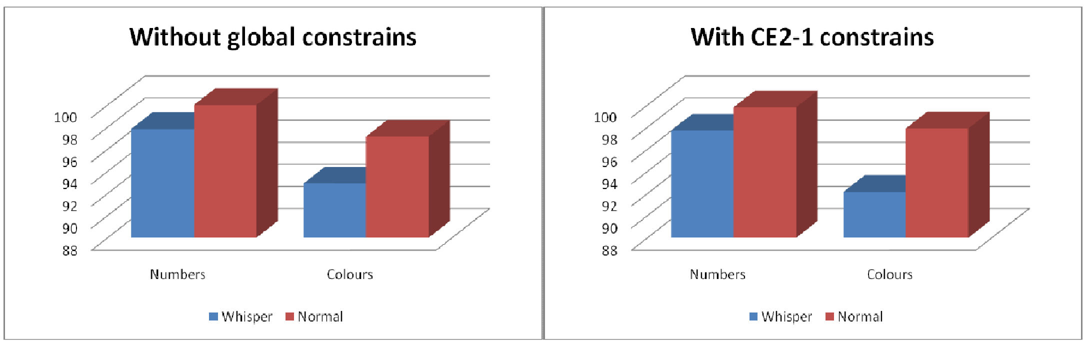


Figure 5: Results of words recognition for numbers and colours without and with global constrains.

When we have used CE2-1 global constrains than for colours we have 97.68% recognition rate, and 92.13% for normal speech and whisper respectively. In case of numbers the rates are 99.80% for normal speech and 97.88% for whisper.

We can conclude the recognition rate for colours is better around 5% for normal speech than for whisper. Related to numbers this gain is 1-2%. When we used global CE2-1 constrains, this give a small improvement. But using a different type of vectors (cepstral, delta, delta-delta) with the local Type I constrain we did not get an important gain.

Further analysis should include all 10 speakers and based on different constrains (local and global) may lead to new and better results.

REFERENCES

1. T. Ito, K. Takeda, F. Itakura, "Analysis and Recognition of Whispered speech," *Speech Communication*, 2005, pp. 129-152.
2. S.T. Jovičić, Z.M. Šarić, „Acoustic analysis of consonants in whispered speech," *Journal of Voice*, 22(3), 2008, pp. 263-274.
3. J.C.Catford, (1977). *Fundamental problems in phonetics*. Edinburgh: Edinburgh University Press.
4. C. Zhang, J.H.L. Hansen, "Analysis and classification of Speech Mode: Whisper through Shouted," *Interspeech 2007*, 2007, pp. 2289-2292.
5. S.T. Jovičić, "Formant feature differences between whispered and voiced sustained vowels," *ACUSTICA - Acta Acoustica*, 84(4), 1998, pp. 739-743.
6. B. Marković, S.T. Jovičić, J. Galić, Đ. Grozdić,: Whispered Speech Database: Design, Processing and Application, 16th International Conference, TSD 2013, Pilsen, Czech Republic, pp. 591-598 (2013)

7. S.T. Jovičić, Z. Kašić, M. Đorđević, M. Rajković, “Serbian emotional speech database: design, processing and evaluation”, *SPECOM-2004*, St. Petersburg, Russia, 2004, pp. 77-81.
8. L.R. Rabiner, S.E. Levinson, A.E. Rosenberg, J.G. Wilpon, ”Speaker-Independent Recognation of Isolated Words Using Clustering Techniques”, IEE Transaction on Acoustics, Speech adn Signal Procesing, Vol ASSP-27, No.4, 1979. pp. 336-349.
9. H. Sakoe, S. Chiba, “Dynamic programming optimization for spoken word recognition”, IEEE Trans. Acoustics, Speech, Signal Proc., ASSP-26(1):43-49, February 1978.
10. L. Rabiner, B-H. Juang, ”Fundamentals of speech recognition”, Prentice Hall, New Jersy, 1993.

VOWEL FORMANT FREQUENCIES ESTIMATION FOR NEWBORN CHILDREN

MILAN VOJNOVIĆ [1], IVANA BOGAVAC [2], LJILJANA DOBRIJEVIĆ [3]

Life Activities Advancement Center [1,2,3],

Institute of Experimental Phonetics and Speech Pathology [2,3]

vojnovicmilan@yahoo.com [1], ivbogavac@gmail.com [2], lilijen@ymail.com [3]

Abstract: The main problem in the analysis of vowel formant frequencies, spoken by children under the one year of age, is the great centralization of utterance. Another problem is that the physical dimensions of the vocal tract in children of this age are not known. Recognitions of vowels are difficult because of the centralized pronunciation, so for this early stage of language development, it is better to analyze the maximal vowel spaces (MVS). On the other hand, for the calculation of MVS, it is necessary to know the physical dimensions of the vocal tract. Estimation of vowel formant frequencies in one-year old children was done in two phases: defining the MVS and then vowel discrimination on the basis of such defined MVS. Estimated vowel formant frequencies and MVS show the general trend of changes in pronunciation during children development, which can be used for early diagnosis of untypical speech. This method of early screening process is suitable because it is not based on a "stimulus-response" what is inappropriate for children of this age. If this screening method is combined with an analysis of the chronology of the adoption of certain sounds, we can get a more complete and precise evaluation child's language development at an early stage of development.

Keywords: children speech, maximal vowel space, vowel formant frequencies

1. INTRODUCTION

Early detection of atypical speech and language development is extremely important, because in that case speech and language treatments (SLT) are more effective. The most commonly used SLT is with preschool and school children at the moment. This is the ultimate limit for correction of atypical speech. At that age speech have important role in the education and socialization of a child. Unfortunately, parents take action when child starts to have concrete problems in the education and social assimilation. At the point where child's mental and psycho-physical ability is compared with ability of peers, parents see the differences in the development stage. Absence of treatment at this early stage is more problem of uneducated parents or their lethargic behaviour.

The other problem that causes absence of early detection at the speech and language communication is the method of SLT. It means that child has already accomplished some degree of verbal communication in accordance with age. It means that, before SLT, child already has complete assessment of his cognitive, motor and verbal abilities, on which SLT are defined. It is important to notice that certain degree of speech communication is accomplished, because SLT has concaved on that: correction of certain phoneme pronunciation, words pronunciation or sentence making correction. In other words, there is speech communication between child and therapist, so these treatments can lead under group of „inter-communication" method. Basic characteristic of these methods is that child already have certain speech mechanisms, hence that child is a couple of years old. At the age of three, child need to have developed functional speech and at the age of five and a half, all aspects of expressive speech need to be completely developed (phonetic, phonological, grammatical, semantic, lexical and pragmatic aspects).

It is interesting to perceive possibility of the earliest phase when atypical speech can be detected. In that phase there is not classical speech or communication. Child reacts on sound, visual and other stimuli from the birth, so that can be one form of communication, but not in a classic way. This period might be defined as „intra-communication". The question is: does the cuing and babbling from this phase can be used in diagnostic procedure, thus to detect atypical development of speech mechanism. Experience working with children of the youngest age (6-7 months), as well as use of diagnostic procedures with a goal with the aim of monitoring babies from normal and risk pregnancies (Dobrijević, 2013), have shown that atypical speech and language development can be detected in the early developmental period. Beside objective methods, spectrographic analysis and prelingual group of voices, it is possible with adequate observation of babies at this age (primarily monitoring of prelingual phases of speech and adequate interaction with mother) to notice some form of atypical development which will require early intervention and stimulation. This is the way for prevention of speech and language disorders, social and emotional disorders, behaviour and learning disorders, which are more present in the later stage of development. This paper will consider in detail emergence and establishment of vowels during prelingual period, as a hallmark of speech and language development, which can indicate atypical early development.

Generator-filter model of speech (Dudley, 1939) means primary voice generating, filtering through vocal tract and eradiation sound through mouth and nose. If that generated voice have meaning, it will be treated as speech, thus if acoustical structure matches already defined group of phonemes in certain language. Wider concept is "voice" which refers to any form of sound manifestation generated with human's speech apparatus. While sound is passing through vocal tract (VT), transfer characteristic of VT is "incorporated" into it. This transfer characteristic is defined by resonant frequencies (frequencies that amplify sound). The transfer characteristic is in the direct relation with VT geometrical shape. Moving of articulation organs (tongue, mandible, lips, etc.) leads to changing the VT shape, which has as a result, changing of its resonant frequencies. In this stage of intra-communication is analyzed child's voice as an evaluation of how his speech organs work. VT resonances are extracted from child's voice/speech. Formant frequency is usual term that is used in analysing of vowels. The significance of vowels analysing (formant frequencies) in all aspects of speech communication is unquestionable and in this case will be the primary target of research.

Maximal vowel space (MVS) is a method of global voice analysis which is known from earlier (Boë et al., 1989). First three formant frequencies are usually analysed via F_1-F_2 and F_2-F_3 charts. Perceptual vowels discrimination (or other phonemes which are analysed) is not primary in MVS analysis, only theirs formant frequencies. In the other words, it is irrelevant is the spoken vowel, for example /*a*/ seems like /*o*/ or /*i*/, formant frequencies are that what is important. If it is analyzed person's segment of speech that is long enough, MVS represents first three formant frequencies space, which he achieves during the speech. If the person's real speech is used, than it can obtain estimated MVS of that person. In the other hand, if VT geometrical shape is known, than his acoustical model can be made, and then simulate sound spreading through that acoustical structure, and at the end, get simulated (theoretical) MVS. Comparing of these two MVS can be useful for discrimination of atypical speech during development of speech mechanism. This is the basic idea of paper: to perceive the possibility of using MVS as diagnostic method during "intra-communication" stage of child's development.

First problem is insufficient amount of information about anatomical and morphological VT structure at one year old children. That is the reason why is not possible to generate VT acoustical model of a child and simulate MVS. Classical methods for generating of VT acoustical model (Fant, 1970) (Flanagan, 1972) (Ladefoged, 1975) include VT X-ray imaging during the pronunciation of steady vowels. Recently, X-ray imaging is replaced with MRI. These methods are not appropriate for one year old child, so the new one must be found for estimation of VT shape.

Second problem is the MVS simulation based on known VT acoustical model itself. Even when the VT acoustical model for one year old child is known, there are some problems with finding theoretical MVS. MVS means resonant frequencies estimation of all possible VT configurations. If accrue acoustical models of VT are used, then the number of possible configuration is enormous and all of them cannot be treated. Solution for this problem is to choose some part of possible configuration which is going to be representative for all the others. In the other words, chosen set needs to cover as many VT configurations as it is possible to achieve in real. Configurations that are not achievable need to be rejected from procedure of MVS estimation.

Paper is organized in certain way: First general problems of generating VT acoustical model of one year old child are consider. One procedure for estimation of VT shape is proposed. As a final result is shown acoustical model, thus dependence of the VT cross-section in the function of distance from glottis is given. These data are fully sufficient for simulation of spreading sound through VT and calculation of transfer characteristic. First the problems of MVS simulation for grown male are done, VT configuration are taken over from (Fant, 1970). After this process is elaborated and defined, it was applied on one year old child. At the end, the real MVS was estimate for one child, whose voice was recorded from two till twelve months old.

1.1. Vocal tract shape in one year old child

As it had been said, traditional methods for the estimation of VT shape with MRI and X-ray imaging are not appropriate in one year old children. One of ideas is to transform VT shape of an adult to one year old child, considering anatomical, morphologic, articulation and other differences between an adult and a child (Vojnović, 2013a). We are talking about VT length, cross-sectional area, articulation, oral and pharyngeal cavity size relation, etc. In what way these differences affect vowel formant frequencies is in detail analysed in (Vojnović, 2013a). Baseline data for acoustical VT model of an adult are taken from (Fant, 1970) and they refer on Russian vowel pronunciation. In that paper is analysed only five vowels, which are present in Serbian language also. Final result of these detailed analyses and VT transformation are hypothetical VT shapes of a one year old child which are generated for each of five vowels. Cross-section dependency of these VT configurations in the function of distance from glottis is shown in Figure 1.

It is selected half length of an adult VT for VT of a child. Number of cylindrical segments which is used to approximate acoustical model VT of an adult and a child is the same, but segment length in an adult is 5mm, and in a child is 2.5mm. VT length can be correct by changing cylindrical segment length.

One of anatomical and morphological differences between adult and newborn is larynx height index – LHI (Goldstein, 1980). LHI is ratio of the length of the pharyngeal and oral cavity. LHI is 0.5 in newborn and 1.1 in adult male. Figure 1 shows differences in the VT shape of an adult and a child, which are consequence of different LHI and different “articulation depth”. There are essential cross-sectional differences, but they cannot be seen because VT of an adult (thin dashed line) is scaled so that can be compared with VT of a child. VT scaling of an adult means reducing the length two times and cross-sectional area four times.

VT of a newborn is analysed in (Goldstein, 1980). Result of this study is VT configurations of a newborn for three vowels: */a/*, */i/* i */u/* (Picture 2.). General shapes of VT for these three vowels are very similar. Some differences in the VT length and cross-sectional area are present. Differences in the VT length are justified. Goldstein (Goldstein, 1980) treated newborn, while Vojnović (Vojnović, 2013a) treated one year old child. That is the reason why is VT length longer in (Vojnovic, 2013a).

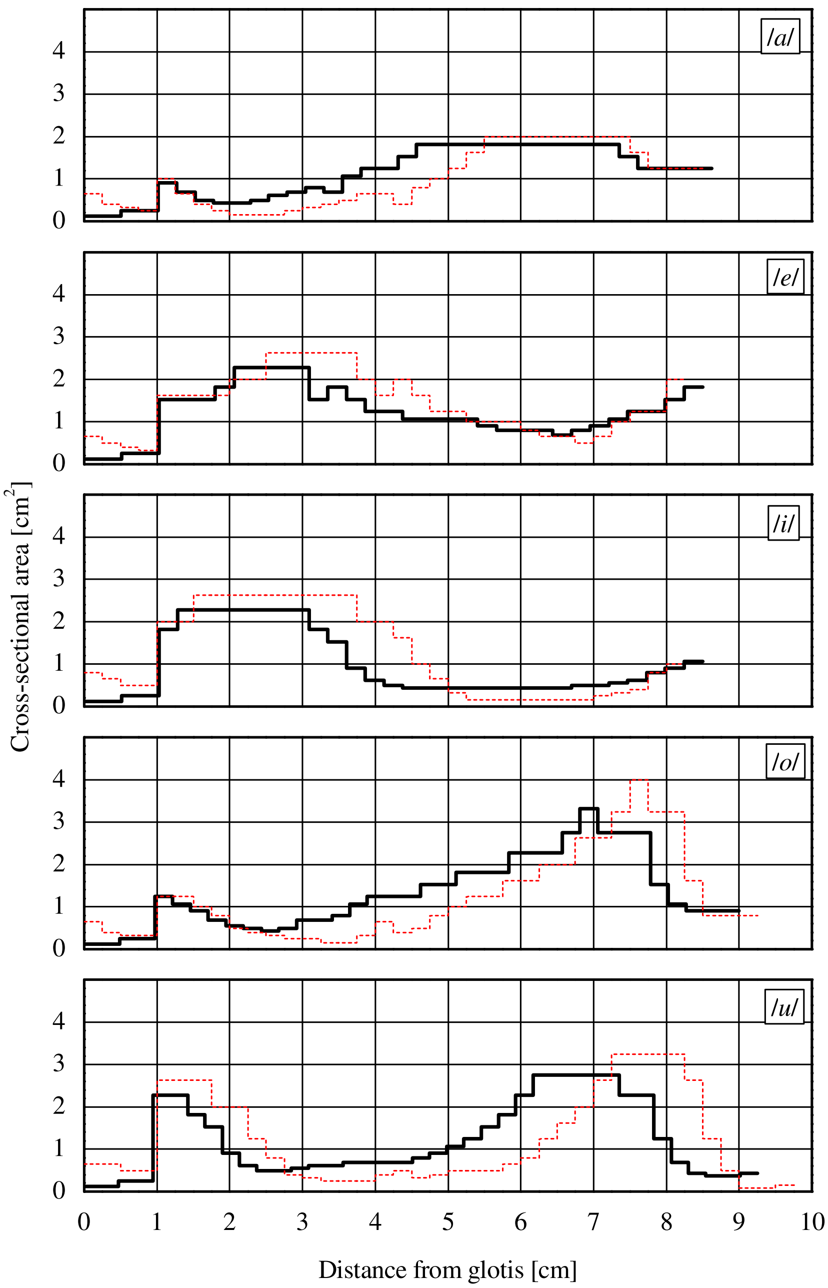


Figure 1. Estimated VT shapes of one year old child (solid line) and scaled VT shapes of an adult male (dashed line), in the case of vowel pronunciation.

In some VT region cross-sectional area is bigger in (Goldstein, 1980) then in (Vojnović, 2013a). In any case, this is a good cause to verification estimated VT configuration of one year old child using analysis of formant frequencies in child real speech.

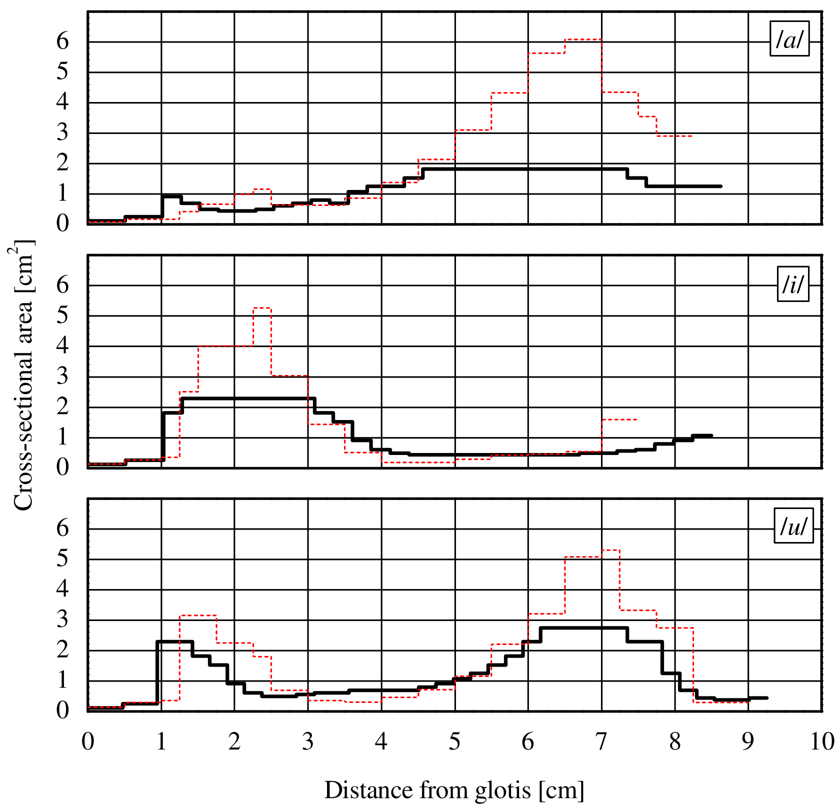


Figure 2. Estimated VT shapes in one year old child (Vojnović, 2013a) (solid line) comparing with literature data (Goldstein, 1980) (dashed line).

1.2 Maximal vowel space

Enormous number of possible configuration of VT acoustical model is the basic problem in MVS simulation. In the case of vowel pronunciation, VT can be present as a tube with irregularly form which is on the one end open (mouth), and on the other closed with rigid baffle (glottis). Theory of analogy is used for simulation of sound spreading through acoustical structures. So, acoustical model is converted into equivalent electrical model. For this transformation it is necessary to approximated acoustical model with certain numbers of short cylindrical tubes (segments), which length and cross-sectional areas are defined. The VT shape is approximated through cascade connection of these cylindrical tubes. The number of cylindrical tubes (segments) determines modelling accuracy: the greater this number is, the accuracy is higher. This approximation of VT shape gives a possibility to calculate the transfer characteristic, i.e. determine resonant frequencies of acoustical structures. Analysing the sound spreading trough these acoustical structures implies calculation of its transfer characteristic, calculation of resonant frequencies. Instead resonant frequencies term it is use formant frequencies term, due to it is sound spreading trough acoustical model of VT. MVS represent range of all formant frequencies for all possible changing of VT shapes. It is practice to consider only first three formant frequencies via F_1-F_2 and F_2-F_3 chart.

But, if the estimation of transfer characteristic need to be more accurate, it is necessary to have more precise approximation of VT shape, therefore increase number of cylindrical segments. Cylindrical segments length is usually 5 mm; therefore VT of 17.5 cm length is approximated with 35 cylindrical tubes. Researchers suggested (Fant, 1970) (Fant, 2004) that cross-sectional areas chose by logarithmic law and there are 16 different values cross-sectional areas from 0.16 to 16 cm^2. In the acoustical domain, VT is modelling with 35 cylindrical tubes 5 mm long, whose cross-section area can have one of 16 defined values. Total number of a different acoustical structures, that can be generate, is $16^{35} \approx 1.4 \times 10^{42}$. That is enormous number. MVS cannot be estimated by analyzing resonant frequencies of all the possible cases. It needs to implement more acknowledgment about changing the VT shape. In that way, the number of analyzed configuration is reduced to reasonable level and estimated MVS is aligned with real VT configuration.

Formant frequencies group of all configurations must be reduced, because MVS cannot be generated by analysing that whole group. Also, group of configurations needs to be representative – adapted to the reality, after the reduction. Because of that it needs to be considering all acknowledgment about VT shapes and VT changing lows. Thus, for example, glottis area can be fixed, because there is no significant changing during the pronunciation. There is no sudden change in VT shape. This and many other acknowledgments can be used for the real configuration reduction. (Vojnović, 2013b) considered this problem in the detail and at the end showed that MVS can be generated if the cross-section area of glottis is fixed and changing of adjacent segment area is by Gaussian distribution. Because of Gaussian distribution it is necessary to know VT configuration for five vowels. Enough number of configuration is 50000, and all procedure is been doing cumulative for three VT length. These three lengths correspond to VT length during pronunciation of vowels: /*u*/, /*a*/ and /*i*/.

