THE INFLUENCE OF MUSICAL NOISE, TYPE MAJOR AND MINOR CHORD, TO THE INTELLIGIBILITY OF SPEECH IN SERBIAN LANGUAGE

Dijana Kostić, Zoran Milivojević, Zoran Veličković
College of Applied Technical Sciences of Nis, Serbia

Darko Brodić
University of Belgrade, Technical Faculty in Bor, Serbia

Abstract

The paper presents results of influence musical noise type major and minor chords, on the intelligibility of speech in Serbian language. First part of the paper describes experiment implemented on the test group, people with normal hearing. Material for testing was taken from Serbian Matrix Sentence Test, degraded with a chord, major or minor. Such generated speech signal, for values of parameter SNR = {0, -2, -5, -10} dB, was reproduced to the subject tested using the MOS test. Second part of paper present results in graphical and tabular form, and their analysis. Based on comparative analysis with Gaussian, Babble noise and the International Standard IEC 60268-16, it was brought the conclusion of the speech intelligibility.

Keywords: *Musical noise, Matrix Sentences Test, Intelligibility, major, minor*.

1. INTRODUCTION

For the proposed to predict speech intelligibility in the presence of background noise it was developed numbers of measures.

Speech audiometric has a different kind of test of speech intelligibility. Testing normal hearing subject with the short sentence with fixed syntax structure, in quit and noise, is the one of standard procedure across different language: Swedish [1], Spanish [2], Russian [3], Serbian [4]... The matrix sentence test has a big lead over Plomb sentence [5], because there are not predictable and every time sentence is a different (one of 100000). In this way one subject can be tested few times.

The measure of intelligibility is a Speech Intelligibility Index (SII), expressed in percentage in range from 0÷100%, where is 0% absolute unintelligibility and 100% absolute intelligibility. There are two methods which is use to determinate the Speech Intelligibility Index: objective and subjective.

An objective method involves assessment parameter: Articulation index (AI) [6], Speech Transmission Index (STI) [7], Speech intelligibility index (SII) [6].

Subjective method use Mean Opinion Score (MOS) test, open and close type, where is the listener the measure of all intelligibility. Close type of MOS test have offer answer and tested subject choose one, which he think is right. This type of test is used for Modified Rhyme Test [8] and Diagnostic Rhyme Test [9]. Open MOS test is using for the testing with the phonetically balanced word, logatom (balanced word without meaning) [10], [11], and sentences (every day sentence [5] and matrix sentence [1] ÷ [4]). For this kind of test we must form test group from the appropriated subject. Test group can be formed from: people with impaired or people with undamaged hear.

Authors of this paper wanted to determinate does and how musical noise, as chord (major and minor) has the influence on the speech intelligibility. In this purpose it was implemented experiment from few steps: a). formed base of clean signal, b). base of musical noise and c) test group.

In the paper [12] results show intensive reaction nervous system170ms after the onset of incoming signal. The induced gamma activity was significantly increased while listening to consonant chords as compared to dissonant chords.

2. EXPOSITION

The paper [12] presents the experiment in which registration of brain activity was performed in the conditions of listening to chords played on piano. Registering these activities was using electrode on head tested subject. This method is known as electroencephalogram – EEG. Brain waves that were analyzed occur at a high concentration stage in range from 30÷60 Hz. The experiment has shown that there is an intense brain reaction after the stimulated with a musical signal.

3. EXPERIMENTAL RESULTS AND ANALYSES

In this section in will be presented steps of experiment procedure, represented the results and given the analysis of results.

3.1. Experiment

In order to determine the impact of musical noise through chords of major and minor, interpreted on the piano and accordion, on the intelligibility of speech it was implemented experiment consisting of several stages was performed.

First the bases were formed: a). speech signal obtained with the help of the computer from the Serbian Matrix Sentence Test (SMST) database, b). base of the musical noise type major and minor chord and c) tested group.

The Fig 1. are represented the model of the experiment.