Figure 3 shows MVS simulation of an adult male with configuration from (Fant, 1970). Small quadrate represents formant frequencies of five Russian vowels. As seen, formant frequencies of Russian vowel are within estimated space. That is indicator of how much representative group of selected VT configurations is.

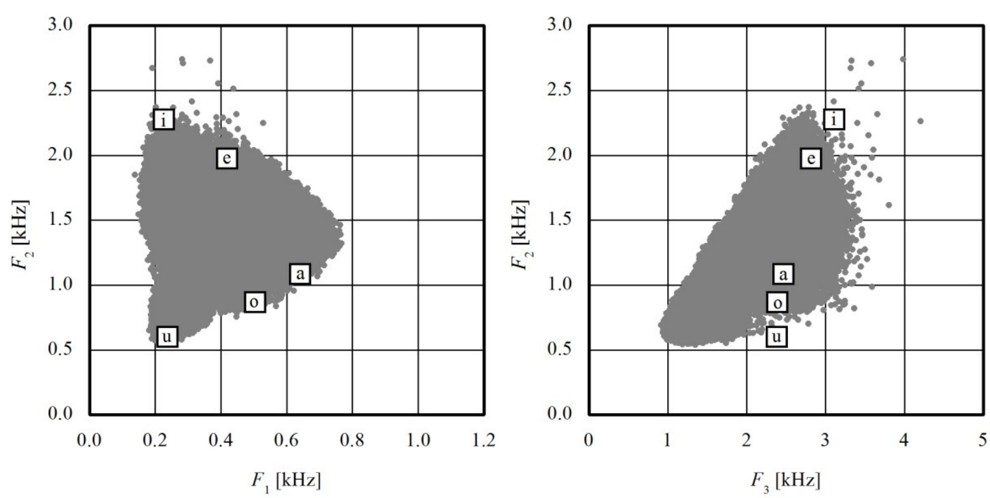


Figure 3. Maximal vowel space simulation for adult male.

By the same principle and methodology MVS simulation for one year old child has been done, but VT configuration data is used from (Vojnović, 2013a). This simulation results is shown in Figure 4.

MVS simulation data in Figure 4 are very useful for future speech researches in one year old child because the formant frequencies ranges are clearly defined. MVS in Figure 4 is tightly linked with VT configurations in Picture 1. Simply, those acoustical structures can cause resonant phenomena within space shown in Figure 4. Practically that means in formant frequencies vowels analyzing that one year old child pronounces needs to accept cases where estimation of:

- First formant frequencies are in range from 400 to 1600 Hz,
- Second formant frequencies are in range from 1350 to 4000 Hz and
- Third formant frequencies are in range from 2500 to 8000 Hz.

These data are valuable for defining initial parameters for software estimation of formant frequencies.

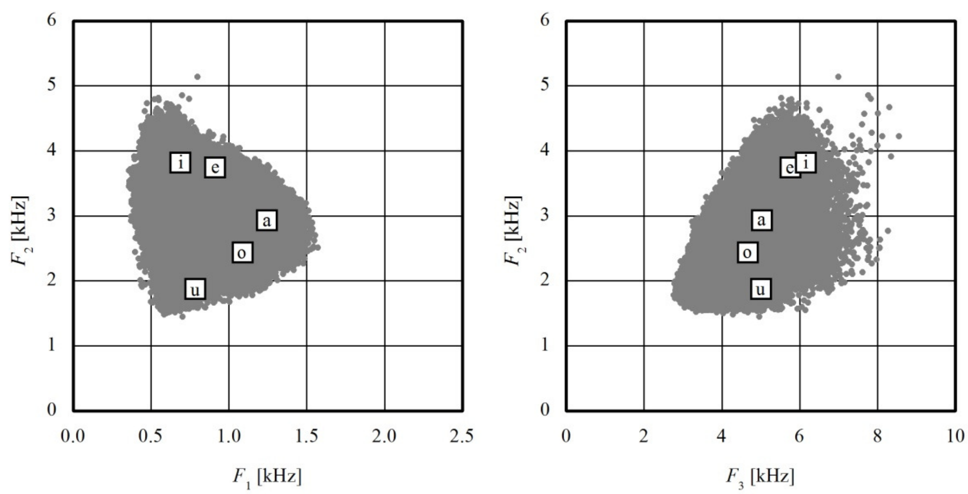


Figure 4. Maximal vowel space MVS for one year old child.

Mean values of first, second and third formant in estimated MVS are: 1000, 3175 and 5250 Hz respectively. For the VT length 8.25 cm and sound speed 35300 cm/s, first four quarter wave resonant frequencies are: 1070, 3210, 5350 and 7490 Hz, what is relatively close to estimated MVS. If it is necessary to analyzed first three formant frequencies of vowels that one year old child pronounced, then upper limit frequency need to be set up on 6500 Hz.

2. EXPERIMENTAL MESUREMENTS RESULTS

It has been done voice recording of a two month old child, relatively a twelve month old child in ten months period (since November 2011. till August 2012.). Recording has been done in 42 sessions, 4 sessions every month in average. Sound parts that look like vowel pronunciation are extracted from the recordings. These separate segments are used for the formant frequencies estimation by PRAAT software (Boersma &Weenink, 1992-2005). The Burg method estimation of formant frequencies has been used (Anderson, 1978.). Accuracy of formant frequency estimation depends on many factors and it is not always ideal. Because of that, after software estimation, it has been done crosscheck with wideband spectrogram. All estimated formant frequencies that are not match wideband spectrogram and that have wrong order are rejected.

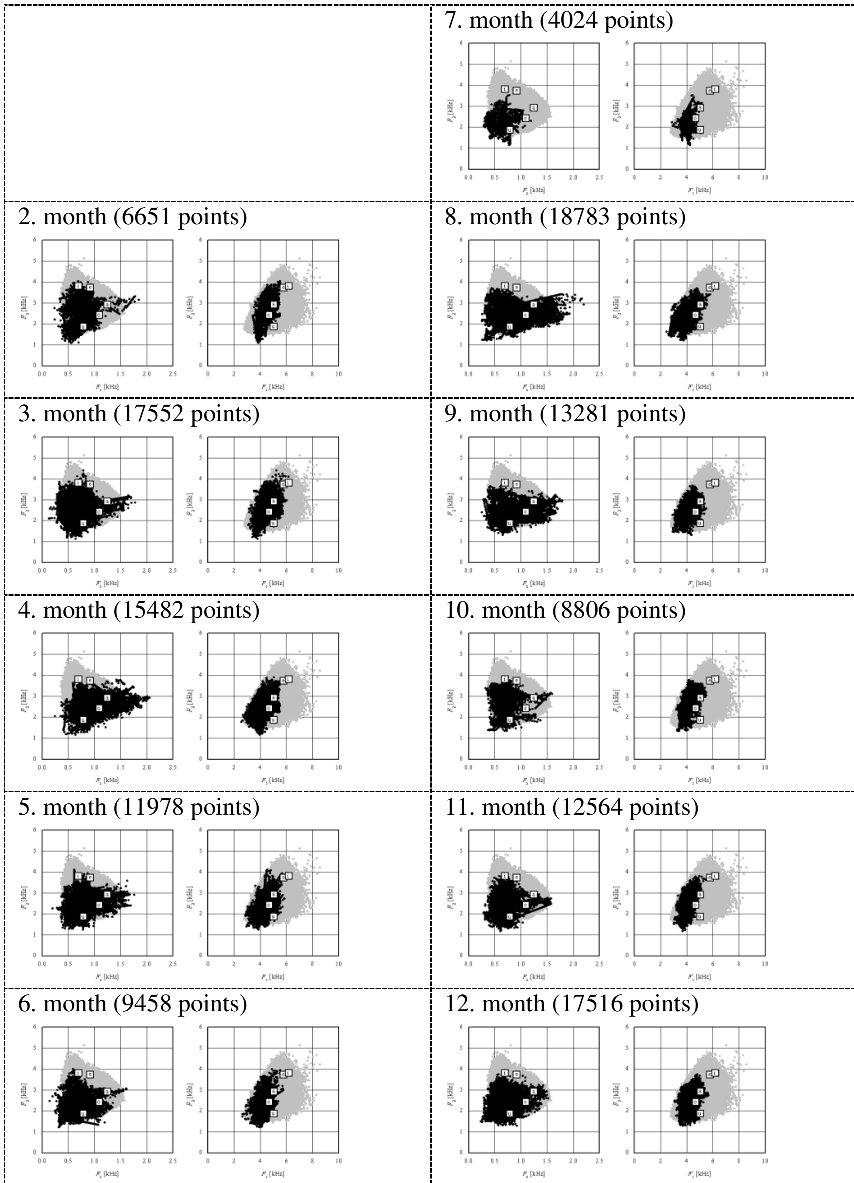


Figure 5. Estimated maximal vowel space for one year old child.

Figure 5 shows the results of formant frequencies estimation for real speech of a one year old child. Every single chart represents theoretical and real MVS of the two month old till twelve month old child. Gray dots represents space of theoretical resonant frequencies (Picture 4) and black dots represents estimated resonant frequencies of child's speech recordings.

It should be noted that all charts are very similar, except the chart for seventh month. This chart has small number of dots (recordings are short), which can be reason for the differences. Chart similarity shows that articulation capability of a child is very large and that they do not change much during the first year of child's life. The width of estimated resonant frequencies range shows large degree of freedom for articulation organs. Primarily that refers to mobility of the tongue and lower jaw, because their changes have the biggest impact on changing of the VT shapes.

There is good matching for first formant, slightly lower at second formant and weakest at third formant. There is good matching of theoretical and experimentally obtained MVS at general. This fact indicates that estimated VT shapes (Figure 1.) are very similar to real VT shapes of a one year old child.

In any case, the partially range mismatching of second and third formant frequencies should be analyzed in detail. That detailed analysis should show is ~~it~~ real MVS narrower than simulated MVS or child in that age hardly or rarely can pronounce front vowels: /*e*/ and /*i*/.

Figure 6 shows means and standard deviations of vowel formant frequencies that child pronounces in the function of his age. General trend is decreasing of formant frequencies and standard deviations. Formant frequencies decrease is not great, it is enough to confirm next: VT length increases as a child grows, that leads to decreases of resonant (formant frequencies.

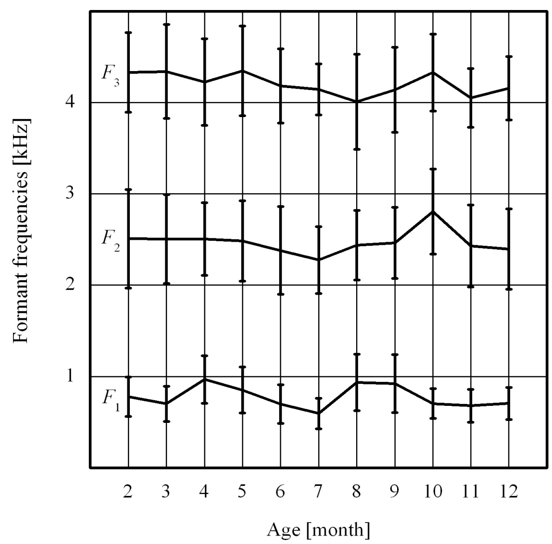


Figure 6. Vowel formant frequencies means and standard deviations that pronounces a one year old child in the function of age.

3. CONCLUSION

Obtained results show that MVS can be used in diagnostic procedure. This diagnostic method has specific significance because it can be used from child's earliest age (from birth itself). It should be noted that method itself is appropriate to that age. It is enough that child pronounce individual phonemes, and not to answers on speech stimuli.

This is pilot study, so shown results needs to be confirmed on large sample. Based on this extended analysis should define criteria for discrimination typical and atypical formant frequencies spaces.

In the case of atypical MVS at the earliest phase of life (up to one year), the development of a child should be monitored and at the later stage of development. This is needed so it can be shown real significance of MVS in the early detection of speech and language pathology.

ACKNOWLEDGMENT

This paper is created within the project „E-logoped“ number TR32032 and project of basic research Interdisciplinary Research of Verbal Communication Quality number OI178027, which are financed by the Ministary of Science and Enviromental Protection in the Republic of Serbia.

REFERENCES

Anderson N. (1978). *On the calculation of filter coefficients for maximum entropy spectral analysis*. In Childers: Modern Spectrum Analysis, IEEE press, 252-255.

Boë, L.-J., Perrier, P., Guérin, B. and Schwartz, J.L. (1989). *Maximal vowel space*, Eurospeech 89, 281-284.

Boersma, P., Weenink, D. (1992-2005). PRAAT: A system for doing phonetics by computer, *http://www.praat.org/*.

Dobrijevic Lj, Vujovic M, Sovilj M. (2013). *Intellectual ability and emotional maturity in children from high risk pregnancies.* 15th International ESCAP Congress. Abstract Book, p. 253, Dublin, Ireland.

Dudley H. (1939): *The vocoder*, Bell Labs Rec., Vol. 18, 122-126.

Fant, G. (1970). *Acoustic theory of speech productionitle*, Mouton, The Hague.

Fant, G. (2004). *Speech acoustics and phonetics*, Kluwer Academic Publishers, Dordrecht.

Flanagan, J. (1972). *Speech analysis, synthesis and perception*, Springer-Verlag, New York, 1972.

Goldstein, U. G. (1980). *An articulatory model for the vocal tract of the growing children*, Thesis of Doctor of Science, MIT, Cambridge, Massachusett.

Ladefoged, P. (1975). *A course in phonetics*, Harcourt Brace Jovanovich, New York.

Vojnović, M. (2013a). *Vocal tract shapes estimatio for children ages to one year*, 4th International Conference on Fundamental and Applied Aspects on Speech and Language, Belgrade.

Vojnović, M. (2013b). *Maximal vowel spaces*, 4th International Conference on Fundamental and Applied Aspects on Speech and Language, Belgrade.

ESTIMACIJA FORMANTNIH FREKVENCIJA VOKALA KOD DECE STAROSTI DO JEDNE GODINE

APSTRAKT

Osnovni problem kod analize formantnih frekvencija vokala, koje izgovaraju deca starosti do jedne godine, su velika centralizacija i nepoznavanje fizičkih dimenzija vokalnog trakta. Centralizacija izgovora vokala otežava njihovu diskriminaciju, tako da je za ovako rani stadijum razvoja govora bolje analizirati maksimalnu oblast vokala (MOV). Sa druge strane, za izračunavanje MOV, potrebno je poznavati fizičke dimenzije vokalnog trakta. Estimacija formantnih frekvencija vokala kod jednogodišnje dece, ostvarena je kroz dve faze: definisanje MOV i diskriminacija izgovorenih vokala na osnovu ovako definisane MOV. Estimirane formantne frekvencije vokala i MOV pokazuju opšti trend promena izgovora vokala tokom odrastanja dece, što se može iskoristiti za ranu dijagnostiku atipičnosti u govoru. Ova metoda rane trijaže je pogodna jer se ne obavlja po principu "stimulus-odgovor" što je neprimereno kod dece ovog uzrasta. Ako se ova trijažna metoda dopuni i analizom hronologije usvajanja pojedinih glasova, može se dobiti potpunija i preciznija procena razvoja govora deteta u najranijoj fazi razvoja.

Milan Vojnović, Centar za unapređenje životnih aktivnosti
Ivana Bogavac, Centar za unapređenje životnih aktivnosti, Institut za eksperimentalnu fonetiku i patologiju govora
Ljiljana Dobrijević, Centar za unapređenje životnih aktivnosti, Institut za eksperimen. fonetiku i patologiju govora

VACCINE INJURY AND ITS TREATMENT

DUBRAVKA MARKOVIC[1], AFTER KATE BIRCH[2]
[1]LCMHom, MBRCP
[2]RSHom (NA)

Abstract. Prior to the introduction of the vaccination, there were no clinical trials carried out to measure the effectiveness of vaccines in preventing disease. Their justification was and still is solely their ability to produce an antibody response. Assuming that certain vaccines succeed in stimulating the body into producing certain antibodies, this still leaves many questions unanswered. Are immunised people healthier than unimmunised individuals or are they more likely to contract more serious diseases? Is natural immunity safer, longer lasting and more effective?
Vaccinations can be directly responsible for conditions as mild as a sore throat, headache, fever or rash to more severe conditions such as neurological disorders, sudden infant death syndrome (SIDS), cancer and auto-immune diseases. Fortunately homeopathy has the potential to treat vaccine damage. For individuals with vaccine injuries, if given the chance, the time and the dedication of the invested party, homeopathy can bring about remarkable changes. The following is a brief outline of what can be expected in treatment. In acute cases of post-vaccinial reaction, only one remedy is needed and the case will be cleared in a relatively short period. In cases where several vaccines have been given and the child is stuck in an immune system reaction phase, with fevers and infections repeating, and some conditions – both mental and emotional and some development delays, several remedies may be given in a short amount of time as the immune system response activates and removes the foreign material. In cases that have developed into full autistic spectrum disabilities, severe food allergies, brain damage or other conditions will require years of homeopathic care with accompanying measures to change behaviour conditions, detoxify the body and clear the imprinted vaccine states.
Key words – Vaccination, vaccine injury, homeopathy, immunity, immune system, prevention.

HOMEOPATHY

A German physician, Samuel Hahnemann developed homeopathy in the late eighteenth century. Through his studies he came upon the concept of ‘’like treats like.’’ He discovered that a medicine could treat a disease because it had a power to cause the same disease. From his observations he developed the concept of the minimum dose. In the process of potentization, a substance has been successively diluted and succussed (a process of vigorous shaking with impact.

Understanding potency and drug action in homeopathy is the basis for all applications of homeopathic remedies. At the core of homeopathy is the concept that the human experience is a collaboration of physical and energetic phenomena. The mechanism which governs our material body in homeopathy, we call the ‘’vital force’’. It is measured in terms of well-being and the ability to adapt to the environment.

Homeopathy is an energetic system of medicine aimed at treating the vital force of the human. Our body is sending us messages in the form of symptoms.

MASS IMMUNISATION

Immunisation has been practised over a century and we have been led to believe that it has been responsible for the decline of infectious disease and is effective in disease prevention.

Prior to the introduction of the vaccination, there were no clinical trials carried out to measure the effectiveness of vaccines in preventing disease. Their justification was and still is solely to produce an antibody response. Assuming that certain vaccines succeed in stimulating the body into producing certain antibodies, this still leaves many questions unanswered.

Are immunized people healthier than unimmunized individuals or are symptoms understood to be a manifestation of a disturbance in the vital force? They are not the problem but the answer to the problem. Taking away the symptoms without treating the problem could result in the vital force finding a different path to express the problem. Homeopathy supports the vital force to create a balance.

In his time, Hahnemann treated relatively healthy people. Today we have the task of removing the many layers of suppression that western medicine has brought upon us, including ailments from vaccinations.

Are they more likely to contract more serious diseases? Is natural immunity safer, longer lasting and more effective? Decades of studies published in the world's leading medical journals have documented that vaccinations can be directly responsible for conditions as mild as a sore throat, headaches, fevers to more severe conditions such as neurological disorders, sudden infant death syndrome (SIDS), cancer and auto-immune diseases.

Infectious diseases declines steadily for decades prior to mass immunisations due to the decline in poverty and related to the increase in hygiene and diet.

HOMEOPATHIC APPROACH TO THE VACCINE DAMAGE

Homeopathy has the potential to treat vaccine damage. There is an evident potential of full recovery. If given the chance, the time and the dedication we can be more optimistic towards the prognosis. Lack of education, lack of understanding of the process of homeopathy, impatience, lack of money or commitment or just skepticism often leads people who are looking for treatment astray (in the wrong direction.)

The following is a brief outline of what can be expected in treatment. In acute cases of post-vaccinial reaction, only one remedy is needed and the case will be cleared in a relatively short period. In cases where several vaccines have been given and the child is stuck in an immune system reaction phase, with fevers and infections repeating, and some conditions – both mental and emotional and some development delays, several remedies may be given in a short amount of time as the immune system response activates and removes the foreign material. In cases that have developed into full autistic spectrum disabilities, severe food allergies, brain damage or other conditions will require years of homeopathic care with accompanying measures to change behaviour conditions, to detoxify the body and to clear the imprinted vaccine states

Homeopathic remedies are used to stimulate health. We call the method of taking homeopathic remedies to prevent a disease Homeopathic Prophylaxis. The idea is to take a particular remedy into the system so that it is ready to act should the person come into contact with the corresponding disease. The disease will therefore not get a chance to establish itself. If the action of the remedy isn't needed, the body simply doesn't use it.

References

Kate Birch: Vaccine Free.
Trevor Gunn: Mass Immunisation
Alan Phillips: Dispelling vaccination myths.
Inspired by the works and writings of Dr. Isaac Golden.

PROBLEMS OF CHILDREN IN SCHOOL WORK

IVANA PAVKOVIC
[1]Institute for experimental phonetics and speech pathology, Belgrade
[2]Life activities advancement center, Belgrade

Abstract. In recent years there were lot of problems for children in school work. The reasons for the failure need to look at the different and complex relationships in relation to the causes. Often failure in school work related to implementation of the physical, emotional, social and intellectual development.The aim of this research was to determine whether children independently solve problems in school work or seek proper help. The sample consisted of 30 normal hearing and 30 hearing impairment children from 10 to 14 years (grades 3-8) in elementary schools on the territory of Belgrade. Adequate statistical analysis of the study results confirm that the majority of children with normal hearing problems in school work solved independently, while hearing impaired children seek help from a parent or professional.