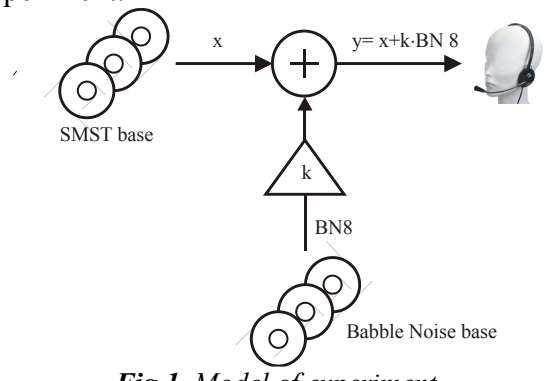


Fig 1. *Model of experiment*

Signal x represent speech signal generated from base Serbian Matrix Sentence Test. From the base of musical noise comes signal *y*. Generated speech signal with the noise *z* have a variable value of parameter SNR {0,-2,-5,-10} dB. Such signal was reproduce to the tested subjects using headphone.

The following figures from 2÷6 give the time and spectral characteristics of the signals x, y, z respectively.

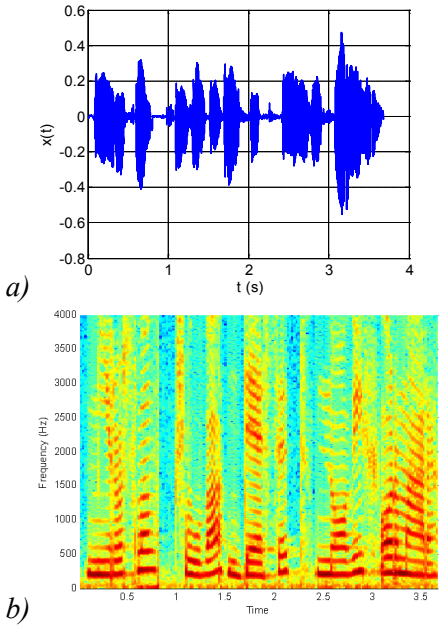


Fig 2. *Time (a) and spectral (b) characteristic of speech signal of sentence "Miroslav keep ten new closets"*

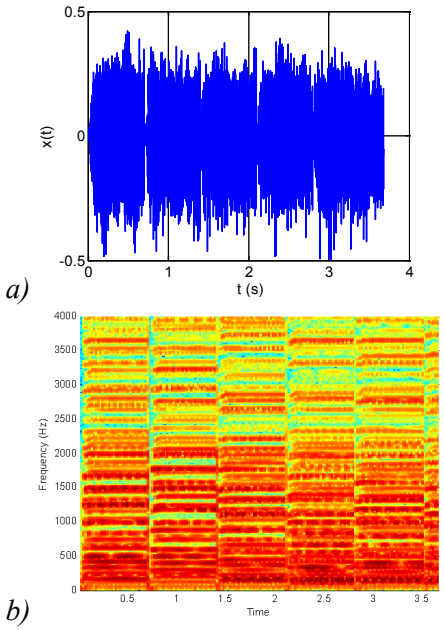


Fig 3. *Time (a) and spectral (b) characteristic of musical noise type major chord on accordion*

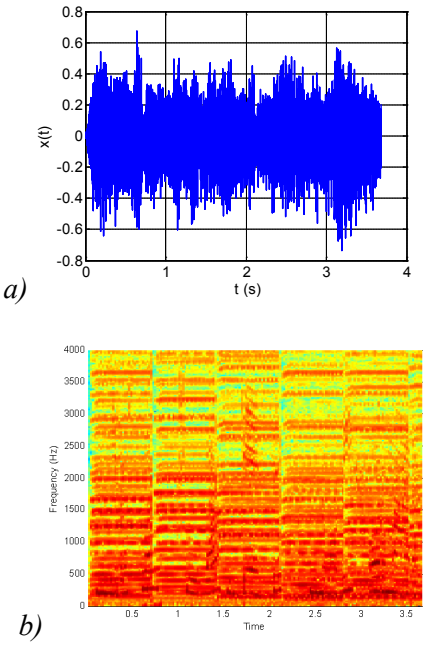


Fig 4. *Time (a) and spectral (b) characteristic of generated signal z on 0dB (accordion)*