1. INTRODUCTION

In recent years, there are an increasing number of children with problems in learning. The reasons for the failure need to look at the different and complex relationships in relation to cause. Often are failing in the work associated with changes in physical, emotional, social and intellectual development. Piaget (1988) referred to the progress and socialization gives the example that if we go to class in the active school where children are free to work either in groups or alone, and at the same time saying, very surprising difference between children who are older than seven years of age and younger children. From the point of view of the individual child relationship after seven years is ready to work because you do not confuse your own point of view with the view of others, but it separates and coordinates (Gali- Jušić and all, 2004.). Kids go through ups and downs in school. It is important that all the successes and failures of parent passed to the child to make the child aware parents presents in support of his work. The parent will also have information if there is a problem in child`s learning. If the problem comes earlier and it`s followed by an appropriate response by the parents, the child has a better chance to solve the problem (Celeste, M., 2007). Problems that may arise are usually solved good relationship between the child and the teacher. Some of the problems in school can be the cause of poor academic performance, then, lack of motivation for school, loss of interest in school work, or poor relationships with peers and teachers. Problems in school work, ranging from small to serious problems that can last for a very short but it can also last much longer (Hon. Julia Gillard, 2008). Even short-term problems in school can have a negative impact and leave a mark on the mind of school children - and themselves. Children do better in school when their parents and families are involved in the education process. Strong triad relationships, school (school team consisting of a teacher, educator and psychologist), parent and child is very important for all children to attend school. Some of the signs that might indicate that a child is having problems at school: lack of parental work, relationships or connections with the school - for example, the child's lack of interest in extracurricular activities and very little gained friends, showing embarrassment or discomfort when talking about school, refuse to talk to parents, family and friends of the school, or rarely talking about school, never or rarely do homework, or rarely talking about homework. This child has a lack of confidence - the child can say to himself that he is "stupid " or not as smart as his friends and peers; returned home at lunchtime or at the end of the school day, finding excuses not to go to school or not go to school without their parents' knowledge, and the reasons cited for the boredom and monotony of school work or they do not feel sufficiently fulfilled - a child can say it does not teach anything new as a result of poor attention or behaviour problems and bullying other children. Sometimes, problems at school can be easily seen, and the child will be happy to talk about them. However, some children hide problems from their parents, teachers and peers. (Janson, U. 1999.). They can be rewritten by another student's homework, pretend to be sick during important tests, or do not bring information home from school. This can make it very difficult to pick up on the problem. Sometimes even teachers may not notice clues - especially if the child is absent a lot. The best thing a parent can do is to regularly talk with your child about school. The problem at the school can contribute to a child's call or belittling impoverished self-esteem and if this feeling lasts longer is not for the benefit of the child (Semrud - Clikeman, M. 2005.). School problems can also lead to increased risk of abandonment. They can make the children lose their desire for education and avoid her. If poor academic achievement, becomes associated with negative long-term consequences such as an increased risk of absenteeism, early dropping out of school and then quite often give up on further education. One consequence of the problems in the school`s "labelling" of children, for example, "indifferent", "easily distracted" or "not trying enough." Children often adopt this view and come to believe that the "problem". All of these labels indicate that the child did not meet the standards according to chronological age. But school problems are often a sign that the systems and networks of support around the child are not adequate. Children who have problems in school may experience a reduced belonging sense. The success of children in school depends on their well-being - how they think, feel and behave both in and out of school.

The most common cause of school problems are underlying learning difficulties (master courses), changes in behaviour or emotional problems. There are many other reasons why children do not achieve good academic results. Personal factors can include: chronic illness, intellectual or cognitive disabilities, or behavioural disabilities or disorders, mental health, such as depression or anxiety, abuse and neglect, poor self - concept or self-esteem, poor communication skills, poor social skills, difficulties with listening, concentrating or sitting. School factors that may cause failure: bullying, dislike, or feeling of not belonging, not the existing school culture - preservation of the environment, not like his choice of subjects, or the feeling of not challenging work, poor school or academic support, particularly in relation to serious load does not get along with teachers and other students in the school, skipping school for any of these reasons, competing demands on time, such as extracurricular activities. Family factors include: parents who do not participate in their children's education, home environment that does not or can`t adequately support the learning of youthful, family problems, such as relationship breakdowns, competing family or social responsibilities, such as caring for family members, or work outside of school hours. Children with special needs: some children with attention problems, high levels of anxiety, and impulsive and aggressive behaviour are at risk for problems in school. This is because they can be difficult to adjust to the demands of the classroom, or they could be difficult to concentrate during tasks and teacher instructions. A child who is absent for a long time and not attending classes because of a temporary or chronic condition, can be difficult to catch up. School success can be influenced by low self-assurance or peer relationships changes that are associated with the special needs of the child (Vujacic, 2009). Teachers in mainstream schools do not know much about the different aspects of deafness. Many teachers have a sense of tension and uncertainty regarding the understanding of hearing impaired children (school curriculum) (Telethon Institute for Child Health Research 2006).

THE STUDY SAMPLE

The sample consisted of 60 subjects (students) who attend regular elementary school, ages 9-14 years. The sample was divided into experimental and control groups. The experimental group consisted of 30 subjects (students) with hearing loss over 91 dB (profound impairment according to the classification of the World Health Organization), while the control group consisted of 30 subjects (students) a proper hearing. In addition to the age of uniformity experimental and control groups were matched and the success of the school. In experimental group was one student with insufficient success, two students with sufficient and good grades , three students with good grades and 22 students with excellent grades . The control group was the same number of children with the same results (Figure 1 and Table 10). The survey was conducted in regular schools in the Republic of Serbia in the period from January 2005.- December 2008.

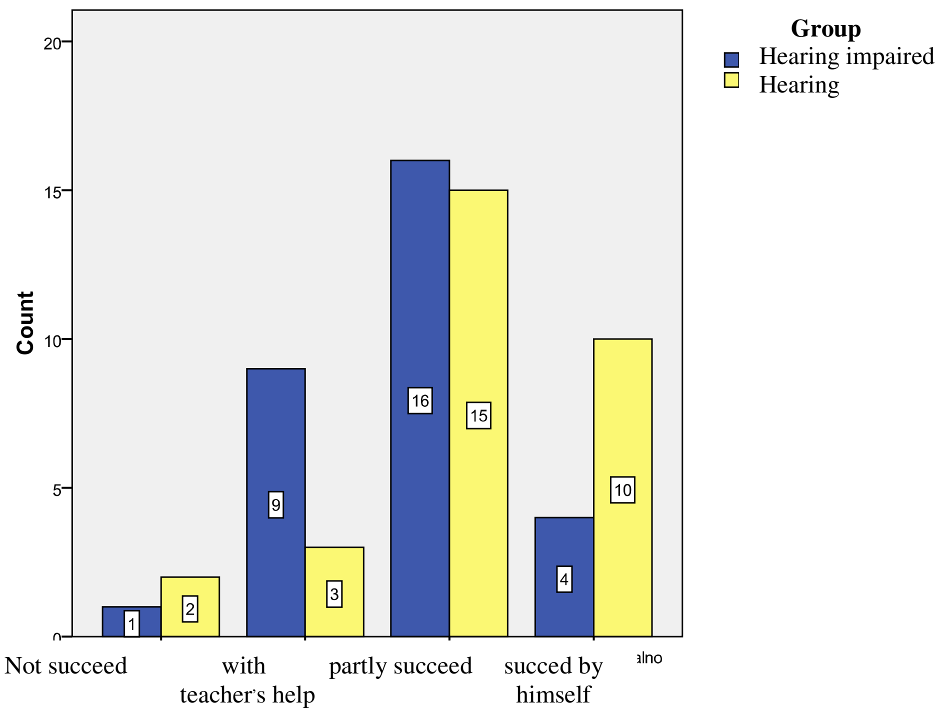


Figure 1 Problem solving in school work by the E and C group

It is well known that students often have difficulty in mastering the curriculum. Therefore, the teachers asked what happens if problems occur in school work , or how those students do. Deaf students (16) and hearing students (15) partially solve the problem themselves . Followed by different dispersion response, 9 of deaf students problem solve with the help of teachers (and students with normal hearing and 3) the approximate number of hearing students (10), which solves the problem independently. The smallest number is in hearing (2) and 1 deaf student who fail to independently solve problems.

From this we can conclude that the majority of deaf and hearing students and partially solve the problem yourself. The graph can also be concluded that the students are independent of deaf students. This confirms the theory of social deprivation persons with disabilities.

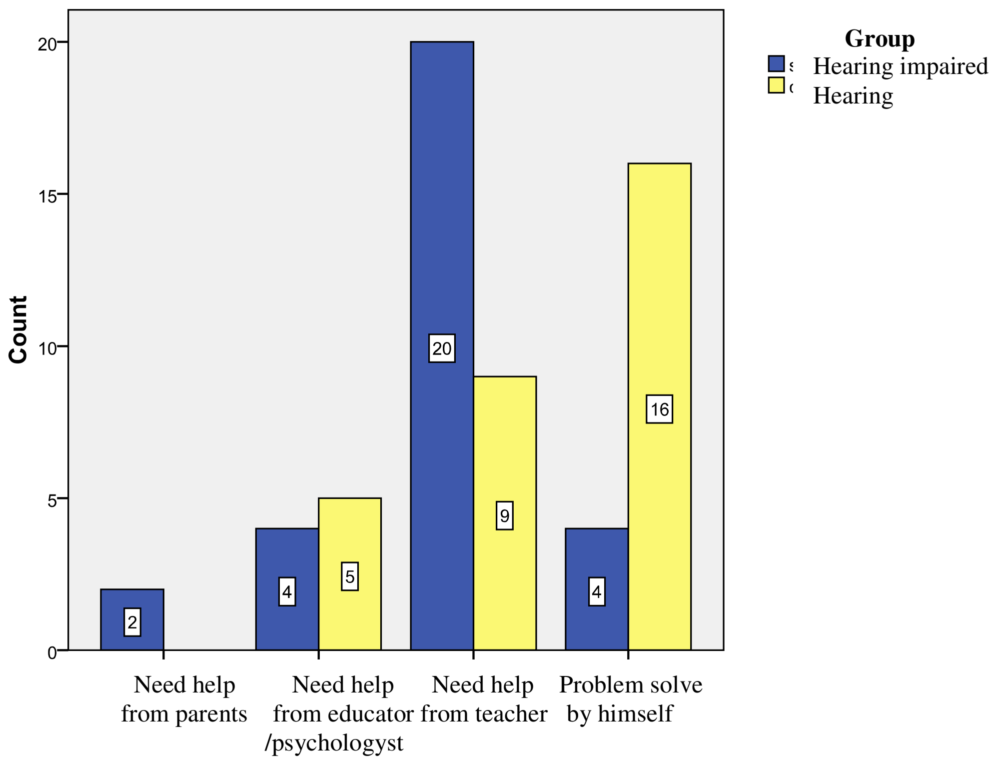


Figure 2 Problems in school work by the E and K groups

Figure 2 shows the responses to the problems in school work or if the student asks for help when a problem arises . The majority of deaf students for help 20 teachers (and hearing 9), while the largest number of hearing students 16 solves the problem independently (and 4 deaf students). There is an equal number of deaf students, hearing 4 and 5 that problem by seeking help (educators , psychologists ...).

The smallest number of those who seek help parents only two deaf students . It is interesting to ding students do not seek help from a parent. This can explain the fast pace of life and life's problems parents occupation, so that parents are thinking does not have to engage with the child and that their child can solve problems that arise in the school program. Hearing children and do not rely on their parents, because the expectations failed . The principle of intuition in teaching the hearing impaired children in accordance with their obvious pictorial way of thinking and comprehension (Jitendra, Griffin, Deatline – Buchman, Sczesniak, 2007). In the process of adoption of the initial concepts for individual subjects, hearing the injured children should be offered a number of synonyms, using materials as diverse apparent. Children with hearing loss showed reduced social maturity due to frequent social isolation from peers with typical development. Delays in the acquisition of speech leads to limitations in social interaction, and the inability to communicate becomes a major obstacle in structuring their social life. These children often exhibit a higher degree of rigidity, egocentrism, lack of internal controls, impulsivity and suggestibility. Prone to frequent outbursts of anger and aggressive behaviour. During the hours of regular classes are remarkably quiet, isolated, pay the teacher and other children only when needed and rarely engage in group activities. Peers often accept them during class , but it is the case at rest and during extracurricular activities. In communication with the teacher is usually a mutual acceptance (Kovacevic, Poplar, Vujacic, 2007)

CONCLUSION

Family and educational institutions play a crucial role in the development of speech and general development of the personality. In solving problems in study, no significant differences between hearing students and deaf students, ie. Both groups often partially solved our problems in school work, noting that hearing students independent of deaf students as a result of social deprivation due handicap. The largest number of hearing students problem solving in school work independently, while the largest number of deaf students seeking help teachers, educators, a psychologist. You should insist on trust and establishing relationships, school (school team consisting of a teacher, educator and psychologist), parent and child to have mastered and successfully managed to prevent problems in school work.

LITERATURE

1. Allen, D., D. Davies (2007) : Challenging behavior and psychiatric disorder in intellectual disability , Current Opinion Psychiatry , Vol . 20, No. . 5 , 450-455 .

2. Australian Government , Department of Education , Employment and Workplace Relations (2008) Family school partnerships framework : . Guide for schools and families . Retrieved 12 May 2010th

3.Bogenschneider & J. Olson (2010), (ed.) Improving educational outcomes : The three policy alternatives .. Wisconsin Family Impact Seminars Briefing Report (p. 1-14). Retrieved 12 May, 2010, from http :www.familiimpactseminars.org/s_vifis11c01.pdf

4. Victorian Auditor-General 's Office (2004) Management of school classes .. Retrieved 10 May , 2010.

5. Winter, E.C. (2006): Preparing for new techers inclusive school and classrooms , Support for Learning , Vol . 21, No. . 2 , 85- 91.By Raising Children Network, with the Centre for Adolescent Health The raising children network , with the Centre for Adolescent Health .

6. Government of South Australia (2007) support the success of youth : Forging links . Retrieved 10 May , 2010, from http :/ / vvv.socialinclusion.sa.gov.au / files / Supporting 20ioung 20peoples %%% 20success_VEB.pdf .

7. Vujacic , M . (2009): Possibilities and limitations of including children with disabilities in regular schools (Doctoral dissertation) . Novi Sad : Faculty of Arts .

8. Gali - Jušić , and . (2004) : Children with Learning Disabilities : the work on cognitive development , learning skills , emotion and motivation. Lekenik : Realization .

9. Poplar , b. , J . Kovacevic M . Vujacic 182 Peculiarities of mathematics instruction for beginners for children with disabilities in regular primary schools

10. Janney , R. & ME Snell (2000) : Modifying schoolwork . Baltimore : Paul . H. Brookes Publishing Co. .

11. Janson , U. (1999) : Interaction and quality in inclusive pre -school social play between blind and sighted children : inclusive pre -school quality and a normative standpoint , CIDREE , Interaction and Quality , Scotish CCC, Dundre , 30-34 .

12. Japundža -Milisavljević , M . (2008): Methods of teaching mathematics for children with intellectual development . Belgrade: Faculty of Special Education and Rehabilitation .

13. Jitendra , AK, C. Griffin , A. Deatline - Buchman & E. Sczesniak (2007) : Mathematical word problem solving in third - grade classrooms : lessons learned from design experiments ,The Journal of Educational Research, Vol . 100 , No. . 5 , 283-302 .

14 Johnson , D.W. & R.T. Johnson (2000) : Making classrooms more cooperative , Education and Human Development , Vol . 20, No. . 1 , 117-132 .

15 Kari , K . (2006): Methods of teaching basic mathematics in schools for hearing impaired children . Belgrade: Faculty of Special Education and Rehabilitation .

16. Kovacevic , J. . (2003) : Didactic systems in education of the deaf. Belgrade : DDS .

17. Kroesbergen , E.H. , J.E.H. Van Luit & C.J.M. Maas (2004) : Effectiveness of explicit and constructivist mathematics instruction for low - Achieving Students in the Netherlands ,The Elementary School Journal, Vol . 104, No. . 3 , 223-249 .

18. Lovett , M.W. & R.W. Barron (2003) : Neuropsychological Perspectives on reading development and developmental reading disorders; in SJ Segalowitz & I. Rapin (eds.) : Handbook of Neuropsychology , Volume 9 (671-716) . Amsterdam : Elsevier .

19. Milic , S . (2004) : Cooperative Learning : Theory and Practice . Podgorica: Institute for textbooks and teaching aids .

20. Mission Australia (2009) National survey of young Australians .. Retrieved 12 May 2010th

21. NSW Department of Education and Training (2005) Report of the consultation on future directions for public education and training : . One size does not fit all .

22. Piaget, Ž. and B. Inhelder (1988) : The intellectual development of the child . Belgrade: Institute for textbooks and teaching aids .

23. Before , M . (1998) . Behavioural problems and learning disabilities in school-age children : studies from Australia Temperament Project Clinical Psychologist , 3 (1), 8-10 .

24.Popović , b. , B. Poplar and J . Nevenić (2009) : Methods of teaching mathematics schools and child-friendly - the new tendencies in s. Hrnjica (ed.): Child-friendly School 2 Belgrade: Save the Children .

25. Radoman , V . (1996) : Surd psychology . Belgrade: Faculty of Special Education .

26. Rubie - Davies, sm (2007) : Classroom interactions : Exploring the practices of high -and lowexpectation eachers , British Journal of Educational Psychology , No. . 77, 289-306 .

27. Semrud - Clikeman , M. (2005) Neuropsychological aspects for evaluating learning disabilities , Journal of Learning Disabilities , Vol . 38, No. . 6 , 563-568 .Parliament of New South Wales Committee on Children and Youth (2009) Children and young people aged 9-14 years in NSW : missing middle . Retrieved 12 May , 2010.

28. Telethon Institute for Child Health Research (2006) . Factors affecting academic performance . The Western Australian Aboriginal Child Health Survey , Volume 3 , Chapter 6 (pp. 283-374) . Retrieved 12 May , 2010.

29.Hon . Julia Gillard MP, Commonwealth Minister for Education (2008) . Support for families and schools to work together. Press release , 5 november 2008. Retrieved 12 May , 2010, from30th rnal .

30. Celeste M. (2007) : Social skills intervention for a child who is blind , *Journal of Visual Impairment and Blindness*, Vol. 101, No. 3, 521-533.

IMPACT OF PREMATURITY ON ARTICULATING STATUS OF 5 YEARS AGED CHILDREN

IVANA MILICEVIC STANKOVIC, SELENA TODOROVIC, VIVIEN DJORDJEVIC, MAJA MILENKOVIC
Institute for Experimental Phonetics and Speech Pathology, Belgrade
iva_milicevic@yahoo.com

Abstract: Speech, language implementation, the ability of people to accomplish a message that is acoustically designed and linguistically organized, with the articulation of sounds and their quantitative companions. Articulation means excuse sounds based on its motion peripheral speech organs to adapt to each individual's saund, as well as all possible variations of their articulatory variables in words. Articulation disorders or dyslalia are unable or irregularities in the pronunciation of certain sounds.
Aim of this study was to evaluate the incidence of articulation disorders in preterm children, aged 5 years, compared with their peers born at term.
The study included 60 children divided into two groups of 30 subjects: control (children born at term) and experimental (premature babies). All children were tested with a global articulation test.
The results show that there is a statistically significant difference in the incidence of disorder excuses in premature infants compared with children born at term (p <0,05). Premature children have the disorder excuses more votes than children born at term.
It is necessary to early detection, diagnosis and habilitation in order to prevent and mitigate the disruption of verbal communication.
Keywords : articulation, articulation disorder, prematurely born infant

INTRODUCTION

Speech and language are the most complex human abilities. One of the major causes of delays and developmental disorders of speech and language is premature birth.

The results of many studies suggest that in premature infants are at higher risk for the development of disorders of verbal communication, speech, language, reading and writing.

Speech (implementation language) is the ability of people to use their sounds and articulation of quantitative exercise off message that is organized acoustic and language designed. Serbian language is characterized by: the correct pronunciation of 30 sounds (5 vowels and 25 consonants), four accent and accent two lengths.

For a child to master the speech, there should be an organic basis for the development of speech, primarily preserved hearing, normal intelligence, differentiated motor speech organs and phonemic perception and discrimination. Children who meet the above requirements, a speech and language occur at the same time. The process of building the speech and language closely connected with the language built through speech, and speech is in the process of its formation, the same time, the formation of the language. The ability of child speech will manifest itself with the help of people around him and you will learn the language of their environment, no matter what the language was.

Ontogeny language system is divided into three phases: pre-lingual, which lasts until the third year, lingual, lasting up to seven years and post-lingual, which runs until the end life. (1)

The period from the first cry to the first words a newborn is called the pre-linguistic expression, characterized by: the stage cooing, babbling stage and the period of baby talk, which preceded speech. (2)

The pre-linguistic expression ends with the appearance of the first word, when beginning stages of phonological development. Since then the child eliminate all superfluous forms and manufactured sound their articulatory game is increasingly shaping the phonemes of their native language. The sounds become an integral part of the word they are real sounds. The first sounds child pronounced the imprecise articulatory and acoustic are loose vague. (3)

Articulation means pronounce sounds corresponding motion peripheral speech organs, adjusting to each sound individually, as well as all possible variation of their articulatory variables in words. Articulation is based on tactile - kinesthetic movements of the peripheral speech organs. Articulation process is automated. (4)

Development of sounds takes place through periodization. In each age period ends maturation of individual sounds. In the period from the fifth to the eighth year of life comes stabilization of articulation in all phonetic sound positions in all lexical positions, which should be taken into account in the diagnosis and treatment of children with a pathology verbal communication. (1) Development of sounds is determined by biological and psychological maturation of the individual, especially its maturation of the central nervous system.

Disorders pronounce sounds are disorders of speech in which some sounds do not produce, do not produce correctly or not used correctly. Errors produced by children with the disorder pronounce sounds are classified into three categories: omission of speech, substitution and distortion.

Articulation disorders should not be replaced with: motor speech disorders (dysarthria, paresis and paralysis of speech muscles), developmental language apraxia (in which the heavily damaged motor planning), articulation disorders due to aphasia, articulation impairments associated with developmental disorders receptive and expressive speech, cleft palate and other structural anomalies of the mouth, hearing impairment, mental retardation, autism. Articulation disorder (phonetic disorder) refers to a disorder of the production of certain physical properties of the sounds.

Premature birth is one of the most important risk factors for the growth and development of children, particularly for the development of speech and language. Prematurely born infant is the child born before 37 weeks of gestation and birth weight up to 2500 g. Studies have shown more excuses disorders in premature infants. Causal connection to be found in the frequent perinatal and postnatal complications for these children, especially in children with very low birth weight (below 1500 g). (5) Advances in medical technology and treatment methods resulted in increased survival rates of premature infants, and the increasing incidence of later neuro - developmental complications. (6) For the speech-language development are particularly important perinatal complications related to the nervous system (hypoxic-ischemic encephalopathy, hemorrhage, retinopathy, development malformations, infections) (5). These complications are more frequent and more pronounced with shorter duration of gestation and low birth weight . About 50 % of children born with a 500-750 g significant neuro-developmental bias (blindness, deafness, mental retardation, cerebral palsy) .

AIM

Aim of this study was to evaluate the incidence of articulation disorders in preterm children, aged 5 years, compared with their peers born at term.

METHODS

The study included 60 children divided into two groups of 30 subjects: the control group consisted of children born at term (15 girls and 15 boys), and experimental group consisted of prematurely born children (15 girls and 15 boys). The groups were matched by sex and age. All children were tested with a global articulation test.

RESULTS

The results show that there is a statistically significant difference in the incidence of articulatory disorder in premature infants compared to children born in the term ($p < 0.05$).

In the group of preterm infants had significantly higher frequency of articulatory disorder (60%) than in the group of children born at term (43.33%). In group of premature infants present the damage more sounds than in children born at term, of which the damage often present fewer sound.

Tab. 1. Patient distribution

group/gender	male	female	SUM
control	15	15	30
experimental	15	15	30

Tab. 2. Speech disorder

group/gender	male	female	SUM
control	7	6	13
experimental	10	8	18

Tab. 3. Speech pathology (control group)

		pathology			
gender	patient	s, z, c	č, dž, š, ž	l, lj	r
male	1			x	x
	2			x	x
	3			x	
	4			x	x
	5	x	x	x	x
	6		x		
	7		x		
female	8		x		
	9		x		
	10			x	
	11				x
	12		x		
	13	x			

Tab. 4. Speech pathology (experimental group)

		pathology			
gender	patient	s, z, c	č, dž, š, ž	l, lj	r
male	1	x	x	x	x
	2	x	x	x	x
	3	x	x	x	x
	4			x	x
	5		x		x
	6			x	x
	7		x	x	x
	8			x	
	9	x		x	
	10	x			
female	11	x			
	12	x			x
	13	x	x	x	x
	14	x			
	15	x	x	x	x
	16		x	x	x
	17		x	x	
	18			x	x

In the control group 13 children has articulatory disorder, which is 43.33%, 7 boys (53.85 %) and 6 girls (46.15%).

In the experimental group 18 children has articulatory disorder, which is 60 %, 10 boys (55.56 %) and 8 girls (44.44%).

In the control group, only one boy has the disorder groups sound s, z , c, č, đž, š ž, l, lj, r, 3 boys have a disorder sounds l, lj, r, 2 boys have disorder sounds č, đž, š, ž and one boy has disorder sound l, lj. In the control group, 3 girls have articulatory disorder č, đž, š, ž, 1 has disorder sounds l, lj, 1 has disorder sound r and 1 has disorder sounds s, z, c.

In the control group, 5 boys have the disorder sounds l, lj, rhotacism has 4 boys, 3 boys has the articulatory disorder sounds č, đž, š, ž, and 1 boy has disorder sounds s, z, c.

In the control group, one girl has disorder sounds l, lj, 1 girl has rhotacism, 3 girls have the disorder č, đž, š, ž, 1 girl has disorder sounds s, z, c.

In the control group the most damaged sounds in boys are the l, lj (5 boys), and the sound r (4 boys) and in the girls are often damaged sounds č, đž, š, ž (3 girls), and at the same rate they have been damaged sounds s, z, c, l, lj, r.

In the experimental group 3 boys has a disorder sounds s, z, c, č, đž, š, ž, l, lj, r, 2 boys have a disorder l, lj, r, 1 boy has a disorder sounds č, đž, š, ž, r, 1 boy has a disorder č, đž, š, ž, l, lj, r, a boy has disorder sound l, lj, 2 boys have disorder s, z, c, l, lj, and 1 boy has disorder sounds s, z, c. In the experimental group, 2 girls have sound disorders s, z, c, č, đž, š, ž, l, lj, r, 1 girl has a sound disorder č, đž, š, ž, l, lj, r, 1 has a disorder č, đž, š, ž, l, lj, 1 has disorder l, lj, r, 2 have disorders sounds s, z, c.

In the experimental group, 8 boys have the disorder sounds l, lj, 7 boys have rhotacism, 5 boys have a disorder sounds č, đž, š, ž and 4 boys were with the disorder s, z, c.

In the experimental group, 5 girls have the disorder l, lj, 5 girls have rhotacism, 4 girls have the disorder sounds č, đž, š, ž, 5 girls have disorder s, z, c.

In the experimental group, the most damaged sounds in boys are l, lj (8 boys), and the sound r (7 boys) and the girls in the same proportion as the sounds damaged z, c, l, lj, r.

DISCUSSION

The results suggest an association between prematurity and articulation disorders in children.

Influence of risk factors (gestational age, birth weight and vitality at birth) does not directly affect the development of the skills of pronunciation, but it plays a role in the process adoption of sound systems.

The results showed a significantly higher incidence of difficulty in pronunciation in premature infants, compared with children born at term. These findings are consistent with the largou and research associates who stand with prematurity and bronchopulmonary dysplasia as a risk factor for difficulties in pronunciation of these children. (7) Analysis of species disorder pronounce sounds showed that in premature infants prevalent disorder pronounces sounds from the group sigmatism (sound disorders: s, z, c, š, ž, č, ć, đ, dž), while the control group usually present disorder excuses fewer sound (lambdacism and rotacizam). Number of damaged sounds talking about intelligibility of speech. Unintelligible and difficult to recognize speech in which he distorted 9 sounds than when disorder is present excuses fewer sounds. Given that the sounds of the group sigmatismus frequent in the speech of others, such excuse can significantly disrupt communication in terms of understanding. (8)

In children with speech and language difficulties between the ages of 2 and 8 years Morely said the increased activation of the right hemisphere than the left, while listening and speaking, compared to control subjects proper speech and language status. (9) It is known that most of the brain during the process of hearing and speech takes place in the left hemisphere of the brain, and that the activity of the left hemisphere pronounced.

The most common complications of premature birth are important in disturbed speech - language development, especially the development of oral motor skills, the periventricular - intraventricular hemorrhage (PV-IVH) and hypoxic-ischemic brain damage. (10) The incidence of PV-IVH in premature infants is 15-40 %. The incidence of hypoxic-ischemic injury in preterm is 7-26 %. Consequences of adverse prenatal and perinatal events may be less (slow neuro-motor development, fine awkwardness and gross motor skills, communication, speech and language, behavior disorders, learning disabilities) and higher (cerebral palsy, mental retardation, epilepsy). Heavy neuro-developmental deviations are easier and earlier diagnosis. Slight deviations are often detected only when the child starts school.

Successful early speech therapy can then be interpreted and neuro-biological processes (plasticity), which are time-limited to the perinatal period and early age. (11) It is believed that neuro-developmental outcome of children after perinatal damage depends on the damage (type, extent and localization), compensatory maturation of brain plasticity and professional habilitacionih treatment.

All types of perinatal brain damage are non-progressive, causing compensatory processes of maturation and plasticity can lead to functional recovery. (11)

Beck emphasized the importance of perinatal white matter lesions in premature infants (less than 29 weeks of gestation) for the development of articulatory difficulty and the difficulty of understanding. (12)

CONCLUSION

Premature children aged 5 years had a significantly higher incidence of articulation disorders and disorder pronounces more sounds, compared to children of the same age born at term.

With a multi-disciplinary monitoring, from an early age, it is possible to prevent or mitigate the occurrence of major difficulties and disorders of verbal communication, thereby ensuring quality growth and development of children, especially children with a variety of prenatal and perinatal risk factors.

With early detection, diagnosis and habilitation could to prevent problems in the area of communication, language, speech, reading and writing.

REFERENCES

1. Golubović, S. (1997). Klinička logopedija I. Defektološki fakultet, BIGZ, Beograd. str. 52-4.
2. Bugarski, R. (1996.): Uvod u opštu lingvistiku. Čigoja, Beograd. str. 39.
3. Vladisavljević S. Poremećaji izgovora. 1981. Privredni pregled. Beograd. str. 90.
4. Kostic govor i jezik. str. 139.
5. Kliegman R. M. Behrman R. E. Jenson H. B. Stanton B. F. Nelson: Textbook of Pediatrics; 18th edition 2008;701-709.
6. Willson-Costello D. Friedman H. Minich N. et al Improved survival rates with increased neurodevelopmental disability for exstremly low birth weight in infants in the 1990s. Paediatrics 2005;115:997-1003.
7. Largo R. H. i sur. Intellectual outcome, speech and school performance in high risk preterm children with birth weight appropriate for gestational age, Eur J Pediatr 1990;149(12):845-850.
8. Vuletić D. Govorni poremećaji-Izgovor. Školska knjiga; Zagreb. 1987.
9. Morely M. Brain activity abnormal in children with delayed speech, www.medicalnewstoday, 2003.
10. Davis B. Jakielski K.& Marquardt T. Developmental apraxia of speech, Determiners of differential diagnosis, Clin Linguist Phonet 1998;12:25-45;
11. Mejaški-Bošnjak V. Dijagnostički pristup ranom otkrivanju neurorazvojnih odstupanja. Paediatr Croat 2007.51:105-110.
12. Beck M. M. Cognition, language and behavior in children born prematurely, with and without white matter injury, University of Pittsburgh 2007.

AUTOMATIC DETECTION OF SPEECH PATHOLOGY - TOWARD THE EXPERT SYSTEM

RUŽICA BILIBAJKIĆ[1], SLOBODAN JOVIČIĆ[1,2] , ZORAN ŠARIĆ[1], SILVANA PUNIŠIĆ[1], MIŠKO SUBOTIĆ[1]

[1]Life Activities Advancement Centre, Belgrade

[2]School of Electrical Engineering, University of Belgrade, Belgrade

e-mail: r.bilibajkic@add-for-life.com

Abstract: Starting from the review of variety of approaches that can be found in existing literature dealing with automatic detection of speech pathology, in this paper an ongoing work on expert system for automatic detection and classification of voice pathologies is described. The advantages of systems for automatic detection of speech pathology are manifold, not only due to the fact that the impact of human factors is significantly reduced but also because of the extended availability. This system employs non-invasive, non-expensive and fully automated measures that could be used in screening, diagnosis and early detection of voice pathology as well as reliable tool that can assist professional speech therapists. In order to solve this complex problem, methods of acoustic analysis, parametric and non-parametric feature extraction, automatic pattern recognition and statistical methods were used. The interdisciplinary research was conducted with the aim to create and implement an expert system for the detection of speech pathology disorders, including those specific to the Serbian language.

Keywords: speech pathology detection, speech pathology classification, expert system.

1. INTRODUCTION

Reliable systems for automatic detection of speech pathology are a long sought tool by speech pathologists. Evaluation performed by a trained specialist is usually time and human resource consuming which makes it expensive, time-demanding and prone to errors due to human factors like fatigue and lack of concentration. Although advantages of system for automatic detection of speech pathology are manifold, it is clear that in cases where speech pathology assessment is done by speech therapist an accurate diagnosis is obtained without the influence of factors that are not pathological in nature. With automatic testing the impact of human factors is significantly reduced and the results are consistent. Also, making system accessible via the internet or a public telephone, testing can be performed simultaneously by multiple examinees in specialized centres for voice and speech disorders as well as at home making them more cost-effective. Such an fast, easy-to-use, non-invasive for the patient and affordable detector can also be used for low cost mass-screening, diagnosis and early detection of voice pathology.

For the patient, it can provide valuable tool for auto assessment to determine how severe the disorder is and should one turn to the specialist. Although these systems cannot entirely replace speech therapists, they may provide an assessment of speech disorders and, refer examinees when needed, to specialized medical facilities for further analysis and treatment.

For speech therapist, such a system could be used as a complementary speech therapy method, customized and client-oriented providing a speech therapist with a second opinion and supporting the therapist with a calibrated estimation which could be taken into consideration during the diagnosis or even help to identify additional problems. It would be suitable for keeping track of the evolution of the patient's pathology and ease therapy control and qualification of changes in the disorder. Furthermore, it could be used in therapy evaluation showing which method gives better overall results when tested on groups of patients. Development of automated system based on speech processing algorithms capable of performing the speech pathology detection task brings many benefits to the field of speech pronunciation correction.

2. STATE OF THE ART

In the last years a large number of works have focused on the automatic detection and classification of voice pathologies. The improvements in speech and signal processing technology have resulted in the development of computer-assisted methods for speech therapy. There are various solutions that use different methods. Some are used for monitoring and assistance in speech therapy in terms of intelligent systems that analyze course of treatment and data generated from standardized tests and giving the suggestions for further course of therapy help therapists. Some of them have integrated modules for the automated assessment of articulation problems. Some are designed for home usage in the form of programs for portable devices or available online. Some of the systems will be briefly presented in the following text.

The OLP (Ortho-Logo-Paedia) project (Öster et al., 2002) involves the Institute for Language and Speech Processing in Athens and seven other partners from academia and the medical domains. It is a three–module system (OPTACIA, GRIFOS and TELEMACHOS) that proposes to apply a method to supplement (not replace) speech therapy for specific disorders at the articulation level based on an integrated computer-based system together with automatic speech recognition and distance learning. OPTACIA module is meant to provide the client with real-time visual feedback about speech using the 2D or 3D vocal tract visualization. GRIFOS is a speaker-dependent, small-vocabulary, automatic speech recognition system. In early sessions, GRIFOS served to set appropriate thresholds in OPTACIA to control acceptability of a client's speech productions and to analyze quantitatively these productions in syllable and word context during speech therapy. In later stages, it primarily serves to evaluate client productions in continuous speech. TELEMACHOS is meant to apply distance learning principles based on web database technology to provide the system's remote tutoring and monitoring ability.

Speech Training, Assessment, and Remediation (STAR) system (Bunnell et al., 2000) is intended to assist speech and language pathologists in treating children with articulation problems. It is a joined project of Alfred I. duPont Hospital for Children and University of Delaware which began in 2002. The system is intended to facilitate speech pathologists assessment of speech by helping them to better target therapeutic intervention, augment their efforts in highly repetitive articulation drill and training, and assist in record keeping and reporting. Using the animated character in video game it constantly elicits speech from a child and measures the speech produced by the child. The system, when completed and functioning, is intended to start with basic phoneme recognition tasks, and progress through phoneme production tasks, first in isolation, then in simple and eventually more complex phonetic contexts, and finally in sentences. To assess children's speech, a discrete hidden Markov model recognition engine is used and preliminary results are reasonably encouraging.

PEAKS (Program for Evaluation and Analysis of all Kinds of Speech disorders) is a recording and analysis environment for the automatic or manual evaluation of voice and speech disorders (Maier et al., 2009). It is developed at university Erlangen-Nurnberg, Erlangen Germany and it is used at the University clinic for scientific purposes. Speech is analyzed by automatic speech recognition (ASR) and prosody modules. ASR module is based on hidden Markov model and Mel frequency cepstral coefficients, while 21 prosodic features are extracted in the prosody module. The system can be accessed via internet or public telephone. It does not require any special hardware except for the standard PC and a sound card. It is based on automatically rated standardized test where patient reads text or names pictures. PEAKS is a system for evaluation of speech intelligibility and a five-point scale is used to rate intelligibility of input speech. System is tested on two types of communication disorders: voice and articulation disorders. Results showed that a significant correlation (around 90%) between the automatic analysis and the judgment of human experts is achieved.

TERAPERS project (Danubianu et al. 2009) developed within the Center for Computer Research in the University "Stefan cel Mare" of Suceava, Romania, is an intelligent system designed for assisting the personalized therapy of dyslalia for the Romanian pre-scholars children. The objectives of this project are development of an expert system for the personalized therapy of speech impairments that allows designing a training path for pronunciation, individualized according to the speech disorder category, evaluation of child's progress and development of a therapeutic guide that allows mixing classical methods with the adjuvant procedures of the audio-visual system. The part of the system, marked as LOGOMON, is intended for the initial evaluation of children with speech disorders, registration of them in a database, suggestion of the diagnosis with the possibility for the expert to confirm or to modify this diagnosis, the selection of children for the therapy, the management of the therapy process and the supervision of the children's progress. The main objective of this task is to record the children, using different audio environments during recording and use some phonemes for training a real-time recognition system. Software that helps parsing audio and real time recordings (Schipor and Nestor, 2007) has been developed.

3. SYSTEM FOR THE AUTOMATIC DETECTION OF SPEECH PATHOLOGY

The purpose of this paper is to present expert system for automatic detection of speech pathology for which the scientific research and modules deployment are in progress. Figure 1 shows the block scheme of the proposed expert system. The system consists of three main modules: Preprocessing, Global articulation test and Analytical test. For some of the modules an extensive research was conducted and obtained results confirm the models and methods that were used.

The system is designed as a software package with the recorded speech signal as an input and the evaluation in speech pathology as an output. Preprocessing is an important first step of the processing of speech signal. Bearing in mind that it is one of the first processing steps in these systems, it has to be conducted reliably and correctly because the errors made in this step are propagated throughout the whole system, significantly disrupting its quality. Inputs to this module are words, from which it is necessary to extract the corresponding phoneme that continues to be analyzed through the other modules. This imposes automatic segmentation of speech signal as the most important step in this stage of processing. For this purpose, parameterization of speech is carried out on the basis of which automatic segmentation is performed. Previous studies have shown that the automatic segmentation can be done with sufficient accuracy with different parameterization methods and using the variety of methods for segmentation (Bilibajkić et al. 2007, 2010, 2011). Using the parameterization based on Mel frequency cepstral coefficients and combining it with Dynamic Time Wrapping (DTW) for time alignment and K nearest neighbor method for phoneme segmentation, the segmentation error is proven to be fewer than 5% (Bilibajkić, 2011). High accuracy is achieved mainly because the input stimulus is known in advance. It should be borne in mind that this is a pathological speech whose segmentation is much more complex in comparison with normal speech

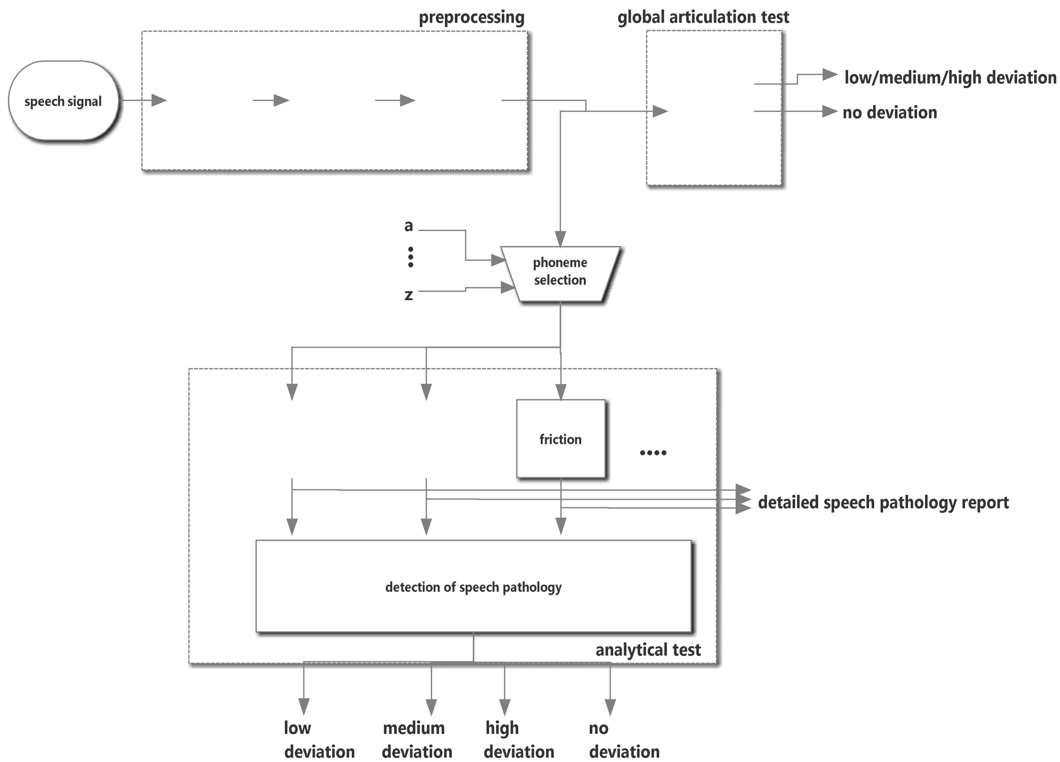


Figure 1. Block scheme of the proposed expert system.

Using the segmented speech signal detection and extraction of features suitable for further analysis is performed. Selected features serve as input to another two modules that realize two commonly used tests in speech therapy: (1) Global Articulation Test (GAT) and (2) Analytical Test (AT). Features used in these modules meet their specific requirements.