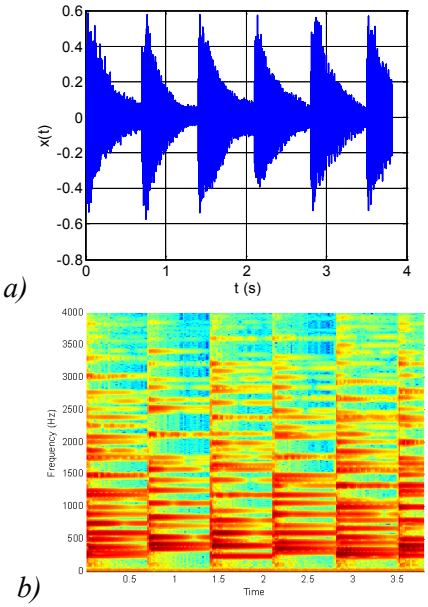
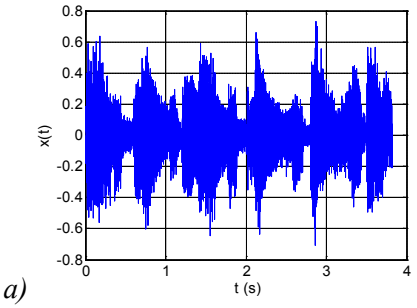


Fig 5. *Time (a) and spectral (b) characteristic of musical noise type minor chord on piano*



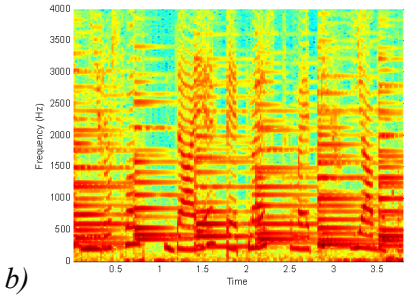


Fig 6. *Time (a) and spectral (b) characteristic of generated signal z on 0dB (piano)*

3.2. Base

For the purpose of experiment it was formed three bases: a). base of speech signal, b). base of musical noise and c) test group.

Base of speech signal was formed from the sentences of Serbian Matrix Sentence Test base [4]. The base of SMST contains ten sentences with fixed syntax structure. The phonetic structure of SMST is good and it was verify by compared with capital literally work on Serbian language such as: “The Bridge on Drina” Ivo Andrić, Bakonja fra Brne" Sima Matavulj, "The Mountain wreath", Petar Petrović Njegoš and "Koštana", Bora Stanković.

Combination type of word witch sentence contains (name, verb, number, adjective, object) by the random law it can be formed 100000 different sentences. For the experiment it was use 100 different sentences.

Base of musical noise was formed from a chord, major and minor, interpreted on piano and accordion. The chord is at the same time a sound of at least three tons of different heights. A chord composed of three tones is called Quint Chord. The quinto chord is composed of: the basic tone, its tierce and its quint. The quint chord can be: a) large (major: big tierce and pure quint), small (minor: small tierce and pure quint), c) reduced (small tierce and reduced quint) and d) excessive (large tierce and excessive quint). On the fig 7÷8 are shown structure of musical noise type chord.

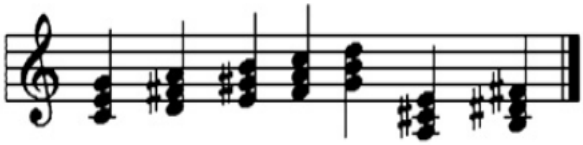


Fig 7. *Structure of musical noise Major chord*

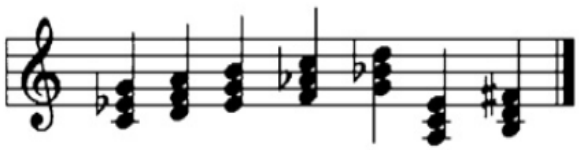


Fig 8. *Structure of musical noise Minor chord*

Test group was formed from 25 student (15 male, 10 females) of College of Applied Technical Sciences of Nis, Serbia,with normal hearing. The mean age of the tested subject is 22 years.

3.3. Results

The results of experiment was given in tabelar and graph form. In table from 1÷3 and graph 9÷14 are shown the results of testing with MOS test, depending from type of musical noise and type of word or the whole sentence.

Table 1: *Intelligibility for type of word and sentence for major and minor chord interpreted on piano*

	Intelligibility (%)											
SNR (dB)	ND	NM	VD	VM	NuD	NuM	AD	AM	OD	OM	SD	SM
0	84	92	100	92	92	96	92	92	92	92	16	16
-2	100	88	100	84	100	96	92	88	88	92	17	14
-5	92	96	88	96	100	96	100	80	68	84	13	14
-10	88	84	84	80	84	72	56	60	68	64	6	8

ND –Name Major, NM- Name Minor, VD- Verb Major, VM- Verb Minor, NuD- Number Major, NuM- Number Minor, AD- Adjective Major, AM –Adjective Minor, OD- Object Major, OM- Object Minor, SD-Sentence Major, SM – Sentence Minor.

Table 2: *Intelligibility for type of word and sentence for major and minor chord interpreted on accordion*

	Intelligibility (%)											
SNR (dB)	ND	NM	VD	VM	NuD	NuM	AD	AM	OD	OM	SD	SM
0	84	80	80	84	96	96	60	64	76	76	7	8
-2	84	84	84	80	80	92	56	68	48	68	6	8
-5	68	72	48	44	64	64	48	44	52	56	4	3
-10	12	12	12	16	16	32	4	28	24	28	0	0

ND –Name Major, NM- Name Minor, VD- Verb Major, VM- Verb Minor, NuD- Number Major, NuM- Number Minor, AD- Adjective Major, AM –Adjective Minor, OD- Object Major, OM- Object Minor, SD-Sentence Major, SM – Sentence Minor.

Table 3: *Intelligibility for type of word and sentence for Gaussian and Babble noise*

		Intelligibility (%)					
	SNR (dB)	Name	Verb	Number	Adjective	Object	Sentence
Gaussian	0	63.33	50	70	63.33	53.33	59.99
	-2	66.67	40	63.33	60	53.33	56.66
	-5	46.67	16.67	53.33	56.67	33.33	41.33
	-10	20	13.33	10	3.33	13.33	11.99
Babble	0	53.33	36.67	53.33	46.67	30	44
	-2	40	10	36.67	20	16.67	24.66
	-5	26.67	6.67	10	3.33	6.67	10.66
	-10	0	0	0	0	0	0

On the following graphic it was shown result from table 1÷2, is DH- major chord on accordion, DP- major chord on piano, MH- minor chord on accordion and MP- minor chord on piano.