To assess the quality of articulation of phonemes the Global Articulation Test is used. The test consists of 30 words shown in Table 1 characterized by specified phonetic structure. Each word from the test is associated with appropriate phoneme from Serbian language, and it is used to assess the articulation of that particular phoneme. Words are formed in such a way that the vocals are at the second position in the first syllable, and consonants are in the initial position in the appropriate words. In cases when one word contains two of the same phoneme, only the articulation of the first phoneme is investigated. It is expected from respondents to pronounce the test words in the order they are listed in the table.

Score values are given for every articulation of the word and can take the values from 1 to 7. The values 1, 2 and 3, depending on the quality, indicate the normal pronunciation. They are not in the area of speech pathology. Value 4 represents the threshold value, 5 marks existence of distortion, 6 marks that phoneme would be hardly understood if pronounced out of the context, and grade 7 means complete absence of an appropriate phoneme or its replacement with another. Values 4, 5 and 6 correspond to low, medium and high deviation obtained at the output of the ANN module of the system shown in Figure 1. Using the Global articulation test it is possible to determine the type and the degree of deviation of mispronounced phonemes.

Table 1. Test words of Global Articulation Test.

words					
i-vidi	p-pada	g-guma	dž-džep	š-šuma	m-moj
e-bebe	b-baba	c-cica	f-fes	ž-žaba	n-noga
a-mama	t-tata	ć-ćebe	v-voz	h-hodi	nj-njiva
o-voda	d-deda	đ-đak	s-seka	j-jaje	l-lice
u-buba	k-koka	č-čelo	z-zima	r-riba	lj-ljudi

Global articulation test module is based on the phoneme selected by automatic segmentation and features extracted from the selected signal segment. As a result it gives the assessment of the degree of speech deviation if it is present. It is anticipated that this module could be made using the artificial neural networks. The first results in Furundzic et al. 2012 encourage the use of this approach.

Results obtained by global articulation test are not fully able to demonstrate the characteristics of individual phonemes that are not produced in a satisfactory manner, i.e. what should be removed or upgraded to be correctly spoken. In that purpose, AT test is used. Labelling of articulation and acoustic deviation from normal voice is given in more detail thereby providing an estimate of the presence of particular deviation in speech typical for the phoneme that is being analyzed.

Analytical test module consists of several sub-modules, each of which corresponds to a particular type of distortion. In speech therapy it is possible to differentiate up to 37 different types of distortion that can occur with certain phonemes in the Serbian language depending on the phoneme group. In this area multiple studies have been carried out that yielded extremely valuable results (Punišić et all., 2007, 2012; Jovičić et al., 2008). The research conducted using the Global articulation test and Analytical test (Punišić, 2012) showed that the highest frequency of atypical production of the distortion type occurred in pronunciation of 7 phonemes (/c/, /č/, /dž/, /š/, /ž/, /r/ i /l/). In this study, different types of sigmatism (faulty articulation of sibilants) , changed duration quality as well as changed friction intensity are designated as the most frequent deviations. Therefore, in the first phase of the research and development AT subsystem is designed to analyze the distortion of the voice types: duration, intensity, stridence and sigmatism with modular expansion to a wider subset of distortions. For some types of distortions such as stridence (a specific form of spectral distortion), we developed solutions for automatic detection (Bilibajkić et al., 2012).

4. CONCLUSSION

This paper presents a work in progress on system for automatic detection of speech pathology. Results of earlier studies support the idea that such a system can be derived in a way that the detection of pathology can be performed with accuracy comparable with the evaluations provided by most experienced trained professionals. Also, it is important to point out that the methods used are congruent with the current achievements in the field of speech signal processing. A small number of fully functional and available systems with similar purpose corroborate the fact that further research in the field of detection of articulator acoustic characteristics of pathological speech and their deployment in expert system are necessary to continue. A complete automated system based on speech processing algorithms capable of performing the recognition task is therefore thoroughly justified and can be viewed as a goal that will bring many benefits to the field of speech pronunciation correction.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Education, Science and Technological Development of Republic of Serbia through the projects TR32032 and 178027.

REFERENCES

Bilibajkić, R., Šarić, Z., Jovičić, S. T. (2007). Segmentacija reči postupkom najbližeg uzorka za potrebe analize poremećaja izgovora fonema. *51. ETRAN Conference.* Herceg Novi.

Bilibajkić, R., Šarić, Z., Jovičić, S. T. (2010). Segmentacija reči za potrebe dijagnostike patologije govora primenom auditornog modela, *54. ETRAN Conference.* Donji Milanovac.

Bilibajkić, R., Šarić, Z., Jovičić, S.T. (2011). Auditory-model based speech segmentation on subphonemic segments. *In proceedings of Forum Acusticum 2011*, 55-60, Aalborg, Denmark.

Bilibajkić, R. (2011). Automatska segmentacija reci korišćenjem MFCC i GFCC spektralnih modela. *Master's thesys, School of electrical engineering, University of Belgrade.*

Bilibajkić, R., Šarić, Z., Punišić, S., Subotić, M. Jovičić, S.T. (2012). Detekcija stridensa u patološkom izgovoru primenom auditornog modela. *DOGS conference*, Kovačica.

Bunnell, H. T., Yarrington, D. M., Polikoff, J. B. (2000). STAR: Articulation training for young children. In *Proc. of the ICSLP 2000*, Vol. 4, pp. 85-88.

Danubianu, M., Pentiuc, S.G., Schipor, O., Nestor, M., Ungurean, I., Schipor, D.M. (2009). TERAPERS - Intelligent Solution for Personalized Therapy of Speech Disorders. *International Journal on Advances in Life Science 1(1*), 26–35.

Furundzić, D., Jovičić, S. T.,Subotić, M. Z.,Punišić, S. (2012). Acoustic Features Determination for Regularity Articulation Quantification of Serbian Fricatives, *11. symposium on neural network applications in electrical engineering (NEUREL 2012).*

Jovičić, S. T., Punišić, S., Šarić, Z. (2008). Time-frequency detection of stridence in fricatives and affricates. In *Proceedings of Acoustics'08*, Paris.

Maier, A., Haderlein, T., Eysholdt, U., Rosanowski, F., Batliner, A., Schuster, M., Nöth, E. (2009). Peaks – A System for the automatic evaluation of voice and speech disorders, *Speech Commun. 51, 5 (May 2009),* 425-437.

Öster, A.-M., House, D., Protopapas, A., Hatzis, A. (2002). Presentation of a new EU project for speech therapy: OLP (Ortho-Logo-Paedia). In *Proceedings from Fonetik 2002, Speech Music and Hearing Quarterly Progress and Status Report* 44,45-48.

Punišić S., Jovičić S., Šarić Z. (2007). Speech distortion assessment: methodological and system approach. *Proc. of Int. Conf. SPECOM'07,* St. Petersburg, 355-360.

Punišić, S., (2012). Artikulaciono-akustički i auditivni aspekt odstupanja glasova u patološkom govoru. *PhD dissertation, University of Belgrade.*

Punišić, S., Jovičić, S.T., Subotić, M., Šarić, Z., Bilibajkić, R. (2012) . Stridens – spektralna distorzija glasova: auditivna i akustička analiza. *DOGS conference*, Kovačica.

Schipor, O., Nestor, M. (2007). Automat parsing of audio recordings. Testing children with dyslalia. Theoretical background., *Distributed Systems, "Stefan cel Mare" University of Suceava Press*, Romania.

LINGUISTIC CAPACITY OF CHILDREN WITH DI GEORGE SYNDROM

SELENA TODOROVIĆ, VIVIEN ĐORĐEVIC, MARIJANA PANIĆ
Institute for Experimental Phonetics and Speech Pathology
mail-todorovic.selena@gmail.com

Abstract:Di George syndrome is a genetic condition in patients with different varieties. It occurs as a result of genetic deletion of the long arm of chromosome 22nd. This syndrome was discovered in the 60s (endocrinologist Angelo Di George) (8).Typical problems associated with this syndrome are heart defects, cleft palate, velofarinx failure, specific phenotypic characteristics, especially the face, problems in acquiring speech and language skills, which later led to difficulty in the learning process and the development of social skills. Sometimes they are associated with mental disorders, endocrine problems (hypothyroidism, hyperthyroidism rarely) and scoliosis. Considering and neurological disorders, often present clumsiness and ability to control the coarse and fine motor skills (3)
The aim of this paper is to present speech and language skills of a child with this syndrome, which comes in IEPSP in audiolinguistics treatments.
Research methodology: A battery of tests IEPSP (Institute for Experimental Phonetics and Speech Pathology), audiological procedures

Keywords: Di George syndrome, speech and language development, cognitive development

1. INTRODUCTION

Di George syndrome is the result of deletion of chromosome 22. Deletion of a gene mutation leads to loss of chromosomes or DNA segment. Such damage is the cause of severe genetic diseases. Di George syndrome missing about three million base pairs in one copy of chromosome 22 in every cell.(1). The syndrome is clinically described Angelo Di George in the 1960s and Robert Shprintzen during the 1970. Di George syndrome characterized by immune defects, and thymic hypoplasia congenital cardiac anomalies. It is also called velocardiofacial syndrome due to damage caused (5). Diagnosis Di George syndrome can be placed before and postnatal. Prenatal ultrasound is set in 18th week pregnant women when they can detect abnormalities of the heart and palate (10). The second method is called fish method, fluorescence hybridization performed on cells after amniocentesis and can be done in the 14th week of pregnancy (6). Methods in 95 % of cases confirmed Di George syndrome. Postnatal diagnosis is based on signs and symptoms that develop after birth.

Symptoms usually occur while children are in the family list (cianosis, symptoms of heart failure, etc.) and may present after several weeks or months. In some patients, the problem is diagnosed only in adulthood because of delays in developing speech or eating problems. This indicates a large variation in the symptoms of this syndrome. Congenital heart defects, and infections are the most common cause of morbidity and mortality in patients. Death occurs shortly after birth or during the first year. However, with timely diagnosis and proper treatment most children survive and experience adulthood, but these are children with special needs who need constant care and care of others (7).

1.1. Characteristics velocardiofacial syndrome (Di George):

- difficulties during feeding
- microcephaly
- hearing loss or ear deformities
- hipocalcemia or low levels of calcium in the blood

- the intellectual level is in the range of 70/90 IQ
- mild mental retardation
- cleft lip or palate
- abnormalities of the genitourinary tract
- psychiatric disorders in adult such as schizophrenia and bipolar disorder
- lesions
- severe immune dysfunction leading to frequent infections
- phenotypic characteristics (lowered eyelids, weeping face, small ears and mouth)

1.2.Prevalent of syndrome

It is estimated that deletions of chromosome 22 occurs every 3000-4000 newborns. For many people the deletion is a random event about 10% of the family of hereditary nature. Gene is transmitted by autosomal dominant. Exact frequency syndrome is not fully known. FISH test is expensive, so that screening every newborn with some risk was too expensive. Based on studies from different countries, the minimum occurrence of deletion 22 is between 1 in 5,900 and 1 in 9,700 live births (9).

1.2. Cognitive and language problems

Children with this syndrome have a specific profile of neuropsychological tests. Usually the average intellectual ability with higher scores on the non-verbal part of the test is in relation to the verbal. The most problem with their language development is hypernasality primary voice for palatal abnormalities (69 % of the children there) which is called velopharyngeal inadequacy (2).

The slow development of speech and language follow expressive language vocabulary inadequate in relation to age. Impressive speech is usually not more in arrears, although it happens that his development slower than usual. Articulation disorders are also present in the form of distortion, substitution or omission of speech sounds and voices of all groups. It is necessary to involve the child in speech therapy as soon as possible because there is a positive trend during the progression of maturation (4). Sometimes I have difficulty understanding abstract content and planning activities. They speak often shorter sentences because they have difficulty in acquiring certain grammatical rules.

2. THE AIM

The aim was to present the speech-language characteristics in children 5 years old with Di George syndrome, coming in at IEPSP on audiolinguistics intensive treatment from January 2013.

3. METHODOLOGY

We used a battery of tests IEPSP's, which may indicate the level of speech and language development of the child, and the progress after a few months of audiolinguistics treatment. Assessment of speech and language status was made by following tests:

• Global articulation test (Kostić Đ., Vladisavljević S).

• A scale for the assessment of psycho-physiological capacities of the child from 0 to 7 years

• Test for the assessment of primary laryngeal voice (Kostić Đ.)
• The test of oral praxis (Radičević V., Stevanković M).
• Test for the assessment of acquisition adverbs and prepositions (IEFPG).
• Test for the assessment of the first and second levels of abstraction (Kostić Đ.)
Psychological evaluation was performed by Leither test.

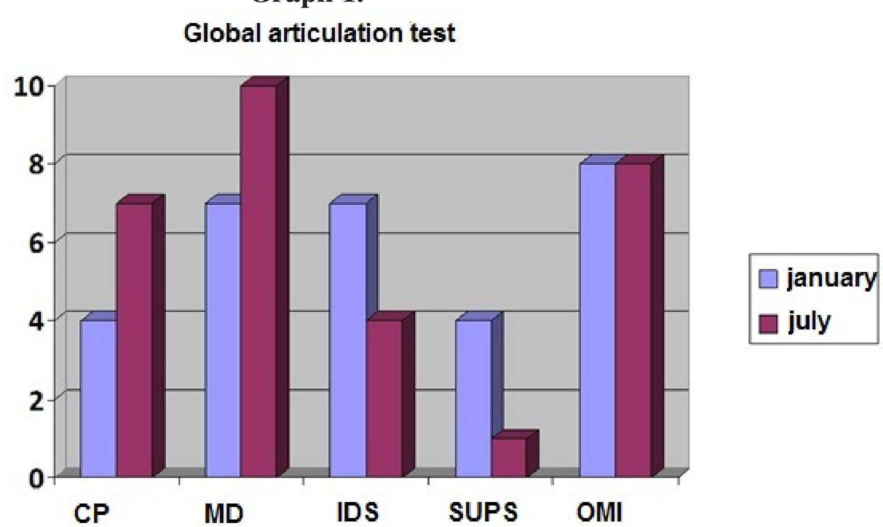
3.1. Case report

Child V.G. arrived at the Institute for Experimental Phonetics and Speech Pathology (IEPSP) from January 2013 on audiolinguistics treatments. From history we learn that in the third month of the genetic examination diagnosed Di George syndrome, and that the child had been repeatedly hospitalized for respiratory problems as well as the recovery of heart defects. Speech and language status on admission was appointed on the basis of observations of the child and parent data since the child was not validate according to the scale for the assessment of psychological development of the child which is related to speech and language, it was a significant departure from the development of standards in development of receptive and highly expressive speech. He has about three words of a social nature. Syntactic development is absent; highly undifferentiated oral praxis; basic laryngeal voice quiet, graphomotoric structures are not in adequated level for ages.

After a six-month treatment audiolinguistics retest was performed and recorded a slight improvement in the development of speech and language which will be presented in tables and graphs.

4. RESULTS AND DISCUSSION

Graph 1.



Legend: KI- correct pronunciation, MD- mild distortion, DS- interdental stigmatism, SUPS – substitution, OMI- omission of speech sounds

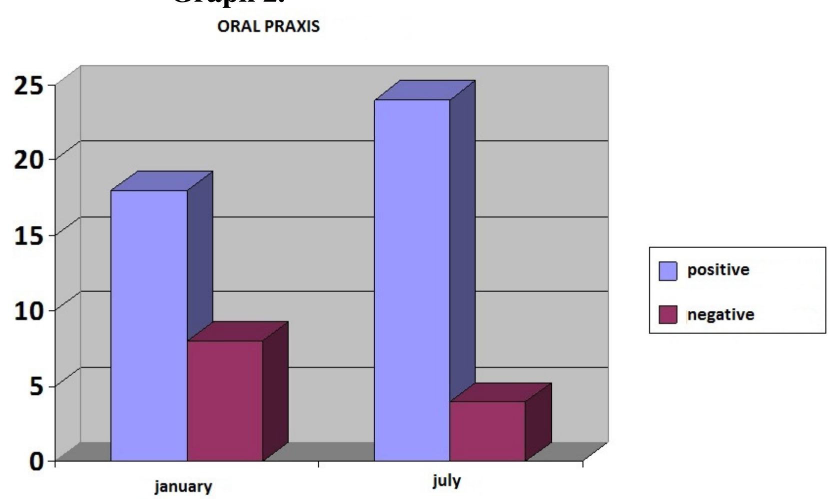
Graph 1 show the results of the global articulatory test and recorded progress in articulatory status. From the graph we see that the majority of voices correctly spoken (estimate 3), the highest number of voices with mild distortion (estimate 4) than the interdental sigmatism (estimate 5) and that the number of voices suspstitutes (estimate 6) who moved to easier forms of distortion. Number of omitates voices remained the same (estimate 7), which is one of the most serious damage to the voice, and the voices of the group affricates, fricatives and vibrant, which is somewhat expected given the relatively short time spent in treatment.

Table 1

Time testing	Active use time testing adverbs and prepositions	
July 2013	2	0
January 2013	0	0

Table 1 show the results of the first test and retest, the level of adoption of proposals and reports in the active vocabulary. The child is in their active vocabulary began to use two proposals (u, s) with the passive, ie. to understand a lot more, almost all of the test, therefore we present here only the state of the active vocabulary.

Graph 2.



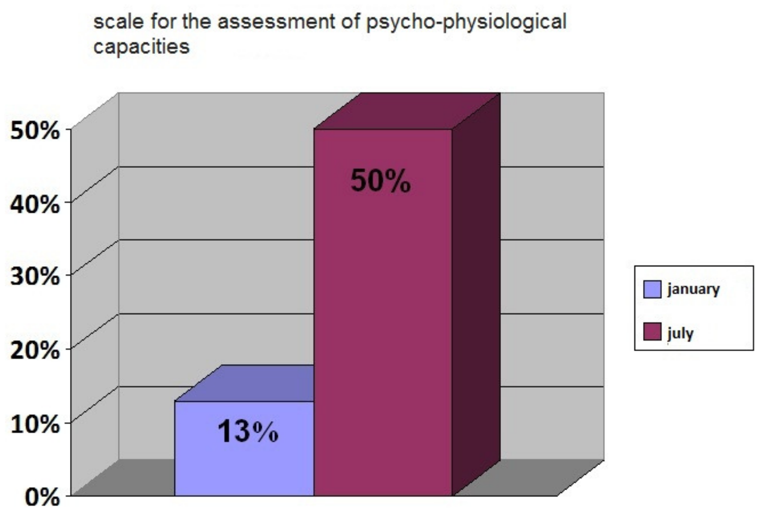
The graph 2 shows the assessment successfully performed items in the scale for the assessment of psycho-physiological capacities of the child, in part related to speech and expressed as percentages. In January, the exact percentage of rated capacity was 13%, while in the retest in July was 50 %, which indicates a significant increase in psychophysiological abilities.

Table 2

	Assessment of oral praxis	
Time testing	**Negative rating**	**Negative rating**
July 2013	**24**	**4**
January 2013	**18**	**8**

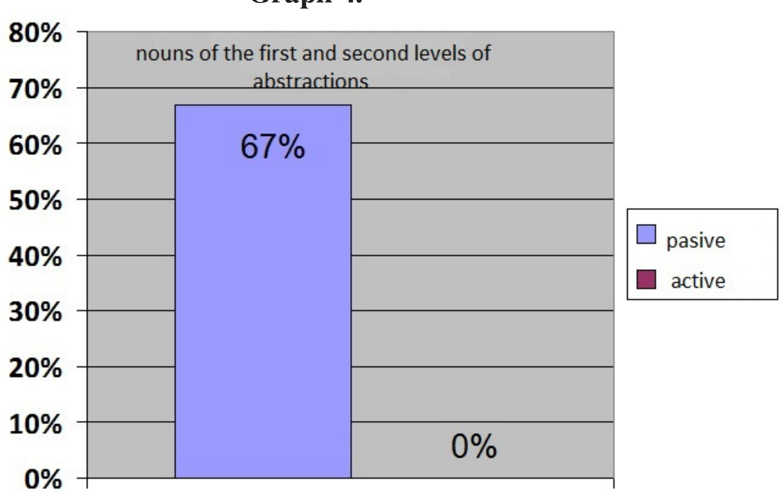
Table 2 shows the results of the evaluation of oral praxis in the first test and retest after 6 months, and we see that the ability of oral praxis improved after six months of treatment. The first test positively evaluated the ability of oral praxis was 18 and the retest 24. We also see that the number of negatively evaluated the ability of oral praxis reduced from 8 to 4. These results are displayed graphically in Figure 2.

Graph 3



The test for assessing noun first and second levels of abstraction and assesses the active and passive use of these nouns , we conclude that the active vocabulary of the child does not have a noun , which is 0 %, and in the passive form, ie. in the level of understanding has a 67 % correct rated items . At the beginning of ALT child was atestabil so that this information on testing in July 2013th. These results are shown in graph 4.

Graph 4.



Regarding laringogram, we see that the basic laryngeal voice ranged from half-whisper to a voice of normal height, which is considered as progress, since he holds the suprasegmental structure of the language and the basis for further phonetical- phonological development.

Table 3.

Time testing	primary laryngeal voice
July 2013	Normal high voice
January 2013	Half-wisper voice

Psychological assessment Leither test, the child showed delayed psychomotor development. At the time of testing had been 3 years and 9 months, and achievement on the test corresponds to the age of 2 years (IQ 52) after repeated psychological testing.

5. CONCLUSION

Display tables and graphs we were able to show partial progress in speech and language development of children with Di George syndrome. Given the relatively short time spent in IEPSP, we expect further progress of the child in this field , among other things, because in the literature dealing with this problem often leads to information about the children maturing and intensive speech therapy can achieve good results. Also, take into account the fact that in this syndrome are permanent damage of certain functions, and thus does not need to have unrealistic expectations, but allow the child to develop a biological maximum.

LITERATURE

1. Couly, G., Laqrue, A., Griscelli, C. (1983.): Di George syndrome, exemplary rhomboenchephalic neurocristopathy, Rev. Stomatol. Chir. Maxillofac.; 84(2): 103-8.

2. *Di George syndrome* , Rev Chil Pediatr. 1991 Nov- Dec , 62.

3. Ehl, S. (2004.): DiGeorge-Syndrom, Allergologie, Jahrgang 27, Nr. 11/2004.,S. 473-476.

4. Faed, M.J.,Robertson, J., Beck, J.S., Cater, J.I., Bose, B., Madlom M.M. (1987.): Features of di George syndrome in a child with 45,xx,-3,-22, +der (3),+(3;22) (p25,q11), *Journal of Medical Genetics*, V 24(4), PMCID 1050000,225-227.

5.http://en.wikipedia.org/wiki/DiGeorge_syndrome.

6. Kar,P.S., Ogoe, R.,Meeking, D. (2005.): Di George syndrome presenting with hypocalcaemia in adulthood: two case reports and a review, *Journal of Clinical Pathology*, V. 58(6), PMC 1770695, 655-657

7.Peg M., Krajinčanić, B. (1989):, Medical Genetics , Institute for Textbooks and Belgrade.

8. Pereira A.C., Correa R.F.R. et al.(2003): High specificity PCR screening for 22q11.2 microdeletion in three different ethnic groups , Braz J Med Biol Res vol.36 no.10 Ribeirão Preto.

9. Philip N., Bassett A., Cognitive , Behavioral and Psychiatric Phenotype in 22q11.2 Deletion Syndrome Behav Genet . 2011 May ; 41 (3) : 403-412.

10.Stevens,C.A., Carey, J.C.,Shiqeoka, A.O. (1990.): Di George anomaly and velocardiofacial syndrome, Pediatrics, V 85 (4), 526-30.

THE INFLUENCE OF RH INCOMPATIBILITY TO SPEECH AND LANGUAGE DEVELOPMENT

IGOR BUZGANOVIĆ [1,2] , MIRJANA SOVILJ [1,2] , NATAŠA ČABARKAPA [1,2]
[1] Life Activities Advancement Center, Belgrade, Serbia;
[2] Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia
buzganovic83@yahoo.com

Abstract: Speech and language, as the most compound human's psychopsychiological functions, are very susceptible to negative influence of many risks factors that affect the development of CNS, and the consequences to speech and language depend on the time of their onset and the intensity of their influence. RH incompatibility is the most common risk factor of speech and language with children and it considers the presence of antibodies in the blood of Rh negative mother and they can go through placental barrier and connect to fetal erythrocytes and cause their decay and destruction (hemolysis of fetal erythrocytes). The decay of fetal erythrocytes causes fetal anemia and high increase of bilirubins in fetal blood. Bilirubin from decayed erythrocytes can deposit in different parts of the brain and cause its hard damage. The consequence of the influence of the mentioned pathological factors are shown later – from the period of speaking to preschool and school period showing slow speech-language and psychomotor development, also including consequences of adopting school skills, behavior, attention and psychosocial development, too. The aim of this research is to determine the influence of RH incompatibility on speech and language development at children. Children are divided into two groups, experimental group consist 34 children with exanguinotransfusion, and 40 healthy children with proper speech and language development.

In this research all children was tested by verbal memory test and semantic test. Early detection of abnormalities and deviations from normal development, and taking appropriate preventive measures can prevent the development of disorder. Thanks to the plasticity of the central nervous system (CNS) to alter their structure and function under the influence of environmental stimulation, it is possible to its reorganization. The goal of preventive activities and early stimulation treatment in KSAFA system is to promote normal development of speech and language, as disturbances of speech would not have occurred or to prevent the occurrence of secondary consequence.

Keywords: RH incompatibility, speech and language development, prevention

1. INTRODUCTION

1.1Rh blood types

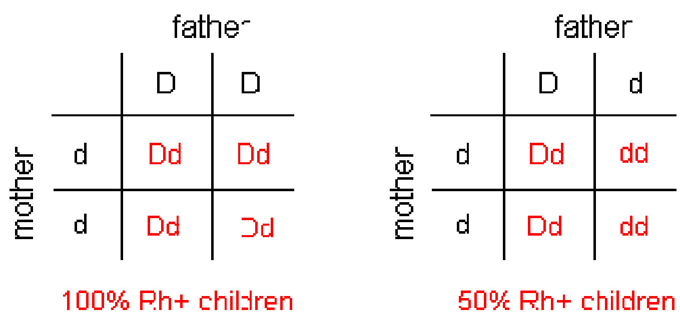
Rh blood types were discovered in 1940 by Karl Landsteiner and Alexander Wiener. This was 40 years after Landsteiner had discovered the ABO blood groups (8,9). Over the last half century, we have learned far more about the processes responsible for Rh types. This blood group may be the most complex genetically of all blood type systems since it involves 45 different antigens on the surface of red cells that are controlled by 2 closely linked genes on chromosome 1.

The Rh system was named after rhesus monkeys, since they were initially used in the research to make the antiserum for typing blood samples (1,5). If the antiserum agglutinates your red cells, you are Rh+. If it doesn't, you are Rh-. Despite its actual genetic complexity, the inheritance of this trait usually can be predicted by a simple conceptual model in which there are two alleles, D and d (picture 1). Individuals who are homozygous dominant (DD) or heterozygous (Dd) are Rh+ (2,7). Those who are homozygous recessive (dd) are Rh-.

Clinically, the Rh factor, like ABO factors, can lead to serious medical complications. The greatest problem with the Rh group is not so much incompatibilities following transfusions (though they can occur) as those between a mother and her developing fetus. Mother – fetus incompatibility occurs when the mother is Rh- (dd) and the father is Rh+

(DD or Dd) (2,3). Maternal antibodies can cross the placenta and destroy fetal red blood cells. The risk increases with each pregnancy. Europeans are the most likely to have this problem-13% of their newborn babies are at risk. Actually only about ½ of these babies (6% of all European births) have complications. With preventive treatment, this number can be cut down even further. Less than 1% of those treated have trouble. However, Rh blood type incompatibility is still the leading cause of potentially fatal blood related problems of the newborn. In the United States, 1 out of 1000 babies are born with this condition.

Rh type mother-fetus incompatibility occurs only when an Rh+ man fathers a child with an Rh- mother. Since an Rh+ father can have either a DD or Dd genotype, there are 2 mating combinations possible:



Picture 1. A simple conceptual model of Rh inheritance

Only the Rh+ children (Dd) are likely to have medical complications. When both the mother and her fetus are Rh- (dd), the birth will be normal (2).

The first time an Rh- woman becomes pregnant, there usually are not incompatibility difficulties for her Rh+ fetus. However, the second and subsequent births are likely to have life-threatening problems. The risk increases with each birth. In order to understand why first born are normally safe and later children are not, it is necessary to understand some of the placenta's functions. Nutrients and the mother's antibodies regularly transfer across the placental boundary into the fetus, but her red blood cells usually do not (except in the case of an accidental rupture). Normally, anti-Rh+ antibodies do not exist in the first-time mother unless she has previously come in contact with Rh+ blood. Therefore, her antibodies are not likely to agglutinate the red blood cells of her Rh+ fetus.

Placental ruptures do occur normally at birth so that some fetal blood gets into the mother's system, stimulating the development of antibodies to Rh+ blood antigens. As little as one drop of fetal blood stimulates the production of large amounts of antibodies. When the next pregnancy occurs, a transfer of antibodies from the mother's system once again takes place across the placental boundary into the fetus. The anti-Rh+ antibodies that she now produces react with the fetal blood, causing many of its red cells to burst or agglutinate. As a result, the newborn baby may have a life-threatening anemia because of a lack of oxygen in the blood. The baby also usually is jaundiced, fevered, quite swollen, and has an enlarged liver and spleen. This condition is called erithroblastosis fetalis. The standard treatment in severe cases is immediate massive transfusions of Rh- blood into the baby with the simultaneous draining of the existing blood to flush out Rh+ antibodies from the mother. This is usually done immediately following birth, but it can be done to a fetus prior to birth. Later, the Rh- blood will be replaced naturally as the baby gradually produces its own Rh+ blood. Any residual anti-Rh+ antibodies from the mother will leave gradually as well because the baby does not produce them.

Erythroblastosis fetalis can be prevented for women at high risk by administering a serum containing anti-Rh+ antibodies into the mother around the 28th week of pregnancy and again within 72 hours after the delivery of an Rh+ baby. This must be done for the first and all subsequent pregnancies. The injected antibodies quickly agglutinate any fetal red cells as they enter the mother's blood, thereby preventing her from forming her own antibodies. The serum provides only a passive form of immunization and will shortly leave her blood stream. Therefore, she does not produce any long-lasting antibodies. This treatment can be 99% effective in preventing erythroblastosis fetalis. Rho-GAM is also routinely given to Rh- women after a miscarriage, anectopic pregnancy, or an induced abortion. Without the use of Rho-GAM, an Rh- woman is likely to produce larger amounts of Rh+ antibodies every time she becomes pregnant with an Rh+ baby because she is liable to come in contact with more Rh+ blood. Therefore, the risk of life-threatening erythroblastosis fetalis increases with each subsequent pregnancy.

Anti-Rh+ antibodies may be produced in an individual with Rh- blood as a result of receiving a mismatched blood transfusion. When this occurs, there is likely to be production of the antibodies throughout life. Once again, Rho-GAM can prevent this from happening.

Mother-fetus incompatibility problems can result with the ABO system also (5,6). However, they are very rare--less than 1% of births are affected and usually the symptoms are not as severe. It most commonly occurs when the mother is type O and her fetus is A, B, or AB. The symptoms in newborn babies are usually jaundice mild anemia, and elevated bilirubin levels.

2. Rh INCOMPATIBILITY AND SPEECH PATHOLOGY

Among the most common risk factors for the development of hearing, speech and language, is hyperbilirubinemia. It is the appearance of abnormal jaundice, when the blood of a newborn elevated bilirubin levels. It is less common than physiologic jaundice, but in recent years, marked increase in the number of infants with pathological jaundice. In these situations, the most widely used phototherapy (lighting naked child, placed in an incubator and protected the eyes, some blue wavelengths, which reduces the amount of bilirubin in the skin, and indirectly in the blood). In exceptional cases, when the bilirubin values over 300 mmol / L, applied exanguinotransfusion (replacement of blood of a newborn). These methods began to be applied beyond the 1940s. Namely, the patient would gradually, through an hour giving a small amount of fresh blood proper blood type and Rh factor and at the same time taking over patient's blood. That would eliminate a child's blood was full of bilirubin and red blood cells that were damaged mother acting protein - antibodies against the child's rate, and to give blood with no antibodies, so a reduced concentration of bilirubin and thereby to reduce the likely damage to the brain, and would be reduced and further damage to red blood cells. Of course, the implementation of exanguinotransfusion implement all measures of protection against infection and infection entering the bloodstream.

In hyperbilirubinemia, due to high concentrations of bilirubin in the blood, reduces the utilization of oxygen in brain cells, which result in permanent damage to the central nervous system. Forecast of the children depends on the concentration of bilirubin in the blood of the fetus, newborn gestational age, as well as the length of hyperbilirubinemia. Speech and language, as well as the most complex human psycho-physiological functions, are very susceptible to the negative effect of many risk factors. Because of the high degree of interdependence of hearing, speech and language, hearing loss always results in damage or complete lack of voice communication. The consequences of these actions pathological factors are manifested at a later age - from the speech period, to preschool and school age. And in terms of delayed speech and language and psychomotoric development, including the far-reaching consequences on the process of adoption of school skills, behavior and attention.

3. THE AIM OF THE RESEARCH

The aim of this paper is to examine and compare results of the influence of RH incompatibility of semantic development and verbal memory at children with exanguinotransfusion and children with proper speech and language development. The semantic test consist four subtests. Each subtest consists ten items. The tests offer only nouns. With these four subtests four categories of words are examined. These categories of words are homonyms (words of the same shape, but different meanings), antonyms (words of opposite meanings), synonyms (words with different shapes, and the same meaning) and metonyms (words transferred meaning). The verbal memory test consist 55 verbal stimuli, divided by weight into 6 subgroups requests (of syllables over disyllable meaningful, disyllable meaningless words, simple, extended to complex sentences). Test to assess verbal memory is used to examine verbal memory by the respondents were asked to give immediately repeated verbal stimulus. For delayed verbal memory test examiner need a stopwatch, as far as the first delay time of 16 seconds and the second time of 30 seconds. The candidate should remember the information that they had heard and then to repeat it.

3.1 The results of the research

The results of our research we found are shown in tables below. Tables show the level of semantic development in E and C groups.

In Table 1 we show the level of development of homonyms in both groups of respondents. Response was considered positive if the child specifies two or more examples for a given item. If the response was incomplete and contained only a single word, such a response is graded with + / -, while the negative response was considered absent if the answer is or is not correct. Children in E group had worse results than children in C group.

Table 1: The level of development of homonyms

	+	+/-	-
Experimental group	54.50%	27.30%	18.20%
Control group	69%	17.75%	13.25%

In Table 2 we show the level of development antonym in both groups of children. Response was considered positive if the child gave the correct answer for a given item. Otherwise, it was felt that the answer is incorrect. As in the previous case, the children with proper speech and language development have shown better results than children with exanguinotransfusion, provided that the difference was less significant than in the previous survey.

Table 2: The level of development of antonyms

	+	-
Experimental group	68.26%	31.74%
Control group	73.75%	26.25%

In Table 3 we show the level of development of synonyms in both groups of respondents. Response was considered positive if the child gave one correct answer to the offered item, and if the response was absent or incorrect it was graded as a negative response.

Table 3: The level of development of synonyms

	+	+/-	-
Experimental group	70.52%	5.26%	24.22%
Control group	78.75%	11%	10.25%

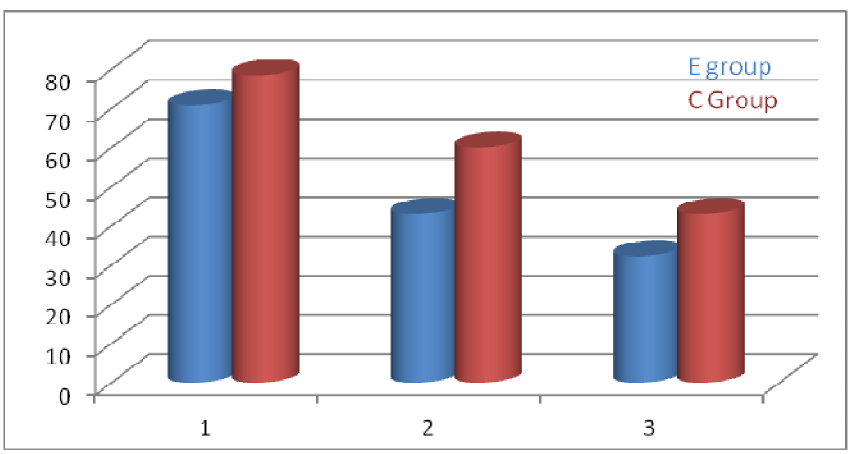
In Table 4 we show the level of development of metonyms in the experimental and control groups of subjects. Positive responses are evaluated if the child gave a correct answer for a given item, otherwise the event is considered that the answer is incorrect.

Table 4: The level of development of metonyms

	+	+/-	-
Experimental group	60.90%	5.92%	33.18%
Control group	72.75%	14.5%	12.75%

In graph no. 1 we show the results of verbal memory in E and C group. In immediately verbal memory(1), children from E group had 46 correct answers (70.76%) and the children form C group had 51 corect answers (78.46%). In delayed verbal memory for 16 seconds (2) children from E group had 28 correct answers (43.07%) and children from C group had 39 correct answers (60%). In delayed verbal memory for 30 seconds (3), children from E group had 21 correct answers (32.31%) and children from C group had 28 correct answers (43.07 %).

Graph 1: Results of immediately and delayed verbal memory



4. SUMMARY

The results of these studies indicate that a group of children with normal speech and language development showed a better result to all four tests than children with exanguinotransfusion. The most significant difference was present during the examination homonyms where the percentage of correct answers in the control group was higher by about 15%, as well as in research metonyms, where the percentage of correct answers in the control group was higher by about 12%. We also noticed that the percentage of incorrect responses in the control group compared to the experimental in all these tests was lower.

In verbal memory test, we saw that the children from E group had worse results in all three categories of verbal memory (immediately, delayed for 16 and 30 seconds) than children from C group. So, we can noticed that Rh incompatibility have influence in verbal memory at children.

From the aspect of speech pathology, all of the possible consequences of elevated bilirubins leads to the disintegration of the function of speech and language, requiring early and prompt intervention. Early detection of abnormalities and deviations from normal development, and taking appropriate preventive measures - can prevent the development of the disorder or disability of the child deepening.

Thanks to the plasticity of the central nervous system (CNS) to alter their structure and function under the influence of environmental stimulation, it is possible to its reorganization (4). The goal of preventive action and early treatment in KSAFA system that encourages the development of normal speech, language and motor skills, speech disturbances that would not have occurred or to prevent the occurrence of secondary effects.

Stimulation should enable all children pass through developmental stages of speech, the exact period of time. Beginning prelingual, to the development of speech and language structure. Audiolinguistic stimulation of the child should start before the sensitive period of development of these functions, because after that period, functional recovery is considerably smaller.

REFERENCES

1. Ivanka Antcic Furlan, Mira Barle, Mila Druzic (2004) Neonatal jaundice. Paediatr Croat 2004; 48 (Supl 1): 67-72

2. Davor Brinc and Alan H. Lazarus (2009) Mechanisms of anti-D action in the prevention of hemolytic disease of the fetus and newborn, American Society of Hematology, 185-191

3. Hiroshi Okuda, Eiji Kajii (2002) The evolution and formation of RH genes. Legal Medicine 4, 139–155

4. Thomas Lloyd (2005) Rh-factor incompatibility : A primer for prevention**.** Journal of Nurse – Midwifery, Volume 32, Issue 5, 297 – 307

5. Avent ND, Reid ME (2000) The Rh blood group system: a review. Blood ,95,375–387.

6. Strachan T, Read AP (1999) Human molecular genetics. 2nd ed.. New York, NY: Wiley–Liss

7. Cartron JP (1994) Defining the Rh blood group antigens. Biochemistry and molecular genetics. Blood Rev;8:199–212.

8. Daniels G. (1995) Rh blood group system: human blood groups. 1st ed.. Oxford: Blackwell Science

9. Kajii E. (1998)Advance in Rh blood group system. Jpn J Legal Med;52:1–18

LEXEMES AND PHRASES IN ASSOCIATIVE FREQUENCY DICTIONARY OF PRESCHOOL CHILDREN

NATAŠA ČABARKAPA[1], SAŠKA FATIĆ[2], IGOR BUZGANOVIĆ[3], ZORANA MILOSAVLJEVIC[4]
Institute for experimental phonetics and speech pathology[1, 2, 3, 4]
Life Advancement activities centre[1, 2, 3, 4]
natasadcabarkapa@gmail.com [1], faticsashka@gmail.com[2], buzganovic83@yahoo.com[3], vetricus@yahoo.com[4]

Abstract: Lexeme is a linguistic unit which presupposes all grammatical forms and all the meanings of a word, while the definition of the phrase is defined as a syntactic unit which is a group of words related to the meaning and function.

The object of our study is the characteristics of lexical phrases in associative-frequency vocabulary in children aged five to seven years.

The aim of our study was to examine the characteristics of lexical and grapheme in verbal associations and their maximum frequency, as well as gender and age differences between the experimental and control groups.

The study included two groups: 100 children with developmental dysphasia, which form the experimental group and 200 children with normal speech and language development, which consists of a control group. As a measuring instrument was used to test of associations by Natasha D. Cabarkapa consisting of 40 word stimulus.

The results show that children in both groups showed statistically significant differences in all forms of testing. Children in the control group (children of normal population) provide a higher percentage of loanwords and phrases in verbal associations, while the children in the experimental group (children with developmental dysphasia) associated to each word a lot longer to answer, among them are more frequent omission of speech, echolalias associative answers of conflict and on what basis it is concluded that the lexical and syntactic development of children with developmental dysphasia significantly different from children with normal speech and language status.

Keywords: *lexeme, phrase, verbal associations*, *children with development dysphasia, children with normal speech- language development*

1. INTRODUCTION

Association of word is defined as a connection between two or more words created by the associative law. More specifically, it can be said that the term means the occurrence whenever one word is spoken or thought, the other words occurring at the same time (or immediately following) in the mind of the speaker or the listener. Technique of free association of words based on the fact that the respondent is a word and then recorded his response, that is the first word that occurred to him in the mind after receiving stimulus-word (Gasic- Pavisic, 1984).

Distribution of free association on syntagmatic and paradigmatic were introduced by Jenkins and Saporta, in the fifties. According to these authors, paradigmatic associations are those in which the stimulus and response are common grammatical paradigm but syntagmatic associations are sequential elements, or at least elements that usually occupy different positions within phrases or sentences (Jenkins & Saporta, 1967).

Syntagmatic associations are an endless source of syntactic testing, distribution, phrasal features word-charm, while paradigmatic responses represent the majority of image semantic relationships in which the stimulus comes (Piper, 2005). Association research showed that the proportion of paradigmatic, syntagmatic responses depends on the grammatical word-class of stimuli. If such stimuli appear nouns, the reactions are often paradigmatic, and if the stimuli are contributions reactions will be syntagmatic. If the stimuli are verbs and adjectives, the reactions are syntagmatic and paradigmatic (Dragicevic, 2007).

Characteristics of the frequency distribution Associations: Generality, diversity and idiosyncracies. Diversity is the average number of different answers to one word - charm. Between generality and diversity there is generally a negative attitude: High generality of associations usually leads to a reduction in diversity of responses (Palermo, et al., 1963). Idiosyncracies of associations represents the average number of responses with a frequency in a given sample. This represents the ability of individual patients to provide original and unusual responses (Jenkins, et al., 1964).