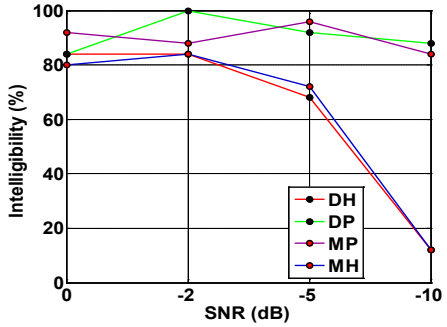


Fig 9. *Intelligibility type of word "Name"*

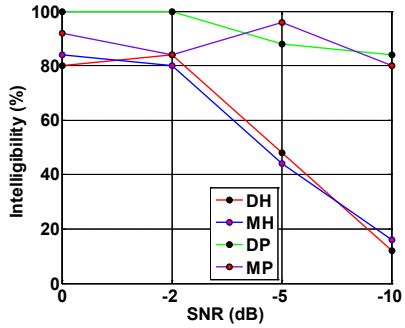


Fig 10. *Intelligibility type of word "Verb"*

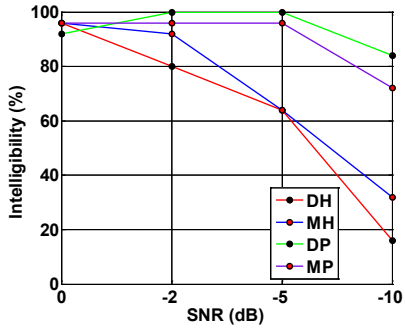


Fig 11. *Intelligibility type of word "Number"*

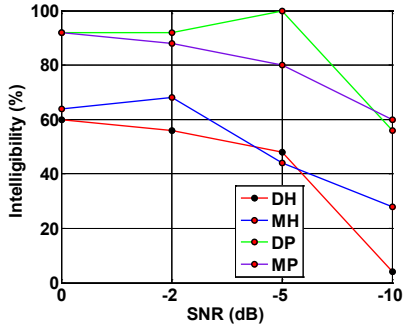


Fig 12. *Intelligibility type of word "Adjective"*

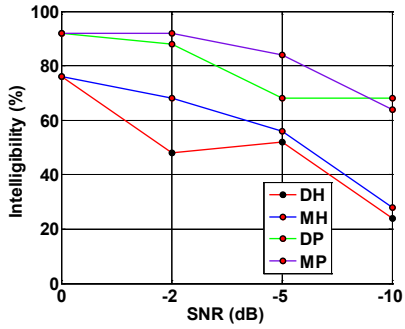


Fig 13. *Intelligibility type of word "Object"*

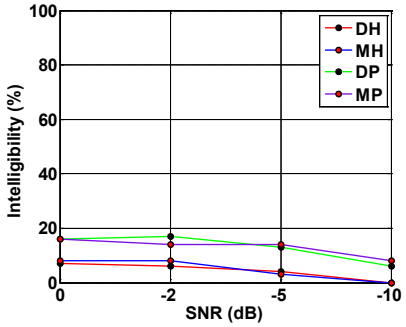


Fig 14*. Intelligibility of sentences*

3.4. Analysis of the results

Analyzing the results of the experiment shown in Tables 1 ÷ 3 and in the Fig. 9 ÷ 14, we arrive at the following conclusions about the intelligibility of speech:

1) for the types of words:

a) *"Name"* is best for major chord on the piano (100%) at -2dB, and worst for accordion (12%) at -10dB for major and minore chord;

b) *"Verb"* best for major chord on the piano (100%) at 0 and -2dB, and worst for major chord on the accordion (12%) at -10dB;

c) *"Number"* best for major chord on the piano (100%) at -2 and -5dB, and worst for major chord on the accordion (16%) at -10dB;

d) *"Adjective"* best for major chord on the piano (100%) at -5dB, and for major chord on the accordion (4%) at -10dB;

e) *"Object"* is best for major and minore chord on the piano (92%) at 0dB, minore chord for piano at -2dB and worst for major chord on the accordion (24%) at -10dB.

2) for the sentence is best for major chord on the piano (17%) at -2dB, worst for major and minore chord on the accordion (0%) at -10dB.

Based on the results of the experiment, it can be noticed that the limit of intelligibility of the word type ranges from 4 ÷ 100%, and the sentence is 0 ÷ 17%.

By comparing with the international standard IEC 60268-16, it is concluded that the quality of intelligibility is within the limits of bad (0 ÷ 67%) to excellent (94 ÷ 96%) for all type of the word, and sentence is bad (0÷67%).

It is interesting to note that the results of the experiment obtained at -10dB are the same or considerably better for the minor chord interpreted on the accordion than the piano.

By performing a comparative analysis of the obtained results with the results of examining the intelligibility of speech for Gaussian and Babble noise, it is observed that the intelligibility in musical noise is better. The best intelligibility of speech shown for Gaussian noise is for the "Number" 70% for 0 dB, and Babble noise is 53.33% for the type of word "Name" and "Number".

Based on the obtained results of the analysis, it has been shown that Babble noise has the greatest influence on the intelligibility of speech, and the explanation lies in its mode of formation (it consists of two or more speech signals) and its spectral characteristic.

4. CONCLUSION

The paper presents evaluation of the influence of musical noise on the intelligibility of speech based on the results of an experiment. The evaluation was based on the results of the MOS test on the test group of people with normal hearing for SNR values = {0, -2, -5, -10} dB. The material used for testing was from the base SMST (speech signal) and the base of musical noise (chord types major and minor, interpreted on piano or accordion).

The analysis of the results showed that the intelligibility is best for the major chord interpreted on the piano, and the worst for Babble noise. The answer to these results is found in the analysis of the spectral characteristics of the signals. The spectral distribution of the signal strength of the noise relative to the power of the speech signal is:

a) Babble - an equivalent distribution of power,

b) Gauss - uniformly distributed over the entire frequency band,

c) musical signal - power distributed around the fundamental frequency and its harmonics.

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