Developmental dysphasia is a developmental speech and language disorder, which causes difficulty in understanding the production and correct use of grammatical forms which are manifested by disturbances in phonological and syntactic structure, morphophonology and derivation morphology and synthesis of linguistic sequences (Cabarkapa, et al., 2007).

For developmental dysphasia is characterized by occurrence of specific "pathological" patterns of expression, which does not occur in any of the stages of normal language development. For example, distortions and substitute of phonemes and words take shape paraphasias production, and they retain for a very long time in the language production of the children (Golubovic, 2006).

Dysphasic children have difficulty in learning polysyllabic words, the inability to cope with the total number of records within the same, and there is a tendency their reducing, example: bue instead of blue, or to their pronunciation only of initial or final syllables. The next level of difficulty are consonant clusters, where the childs, although have a voice, not able to use it in a set of consonant (Cabarkapa, et al., 2007).

Bugarski defined lexeme as a linguistic unit which presupposes all grammatical forms and all the meanings of a word (Stanojcic, et al., 1992).

Lexemes are connected syntagm and paradigmatic relations in a lexical system. Paradigmatic lexical relations are divided into one content, content-formal and formal (Sipka, 1998). While, according to some authors syntagmatic lexical relations called collocations (Dragicevic, 2010).

We believe that the results of the test of free association especially lexical and syntagmatic associations can contribute to better understanding of the speech and language development of preschool grows with developmental dysphasia.

The study of verbal association in children can be determined by the degree of cognitive and linguistic development. In this paper, the authors examine the similarities and differences of verbal associations in children with developmental dysphasia and children with normal speech and language status of children aged 5 to 7 years.

2. METHODOLOGY OF RESEARCH

The first aim of our study was to determine the incidence of paradigmatic and syntagmatic associations in children with developmental dysphasia, and second aim, to determine the effect of age and speech and language status on the characteristics and frequency of verbal associations. The third objective was to compare the incidence and characteristics of verbal associations between the control and experimental groups.

Based on these goals, we present the following hypothesis:

Paradigmatic and syntagmatic associations have a major presence in comparison to other types of associations.

There are differences in the frequency of particular verbal association in children of different ages.

The experimental group will have better results in the characteristics of association in relation to the control.

The sample, in which the survey was conducted, consisting of 100 children with developmental dysphasia and 200 children with normal speech - language development, aged 5 to 7 years old. The subjects were divided into four age groups so that the class interval is six months: 1) from 5 to 5.5 years old, and 2) from 5.6 to 5.11 years old, and 3) from 6 to 6.5 years old, and 4) from 6.6 to 7 yearsold. The age structure of the control and experimental groups were matched.

The gender architecture of the sample of this study is as follows: 32.0 percent were girls and 68.0 percent boys. We did not want to artificially leveraging pattern, but we felt it was right to sub-samples replicated real situation in a population. In previous studies performed in the last decade by us, the obtained results show that among children with dysphasia preschoolers a significantly higher percentage of boys than girls.

To assess associations among children in this study, we constructed a" Test Association for preschoolers "(Natasha D. Čabarkapa), which contains a 40-word stimuli, which were selected from a list of 500 word-association test stimuli in adults. The criteria for their selection were that the words-stimul are:

- Known children;
- Concrete and abstract meanings, represent main categories, which are close to children (body parts, food, activities, emotions, and so on.)
- The different types of words (nouns, adjectives, verbs);
- Subject to the order in which the maximum continuous avoided association.

The test is applied individually. Each child was given identical verbal instructions on how to test and to demand: "Tell me a word that first comes to mind when I say ...". The answer is recorded in the form and classified in the following categories:

1. no reply,
2 echolalia,
3 paradigmatic associations,
4 syntagmatic associations,
5 sentence and phrases,
6 other responses (neologisms).

All collected data were statistically analyzed, and then presented in tables and graphs.

3. RESULTS

All responses from the children of free associations test were classified into six categories

The first category (no answer) is omitted responses , that is, responses in which the children responded "do not know " . So those are the answers which do not indicate no association (omission of speech)

The second category is echolalia (responses that contained repeated word-stimulus or respondents on stimulus-word answered only the changed number grammatical category.

The third category is paradigmatic associations, that is answers with the word stimuli consisted of common - grammatical paradigm. Within this category, we distinguish the following subcategories: answers to word - stimuli are common grammatical paradigm ; answers with the word - stimuli are common grammatical paradigm coincide and grammatical categories, answers that the word - stimuli are common stand with certain grammatical paradigm hiperonimom ; answers with the word - stimuli are common grammatical paradigm with specific hyponyms ; answers with word - stimuli indicate common grammatical paradigm synonymous with outstanding ; answers with word - stimuli indicate common grammatical paradigm with defined antonym given in response to word - mellow; answers with word - stimuli indicate common grammatical paradigm with certain derivative given in response to a word - mellow; answers with word - stimuli indicate common grammatical paradigm with a certain diminutive of a given stimulus to give an answer to the question - charm , and responses that represent a different kind of word in relation to the word – stimulus

The fourth category is syntagmatic associations, that is responses that contain sequential elements representing stringing words without a precisely defined meaning and connection to the word-stimulus or belonging to the noun, verb or adjective phrase.

The fifth category includes responses that contain the dependent or independent-predicate sentence before and that followed the word-charm or within these types of sentences, along with other syntactic constituents, repeated word-appeal and thereby maintained or changed the grammatical category of number , gender, case and face. This category includes the subcategories of associations that make up the answers or parts of sentences are the usual phrases in everyday speech.

The sixth category consists of responses that were pointless and fictional (neologisms).

For our research are important third and fourth category of associative responses.

Of all the six categories of the most common types of associations in children with developmental dysphasia are syntagmatic associations and those occurring in 28.70 percent of the responses. Ranking second in frequency occupied by paradigmatic associations, which in the responses of children with dysphasia preschoolers occur with a frequency of 25.50 percent.

Table 1. Percentage incidence of certain types of associations

types of associations	frequency	Percentages
1) no answer	371	9.30 %
2) echolalia	594	14.80 %
3) paradigmatic associations	1019	25.50 %
4) syntagmatic associations	1147	28.70 %
5) association of sentence and phrases	743	18.60 %
6) other associations (neologisms)	126	3.10 %
In total:	4000	100.00 %

All other types of associations have frequencies less than 20 percent. Sentence associations and phrases take up a third-place ranking in order of frequency encountered in 18.60 percent of the responses of children with developmental dysphasia, and repeat word-stimuli present in 14.80 per cent of responses (fourth grade). Omission of speech and neologisms are present in less than 10 percent of responses. 9,30 percent response falls into the category of omission of speech (ranking fifth in frequency), and the lowest frequency (sixth-place ranking) have association of neologisms (3.10 percent).

The frequency of verbal lexemes in association with children, we have presented in the paradigmatic relations lexeme with word-stimuli.

Table 2. Percentage frequency of lexical association

Types of associations:	frequency	Percentages
paradigmatic	75	1.90 %
paradigmatic coordinated	490	12.20 %
Hiperonyms	70	1.70 %
Hyponyms	25	0.60 %
synonyms	112	2.80 %
antonyms	213	5.30 %
Paradigmatic derivation derived	14	0.40 %
Paradigmatic coordinated derivation, diminutive, augmentative	12	0.30 %
Paradigmatic total in:	1019	25.50 %

Association with the highest frequency of paradigmatic associations were coordinated paradigmatic associations. This is the second criterion in which we evaluated the answers that the word-stimulus paradigm consisted of common grammatical and who were matched in grammatical kategorijama. For example: on stimulus- word Think answer is To think, or think over.The second and third place are synonyms and antonyms.Paradigmatic associations have a minimum range of the responses to the stimulus-word "phone" (8 times), and maximum range of response to the stimulus-word "father" (55 times).

Table 3. Frequency of paradigmatic associations categories in relation to the age of the children

	paradigmatic associations		
age:	AM	SD	Number of children
1. group- 5 years old	7.68	4.75	28
2. group- 6 years old	10.78	8.08	27
3. group- 7 yeras old	11.40	5.63	45
t-test and significantly:	am1 : am2 => т = 1.74 (not significantly) am1 : am3 => т = 2.91 (level 0.01) am2 : am3 => т = 0.38 (not significantly)		

As for the factors age and paradigmatic associations shows that children aged five years on average give 7.68 paradigmatic associations, and children aged six years, on average, give 10.78 associations of this type, which is not statistically significant. Children of the oldest age (seven years) give 11:40 associations of this type on average, which is significantly higher frequency compared to the result for the youngest children (five years). The difference is significant at the 0,01 level (99 percent confidence). We concluded that children aged seven years, in response to the 40 stimulus-word, provide significantly more paradigmatic associations of children aged five years. The difference between the age group of six to seven years is not statistically significant.

It was found that between the variables age of children and number of paradigmatic associations there is a low positive correlation significant at 12,02 (correlation coefficient r = 0.25). This confirmed that the number of paradigmatic associations greater in older children, and vice versa.

Table 4. Percentage frequency of syntagmatic association

Types of associations:	frequency	Percentages
Syntagmatic (one word)	610	15.30 %
Syntagmatic (two or more words)	537	13.40 %
Syntagmatic total in:	1147	28.70 %

Syntagmatic associations are composed of two sub-categories with approximate percentages. But this association occupies the first place in frequency compared to the other categories of associative responses in children with developmental dysphasia.

Table 5. Frequency of syntagmatic associations categories in relation to the age of the children

	Santagmatic associations		
aget:	AM	SD	Broj dece
1. group- 5 years old	9.50	4.57	28
2. group- 6 years old	11.30	4.98	27
3. group- 7 years old	12.80	4.87	45
t- test i significantly:	am1 : am2 => т = 1.40 (not significantly) as1 : as3 => т = 2.88 (level 0.01) ac2 : ac3 => т = 1.26 (not significantly)		

Children aged five years on average give 9,50 syntagmatic associations , and children aged six years , on average, give 11:30 associations of this type, which is not statistically significant. Children of the oldest age (seven years) give 12.80 associations of this type on average, a significantly higher frequency compared to the result for the youngest children (five years). The difference is significant at the 0.01 level (99 percent confidence). We concluded that children aged seven years, in response to the 40 stimulis-word , provide significantly more syntagmatic association of children aged five years. The difference between the age group of six to seven years is not statistically significant.

t was found that betweenthe variables age of children and number of syntagmatic associations there is a low positive correlation significant at the 0.01 level (correlation coefficient r = 0,31). This confirmed that the number of syntagmatic association is higher in older children, and vice versa.

The minimum frequency of syntagmatic association is present in the word-stimulus "bad" (6 answers of this type), and the highest frequency was observed in the word "phone" (54 replies).

As for the most common types of words we find that :

- most of syntagmatic responses obtained for stimulus-words - nouns 31.39 % , that is on the stimulus-word, nouns were the most frequent syntagmatic responses .

- most paradigmatic responses was obtained for srimulus-word- adjectives 28.3% , that is on the stimulus-word, adjectives are the most frequent responses were paradigmatic.

The differences in the features of associative responses between the control and experimental groups are indicated by generality, diversity and idiosyncracies of verbal associations.

The generality of the association is expressed through the frequency of the primary response , and the frequency of the three most frequent answers. Based on the responses of 100 respondents 40 words from the test - stimulus associations (Association of 4000) , it was found that responses (associations) have the highest frequency of each stimulus-word.

The incidence of primary responses (association), for the entire sample, is 26.20 % , that is 1048 .associations. The average frequency of the three most frequent response (association , for the entire sample , is 50.78 percent, that is 2031 association.

Table No. 6 shows a comparison between the generality of free association in children with developmental dysphasia (data from our study) and children with normal speech and language development.

Table 6. Comparison of the generality of the association in children with dysphasia and children with normal speech and language development

	primary responses	The three most frequent responses
children with dysphasia	26.20 %	50.78 %
Children with normal speech and language development	23.02 %	39.52 %
The significance of differences	**Cr 3.78 (level 0.01)**	**Cr 11.84 (level 0.01)**

The free association of children diagnosed with dysphasia primary responses occur in 26.20 percent of cases, which is significantly more than the presence of the associations in the primary responses of children with normal speech and language development (23,02 per cent). The difference is significant at the 0.01 level, as indicated by the value of "cr ", which is the ratio of the difference between percentage and standard error of measurement of the difference between the percentage .

With 99 % confidence, we conclude that children with dysphasia give to 3,17% more primary responses in the free association of children with normal speech and language development .

The free association of children diagnosed with dysphasia , the three most frequent responses are present in 50.78% of cases (2031 association). This is a significantly higher percentage of the representation of the three most frequent responses in the association of children with normal speech and language development (39.52 percent). The difference is significant at the 0.01 level, and with 99 percent confidence, we conclude that children with dysphasia provide for 11,26% over the three most frequent responses in the free association of children with normal speech and language development at age five to seven years.

Thus, the generality of free word associations was significantly higher in preschool children diagnosed with dysphasia than their peers with normal speech and language development, and when it comes to the evaluation criteria "primary answer" when we consider the frequency of the three most frequent answers.

Diversity of association in the group of children with developmental dysphasia is 33.08 percent (1323 associations), which was significantly less than in the group of children with normal speech and language development (68.35 percent). The difference of 35.27% is significant at the 0.01 level, which indicates the reliability of the conclusion of 99% (Table 34).

Table 7. Comparison of the diversity of associations in children with dysphasia and children with normal speech and language development

	Diversity of associations:
children with dysphasia	33.08 %
Children with normal speech and language development	68.35 %
The significance of differences	**cr 39.28 (level 0.01)**

On this basis, we conclude that children with normal speech and language development provided significantly greater number of various free associations in relation to children with developmental dysphasia at the age of five to seven years.

he responses of children with developmental dysphasia idiosyncratic associations, or those that have a frequency, there are a total of 21.60% of the cases (864 associations). On the other hand, the percentage of idiosyncratic associations in children with normal speech and language development is 56.44%. The difference of 34.84% is significant at the 0.01 level, based on the finding that children with normal speech and language development provide significantly more idiosyncratic association of children with developmental dysphasia at the age of five to seven years (Table 8).

Table 8. Comparison of idiosyncracies associations in children with dysphasia and children with normal speech and language development

	idiosyncracies of associations
children with dysphasia	21.60 %
Children with normal speech and language development	56.44 %
The significance of differences	**cr = 41.33 (level 0.01)**

Thus, the universality of free associations (expressed in percentages and the primary responses and the percentages of the three most frequent response) was significantly higher in children with developmental dysphasia, and the diversity and idiosyncracies of free association significantly more present in children with normal speech and language development.

In addition, the differences in the variety of associations (35.27%) and idiosyncracies association (34.84%) are far greater than the differences related to the generality of the association (3.17% and 11,26%).

3. CONCLUSSION

Based on these results , their interpretation and analysis , make the following conclusions:

The most common types of associations in children with developmental dysphasia , ages 5 to 7 years, are the syntagmatic associations and those occurring in 28.70 per cent of their responses to the test of free association . Ranking second in frequency occupied by paradigmatic associations disappeared to be the answer children with dysphasia preschoolers occur with a frequency of 25.50 percent. All other types of associations have frequencies less of than 20 percent.

The frequency of a large number of paradigmatic responses for examples, stimulus-word father (dad, flower, mother) is due to expansion of the child's vocabulary and principles of selection that the child selects the appropriate word for a given stimulus from your vocabulary. This finding can be explained by the fact that the paradigmatic relations in the structure of the language are located on the axis of selection determined by the principle of similarity of any unit can be selected at any point of a statement. On the other hand syntagmatic relations are based on combinations of axes which assumes stacking selected units, children gave answers that reflect their primary meaning of the stimulus-word. For example, on the stimulus- word phone children gave the answer ring. Answers by type phrases and sentences were put into one category because of their low frequency in cildren responses. For example, on the srtimulus-word life, children gave the answers: to live life , life is good and phrases : to live in, is beautiful, it can explain by the child's understanding of the proposed stimulus , and gives an answer that is a reproduction of what it is without understanding the same sense in their environment.

Our results clearly show that the type of free association is largely dependent on the type of stimulus-word. So most of the omission and neologisms response occurs in words-the types of stimuli words adjectives which can be explained by the developmental sequence for the adoption of deeper structure of the language syntax-lexical and grammatical-free word associations, which is development of the speech-language structure directly affects the level of free association.

It was found that there are significant differences in the frequency of free associations in children with developmental dysphasia different ages.

The frequency of lexemes and phrases in associative responses increased with age, but they were very small movements which did not show statistical significance. The frequency of free associations of the omission, echolalia and neologisms significantly reduced in older children, and the frequency of paradigmatic, syntagmatic association and sentence and phrase, increases with increasing age children with developmental dysphasia.

Characteristics of the association between the control and experimental groups are in favor of the control group. Thus, the universality of free associations (expressed in percentages and the primary responses and the percentages of the three most frequent responses) was significantly higher in children with developmental dysphasia, and the diversity and idiosyncrasies of free association significantly more present in children with normal speech and language development.

The practical importance of this test and associative vocabulary consists of identifying the level of development of grammatical categories child with dysphasia to discover semantic content of the field that some words have for children with developmental dysphasia, as well as elements of meaning and mutual organization of these elements for the given word. . Looking associative vocabulary, we concluded that the dysphasic child busiest word "creature” and that she has a very extensive semantic field as it emerged in response to each of the word - stimuli from the test of verbal associations. These data are a good basis for designing therapeutic exercise programs and methodology for working with children dysphasia. Test of verbal association allows us to understand what the linguistic behavior of the respondents, if there are certain regularities in the behavior and the nature of their linguistic relationships. The research will allow the improvement of early habitation and rehabilitation treatment with KSAFA m - device, which is used at the Institute for Experimental Phonetics and Speech Pathology, within KSAFA system in the treatment of dysphasic children .

Verbal associations can be used for diagnostic purposes and can greatly help to establish a process automation excitation , determining and monitoring the different level of verbal communication , given that these children have insufficient capability and inadequate communication verbal language development . Verbal associations can be used for diagnostic purposes and can greatly help to establish a process automation excitation, determining and monitoring the different level of verbal communication, given that these children have insufficient capability and inadequate communication verbal language development.

REFERENCES

Cabarkapa , N., Punisic , S. Subotic , M., & Covic , B. (2007). The frequency of free association of children with developmental dysphasia , *Pedagogy*, 3: 453-458 , ISSN 0031-3807 , Belgrade.

Cabarkapa, N., Punisic , S. Subotic , M., & Covic , B. (2007). Free association frequency in children with dysphasia and children with normal speech and language development in preschool children , *Belgrade special schools* 1/2007 , 91-98 , ISSN 0354-8759 , Belgrade.

Golubovic , S. (2006). Differential diagnostic specificity and accuracy in the assessment of children with Disabilities and mental disabilities . *International scientific and professional meeting, rehabilitation-* Rijeka, Hotel Savoy, 12-13. October / October Book of Abstracts, p . 9 Proceedings, p. 24-45 .

Dragicevic, R. (2010). *Lexicology of Serbian language*. Belgrade: Institute for Textbooks

Dragicevic , R. (2005). Associative Dictionaries Slavic language in semantic research, *Institute and Experimental Phonetics and Speech Pathology*, Belgrade.

Gasic - Pavišić, S. (1984): Associative norms for preschoolers , Institute for Educational Research , education, Belgrade

Jenkins , J. , & Saporta , S. (1967). Psycholinguistics and communication theory. In F. E. X. Dance (Ed.*) , Human Communication Theory* . New York: Holt , Rinehart , & Winston , pp . 160-201 .

Jenkins, J., & Palermo, D. (1964). A Note of Scoring Word Association Test. *Journal of Verbal Learning and Verbal Behavior*, 3, p 158-160.

Palermo, D. & Jenkins, J. (1963). Frequency of Responses to super ordinate a Word Association Test as a Function of Age, *Journal of Verbal Learning and Verbal Behavio*r, p. 378-383.

Rod, D. (1998). *Fundamentals of lexicology and related disciplines*, Novi Sad: Matica Srpska

Stanojcic, Z. , & Popovic , Lj . (1992). *Grammar Serbian language I, II, III, IV year of high school*. Belgrade-Novi Sad: Institute for textbooks and teaching aids , Institute for Textbooks

THE INFLUENCE OF EARLY COMMUNICATION ON CHILD DEVELOPMENT AND LEARNING

MARIJANA RAKONJAC[1,2] LJILJANA DOBRIJEVIĆ[1,2]
[1]Institute for experimental phonetics and speech pathology, Belgrade, Serbia
[2]Life activities advancement center, Belgrade, Serbia

Abstract. To find out what causes the communication and language disorders in some children, it is of an invaluable importance to understand early learning process and to sudy recent studies of early communication development. Normal development of preverbal communication positively affects subsequent normal speech - language development. Preverbal and verbal communication, in addition to be able to fulfill social needs, are also the foundation of learning, cognitive and social development of the child. In order to avoid developmental problems and decrease parental uncertainty as well as prevent further disturbances and recognize the disorder at a proper time with providing adequate therapy, it is crucial to understand the early predictors of speech-language disorders. There are four variables that have predictive validity for later language development: babbling, development of joint attention, lexical comprehension and combinatorial-symbolic play.
This paper discusses the counseling and prevention programs which aim is to help parents in optimization the factors that influence the encouraging of communication development of their child.

Key words: early learning process, preverbal communication, early predictor of speech and language disorders

1.INTRODUCTION

An adequate development of preverbal communication positively affects at later normal speech - language development. Preverbal and verbal communication, in addition to provide satisfying social needs, are also the foundation of learning and cognitive and social development of the child. In order to avoid developmental problems, it is necessary to existence of counseling and prevention programs to help parents to optimize the conditions for encouraging communication development in their child.

1.1 IMPORTANCE OF EARLY COMMUNICATIONS

The period of early communication, which is divided in preverbal and early verbal communication refers to the period from birth to about six years of age. The transition from non-verbal to verbal communication is achieved gradually, from the first word in the second year of life, a child with delays in development for several years. This period in the development of verbal communication is called the transitional period (Golinkoff, 1983). The appearance of the child consolidates his attention to adult care in the same case and found a way to direct the attention of the adult to the desired object, and thus the child becomes mature enough to experience the other as intentionally being. The results show that these changes occur between the ages of 8 - 12 months. Messages that emits a child in period of preintensed communication, are the result of his physical and mental condition, and parents react to them as intentionally communicative signals, although they actually are not. During the second half of the first year of life the child begins to realize that he can manipulate others to transmit their intentions. Means of communication used by the child during the preverbal communication to express their communicative intentions gesture, vocalization and first words. Fifteen month child will, pointing to a particular case, a view to check that the other and gain the interest of a particular word or intonation require the subject, while for the example nine months child will just stretch their hands to the desired object and vote to express dissatisfaction.

Child's learning is optimal when parents adequately stimulate their child. If a parent and child to enjoy their interaction, and if the child's parents pay full attention, react to his message, and do not show any signs of pressure and stress, encourage the child appropriate to his developmental level and needs. Ideally stimulating environment parents intuitively pay their child a voice that is higher, serves a number of repetitions, pauses and gestures, and emphasize certain words, speak slowly and clearly, and all of this takes place with the optimal alignment with the needs of the child.

In contrast, stimulation of the child may be excessively or insufficiently. There may be a variety of problems in the interaction between child and parent, as a consequence of interaction disturbances. In today's generation of young parents more prevalent insecurity and state of increased stress which contributes greatly to communication difficulties in the parent and a small child (Mechthild Papoušek, 1999).. The negative factor is the intent of the parents to carry all perfect and have complete control over the child. This behavior stems from a lack of experience with young children. Circumstances such as a permanent state of uncertainty and mental stress threaten stronger in dealing with the child in the preverbal period and its needs.

Verbal communication is based on the accumulation of cognitive skills achieved in predverbalnoj communication. In the period of early child verbal communication combines words and uses short simple sentences. Ability to combine words and gradually adopt the mother tongue proves that the child observes and understands all the complex relationships between objects and events in the surrounding area. Analysis of a large number of studies concluded that there are certain things that may sugests later language development . Many parents are confused and feel helpless when they notice some differences in language development compared to other children because they do not know whether a particular problem disappear over time or is it a warning to the difference that would be more permanent in nature. To reduce parental uncertainty , prevent further disturbances at the time recognized the disorder and provide timely therapy , it is crucial to understanding the early predictors of language - speech disorder. McCathren, Warren and Yoder (1996) cites four variables that have predictive significance for the later language development: babbling, the development of joint attention, lexical comprehension and combinatorial and symbolic play. Delayed appearance of babbling ie. canonical vote, are alerting sign for later speech - language development (Oller et al, 1999).. Oller et al (Oller et al 1995, 1998, 1999). has researched the development of vocalization phonatory to the stage of babbling. Stages of development is divided on phonatory, which lasts from birth to 2 month in which the child's voting and false glotals ; primitive articulation stage, which covers the period from 2 to 4 m. which the child cooing; stadium expansion which covers the period from 4 to 7 m. and it marks the appearance of vowels and marginal babbling, and at the end of stage of babbling, which runs from 7 d. 10th m. and is characterized by well-formed syllables. The phonetic stage of a child has a passive vocal tract during the production of false glotals, ie. without positioning the tongue, lips and design of resonant space. In contrast, primitive stage of articulation child cooing, and when it is active supraglotal tract. In the expansion phase, there is a similarity with real vocals . It has been shown that the appearance of a real chatter is highly dependent on environmental factors. Great role in creating conditions for language development have the parents when respond to the babbling as an words attributing meaning to them.In prelinguistic period is not easy to predict later language development for parents of subjective data. Therefore it is better to give your parents, or provide an answer, and not seek to formulate themselves. It should be explained to parents the difference between situational and linguistic understanding, because the only language understanding predictive of later language development. Children who did not understand certain lexical models had the least progress in expresive dictionary.

Symbolic play is during the second year of life and is characterized by the fact that a child takes a case that would indicate otherwise, eg. sheet of paper can be a plate. Combinatorial game kid puts objects in certain relations, for example. placing the doll in the car. Symbolic play develop skills that are essential for language acquisition. Studies have shown that combinatorial play and language development in correlated. If a child enters the early phase combinatorial games, usually earlier start to talk (Bloom, 1993).

The level of development of pragmatics in children is the result of its linguistic, cognitive, and social skills. In the analysis of use of language in a social environment should consider the development of communications functions in the child, answering correspondence and changing roles in the conversation (Dewart, Summars, 1995). Learning the model of verbal communication greatly affects the development of pragmatics in children. During the period of preverbal communication, when the child is not yet walking, holding and carrying in the arms allows more face to face interaction with the parent. The child begins to learn communication contact, or change of the role of communication (Child vocalise and parent vocalise). In the early verbal conversation, pragmatic skills are still underdeveloped, and therefore break during a speech in the child long. For this reason, it is important to patiently allow the child to say what he was up to. To encourage children in the pragmatic skills, should have adequate knowledge of the child's develop.

1.2. THE ROLE OF COMMUNICATION IN EARLY CHILD DEVELOPMENTMENTAL CHARACTERISTICS

In order to the child emotionally develops normally, you need a strong emotional relationship between the child and the person, usually the mother, who has a stable and protective of the child. These actions lead to the development loyalty, which is reflected as a separation fear of the unknown persons in the transition from the first to the second year of life. Difficulties in establishing regulation between children and parents in infancy may have lead to the so-called . regulatory disorders. The information about in what conditions of life can come to such forms of interference is very contradictory because aside to poor countries in which these disturbances occur most frequentl, these are present also in developed countries. The problem actually lies in psychosocial stresses the increasing number of today's families. Therefore, it is necessary to inform the society about the importance of quality early interactions to prevent later behavior disorders.

Regulatory disorder, which is also known as disorder of early interactions, marked by excessive crying and sleeping and feeding disorders without organic cause and thus hinders the child's first year of life. When a child is deprived of communication, there is the learning behavior of appropriate age and the child's socialization. If the during does not intervene and does nothing to implement such problems, the situation is getting worse, a child often expresses defiance and anger, and there sulting "sticking" to the parents. Adherence is crucial for a child shown interest in exploring the environment. A child in himself has a tendency for new ideas and explore their possibilities which is encouraged by preverbal communication and adequate relationship of the child and the parents in their daily activities. Child needs encouragement from the environment to spread their knowledge. At maturation the child's cognitive processes affect parents if they are willing to manipulation by the child, if the child is motivated to act independently and imitating child and encourage him to it imitates them (Papoušek et al. 1990). With the advent of babbling in the child's parents slowing down speaking pace and introduce various music - rhythm games, and the first appearance of words simplifying syntax, choosing clear, the most common words, and such stimulation are a major step towards the development of cognition and language in the child.

2. CONSLUSION

Language acquisition occurs in the period of preverbal communication, whose developmental marks have great influence on later language development. There are differences among children in the levels of of development of communication as a result of unequal stimulation of children in preverbal communication. Wider public is not yet known the importance of preverbal communication development on verbal communication, so the society should be informed about the need for prevention and the importance of preverbal communication in order to facilitate the early child therapy

REFERENCES

1. Bloom, L. (1993). *The transition from infancy to language: Acquiring the power of expression*. New York: Cambridge University Press. Recipient of the Eleanor E. Maccoby Book Award, Division 7, Developmental Psychology, American Psychological Association
2. Dewart, H. and Summers, S. (1995). *The pragmatics profile of everyday communication skills in children* (Rev. ed.).
3. Golinkoff, R. M. (Ed.) (1983). *The transition from prelinguistic to linguistic communication*. Hillsdale, NJ: Lawrence Erlbaum Associates.
4. McCathren, R. B., Warren, S., & Yoder, P. J. (1996). Prelinguistic predictors of later language development. In K. Cole, P. Dale, & D. Thal (Eds.), *Assessment of communication and language* (Vol. 6, pp. 57-76). Baltimore, MD: Paul H. Brookes.
5. Mechthild Papoušek. *Sozialpädiatrie: Kinder- und Jugendheilkunde/Social Pediatrics*, 1999, *5-6*, 192-194.
6. Oller, D. K. (1995). Development of vocalizations in infancy. In H. Winitz (Ed.), Human communication and its disorders: a review, volume IV. Timonium, MD: York Press, Inc, 1-30.
7. Oller, D. K., Levine, S., Eilers, R. E., & Pearson, B.Z. (1998). Vocal Precursors to Linguistic Communication: How Babbling is Connected to Meaningful Speech. In R. Paul (Ed.), The Speech/Language Connection, Paul H. Brookes, Pub., Baltimore (pp. 1-23).
8. Oller, D. K., Eilers, R. E., Neal, A. R., & Schwartz, H. K. (1999). Precursors to speech in infancy: the prediction of speech and language disorders. *Journal ofCommunication Disorders, 32,* 223-245
9. Papoušek, M., Borstein,M.,H., Nuzzo, C., Papoušek,H., Symmes, D.,(1990) Infant responses to prototypical melodic contours in parental speech. *Infant Behaviour and Development,13,539-545.*

UTICAJ RANE KOMUNIKACIJE NA UČENJE I RAZVOJ DETETA

Marijana Rakonjac[1,2] Ljiljana Dobrijević[1,2]

[1]*Institute for experimental phonetics and speech pathology, Belgrade, Serbia*

[2]*Life activities advancement center, Belgrade, Serbia*

Apstrakt. Da bi saznali kako i zbog čega dolazi do komunikacijskih i jezičkih poremećaja kod neke dece, od neprocenjive je važnosti razumevanje ranih procesa učenja i praćenje novijih istraživanja ranog komunikacijskog razvoja. Uredni razvoj preverbalne komunikacije pozitivno utiče na kasniji uredan govorno – jezični razvoj. Preverbalna i verbalna komunikacija, osim što omogućavaju zadovoljavanje socijalnih potreba, takođe su i temelj učenju, te kognitivnom i socijalnom razvoju deteta. Kako bi se izbegli razvojni problemi, smanjila se roditeljska neizvesnost, sprečile dodatne smetnje, na vreme prepoznao poremećaj i omogućila pravovremena terapija, od presudne je važnosti poznavanje ranih prediktora jezično – govornih poremećaja. Postoje četiri varijable koje imaju predikcijsku valjanost za kasniji jezični razvoj: brbljanje, r Nužno je postojanje savetodavnih i preventivnih programa koji bi pomogli roditeljima u optimiziranju faktora koji utiču na podsticanje komunikacijskog razvoja kod njihovog deteta.

Ključne reči: rano učenje, preverbalna komuikacija, rani prediktori govorno-jezičkih poremećaja

GRAPHOMOTOR SKILLS OF CHILDERN WHO STUTTER

NINA STANOJEVIC[1], MARINA RANDJELOVIC[1]
[1]Institut for experimental phonetics and speech pathology 'Djiordje Kostic'
Belgrade, Serbia
ninastanojevic88@gmail.com

Abstract. Graphomotor ability requires the development of complex perceptual-motor abilities that depend on the maturity of the brain and the integration of higher cognitive, perceptual and motor abilities. Production of fluent speech is based on linguistic and motor programming and neural signals that initiate execution of motor movements. Given that speech involves coordination of sequential movements of speech organs and as people who stutter have a problem with this ability, this implies a examination of their abilities related to other motor movements such as precise hand movements.
The aim of this study was to investigate and analyze graphomotor skills of children who stutter.
The study sample consisted of N = 10 children who stutter, ages 6 to 11 years who are receiving treatment at the Institute for Experimental Phonetics and Speech Pathology "Djordje Kostic '. For the evaluation of graphomotor skills of these children subtests of Acadia test development skills were used: subtest 2-Visual-motor coordination, subtest 4-Draw shapes
The results suggest that the graphomotor skills of the children in our sample are lower than expected for their chronological age.
Keywords: stuttering, graphomotor skills, visual-motor coordination

INTRODUCTION

Stuttering is a fluency disorder that occurs in early childhood. It is most commonly defined as a disorder of speech fluency due to spastic blockage of speech organs, involuntary termination of speaking course, speaking obstruction of breathing and phonation, repetition and extension of the votes and syllables (S. Golubovic, 1997, 2000).

In the literature we can find different definitions of stuttering made by different disciplines experts. Stuttering is studied by experts in field of speech pathology, medicine, psychology, etc.

According to the World Health Organization (1992) stuttering is a speech rhythm abnormality in which a person who stutters knows exactly what he wants to say but is in that moment unable to express it due to involuntary extension or repetition of sounds (Yaruss, Quesal 2004, according Stevovic, Golubovic 2004).

Maguire (2012) states that stuttering is a multifactor speech disorder that is often characterized by prolongation, repetition or blockage in pronunciation of votes or syllables, and that is common disorder that affects about 1% of the adult population.

The most common form of stuttering is developmental stuttering, which begins in childhood. 80-90% of developmental stuttering starts by the age of six and affects about 5% of children. Rare cases of acute stuttering is happening and begin in adulthood, but are associated with secondary cases like the intake of certain drugs, brain trauma or stroke. In approximately 60% of children who stutter symptoms are withdrawn by the age of 16. But in many cases, stuttering continues into adulthood, and bearing in mind the importance of communication for the development of the child treatment for children who stutter require timely response.

Studies on this issue conducted in different countries during the 20th century have clearly established that in most cases stuttering occurred in childhood, especially in early period, sometimes even before 18 months of age (Darley, 1955 and Yairi, 1983).

The primary symptoms of stuttering is often referred to motor problems, or disruption of fluent speech flow as a result of the inability of the nervous system to by the generation of adequate signal lead the muscles that participate in speech. There are theories that about motor problem in stuttering are saying that it is a consequence of the basic deficit of the linguistic processing. (Smith et al, 2012.)

In adults who stutter there were recorded abnormal structural and function brain activity during speech compared with fluent control group subjects (Cykowski et al., 2008 and Sommer et al., 2002). Neural brain research methods revealed an increased activation of the right hemisphere or bilateral activation of speech-language areas and the cerebellum (Brown et al., 1997, De Nil et al., 2000, Fox et al., 1996, Fox et al., 2000, Ingham et al., 2000 and Ingham et al., 2004), and reduced activation of the auditory regions (Brown et al., 1997, Fox et al., 1996 and Ingham et al., 2000) in people who stutter compared to fluent respondents. Imaging studies have also provided evidence linking speech and manual motor systems on corticar level (eg Floel, Alger, and Brajtenstajn Kneht, 2003 Meister et al, 2003).

Production of fluent speech is based on linguistic and motor programming and neural signals that initiate initiate motor movements. Motor control represents coordinated and precices movements who are planned and commanded by the CNS and it depends on the interaction between the individual, the task and the environment and is the result of perception, cognition and 'action' system. Since the speech is dynamic process of motor function it requires a highly synchronized and adaptive neural network activity in order to function without interruption.

Motor control of movement depends on the interaction between the individual, the task and the environment and is the result of perception, cognition and 'action' system.

Many studies have been conducted using various manual movements to study differences in coordination between people who stutter and people who do not stutter. Zelaznik et al. (1994) reports that people who stutter have lower scores on tests of coordination than people who do not stutter. They also conclude that the performance on tasks that are similar to speech involving multiple systems and multiple-precision require a greater challenge for people who stutter than those who do not stutter. The selected task is typing as it is assumed that it requires precision and coordination. Thus, the difficulties that individuals who stutter encounter in tasks are expected and performance of this group can be characterized by reduced coordination and precision with reduced effects of hemispheric dominance (Zelaznik HN, Smith A, Franz EA, 1994)

Graphomotor skills as praxis ability is a directed voluntary activity in the field of hand movement. It represents fine motor skills, and the ability to make small precise hand movements while maintaining good coordination between the fingers and eyes. Graphomotor skill requires the development of complex perceptual-motor abilities that depend on the maturity of the brain and higher integration of cognitive, perceptual and motor abilities. Given that speech involves coordination of sequential movements of speech organs and that people who stutter have a problem just with this ability, this implies a test of their ability related to other motor movements and precise hand movements.

METHODOLOGY

The study sample consisted of N = 10 children who stutter, ages 6 to 11 years who are receiving treatment at the Institute for Experimental Phonetics and Speech Pathology "Djordje Kostic '. Sex ratio is only the N = 1 is female respondents, N = 9 are male respondents.

For the evaluation of graphomotor skills of these children there were used subtests of Acadia test for development skills: subtest number 2 - visual-motor coordination and ability to track and subtest number 4 - Drawing shapes. Each subtest of Acadia test measure some aspect of the evolving capacities of children, which are required for successful curriculum material. In the test, there are tables which help each subtest receive a number of standardized scores in relation to chronological age and the number of points scored. Each standardized score have its arithmetic mean and standard deviation, which helps to determine whether the child's abilities are in accordance with the age or a certain number of standard deviations below or above age.

Subtest of 2 – Visual-motor coordination and ability to track examines the child's ability to follow with a pencil a line between the lines or to complete the shapes. What is important for fine motor expression is eye and hand coordination and also the control of small muscle groups. Subtest number 4 - Drawing shapes examines the ability of a replicates shapes of varying complexity which requires the control of small muscle groups, as well as visual perception.

RESULTS

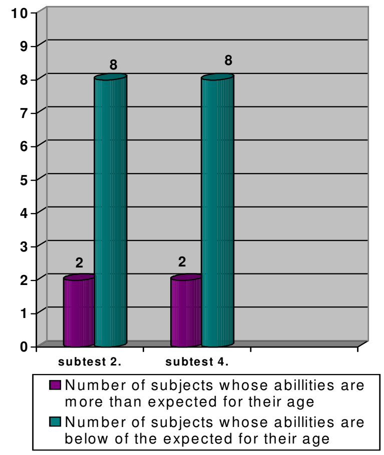
The results of subtest 2 given in Table 1 show that only N = 2 subjects achieved scores indicating that their ability is higher than expected for their chronological age, and that they are two standard deviations above the expected level for their age. Achievement of other N = 8 subjects shows that they are fit for 2 or more standard deviations below age. We can also notice that the two youngest subjects achieved the best results, while the two oldest recorded the worst results, and their skills are up to 6 standard deviations below expected for tha age. Problem number 4 none of the respondents successfully completed, and at the task number 3 only N = 1 respondent made a point.

Table 1 Showing subjects, achieved points and standard deviations

Examinee	Age	Subtest 2.		Subtest 4.	
		Number of points	Number of standard deviations from the age	Number of points	Number of standard deviations from the age
No 1	6y and 1m	4	+2	2	-1
No 2	6y and 4m	4	+2	4	+2
No 3	7y	3	-2	2	-3
No 4	7y and 3m	3	-2	3	-6
No 5	8y and 7m	10	-2	9	-2
No 6	10y and 9m	8	-5	11	-2
No 7	10y and 11m	11	-2	5	-5
No 8	11y and 8m	11	-5	11	-2
No 9	11y and 11m.	9	-6	14	2+
No 10	12y and 2m	6	-6	12	-1

Results of subtests 4 showed that only N=2 subjects achieved scores that indicate that their skills measured by this test are higher than expected for their age, and 2 standard deviations above age. Respondents were most successful at problem 3 where they were asked to copy a shape of a cross. This task is not effectively resolved only by respondents under the age of 7, and only by N=2 subjects. Problem number 5 (replicate equilateral triangle), 11 (replicate geometric shapes, which consists of two squares and a circle) and 12 (replicate cube) has been successfully solved by only one respondent. Problem number 14 in which the respondents were asked to replicate a geometric shape composed of two equilateral triangles and one rectangle no respondent successfully completed.

Chart 1 Number of subjects according to achieved results



When comparing the results of the subtests we can see that the N=4 subjects achieved higher scores on the subtest number 2, while also N=4 achieved higher scores on the subtest number 4. For N=2 subjects number of standard deviations in relation to age is the same for both subtests and is 2 standard deviations below the expected for the age of the one subject, or higher than expected for the age of the other subject.

CONCLUSION

Based on these results we conclude that the graphomotor skills of children who stutter from the sample is below expected for age.

By analyzing the results we can see that children who stutter have higher ability of visual-motor coordination compared to chronological age developed at a younger age, which is the implication for further research that would further examine the development of this ability of children who stutter.

REFERENCES

Golubovic S. Poremecaji fluentnosti govora, Drustvo defektologa Srbije, 2007, Beograd

Liotti M et al. Spatiotemporal dynamics of speech sound perception in chronic developmental stuttering, Brain and Language, Volume 115, Issue 2, November 2010, Pages 141–147

Maguire GA, Yeh CY, Ito BS. Overview of the Diagnosis and Treatment of Stuttering, Journal of Experimental & Clinical Medicine, Volume 4, Issue 2, April 2012, Pages 92–97

Smith A et al. Language and motor abilities of preschool children who stutter: Evidence from behavioral and kinematic indices of nonword repetition performance, Journal of Fluency Disorders, Volume 37, Issue 4, December 2012, Pages 344–358

Stevovic N. Znacaj i uspesnost tehnike pasivnog izdaha u primeni KSAFA metode u terapiji mucanja, Poremecaji verbalne komunikacije, str: 384-398, 2007, Beograd

Zelaznik HN, Smith A, Franz EA. Motor Performance of Stutterers and Nonstutterers on Timing and Force Control Tasks, US National Library of Medicine National Institutes of Health, 2004, 26(4):340-347

Webster, William G. Motor performance of stutterers: A search for mechanisms, Journal of Motor Behavior, Vol 22(4), Dec 1990, 553-571

Yairi E, Ambrose N. Epidemiology of stuttering: 21st century advances, Journal of Fluency Disorders, Volume 38, Issue 2, June 2013, Pages 66–87