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MULTIDIMENSIONAL VOICE ANALYSIS IN PATIENTS WITH BROCA'S APHASIA¹

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The subject of this study is a multidimensional voice analysis in patients with Broca's aphasia. The acoustic tests were done on twelve female patients with Broca's aphasia and twelve female control subjects without speech and language disorders. Each subject was asked to perform maximal vowel 'a' phonation. The several acoustic parameters were analyzed. The Multi-dimensional Voice Program and Computerized Speech Lab were used. The results showed that analyzed acoustic parameters in the Broca's aphasics are significantly different from the acoustic characteristics of voice in control group of subjects. It was pointed out that acoustic analysis of voice could have significance in the evaluation of speech production deficits in Broca's aphasia.

Key words: *acoustic characteristics of voice, Broca's aphasia, speech production deficits*

INTRODUCTION

Damage to Broca's area, motor and premotor regions, together with the underlying white matter, the basal ganglia, and the insula leads to Broca's aphasia (Bradshaw and Mattingley, 1995; 2010). The core features of Broca's aphasia include nonfluent, halting verbal output that is characterized by syntactically simplified sentences, reduced phrase length, a prosodic impairment and awkward articulation (Kearns, 1997; Vuković, 2010).

Measurement of acoustic voice parameters has been used in several studies for the objective assessment of the nature of speech errors production in aphasic patients (Baum and Kim, 1997, Katz, 1988). Impairments in the production of both consonant and vowels have revealed. These data are mostly based on examination of syllables or utterances production, while examination of isolated vowels voicing in the aphasics, according to our knowledge, didn't attract particular science attention.

In view of the fact that some aphasic patients have severe impairment of speech production, which sometimes appear to be complete inability of voicing, our aim was to investigate the measurements of acoustic voice parameters, using objective methods in patients with Broca's aphasia.

METHOD

Aphasic subjects. Twelve female patients aged from 37 to 67 years (mean: 56.7) with Broca's aphasia who were at least 3 months post onset were selected to participate in the present study. Inclusion in the study was limited to those who had suffered a single cerebro-

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vascular accident resulting in a localized infarct. Patient selection was also restricted to those without oral cavity anomalies, or prior speech, neurological and hearing impairment. All patients were native speakers of Serbian. Patients were diagnosed on the basis of clinical assessment reports and results of the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1983).

Table 1 – Demographic and neurologic data of aphasic subjects

Patient Code	Age	Handedness history	Time post onset (months)	Site of lesion (CT or MRI)
TIK	47	right-handed	3	Left frontoparietal region
LIM	59	right-handed	6	Left Sylvian region with Ventricular displacement
PAM	37	right-handed	4	Left MCA territory
DEM	60	right-handed	4,5	Left frontoparietal region
BAV	61	right-handed	3	Left motor cortex, nucleus Caudate
RIB	58	right-handed	5, 5	Left motor cortex, nucleus Caudate, internal capsule
SOP	67	right-handed	5	Left Sylvian region with Basal ganglia involvement
GAD	57	right-handed	5	Left motor cortex, nucleus Caudate, extending to anterior
KEN	63	right-handed	7	Limb of internal capsule Left frontal lobe lesion which extends to the anterior limb of the internal capsule, basal ganglia and insula
RIS	54	right-handed	5	Left MCA territory
DEG	62	right-handed	4	Left motor cortex, nucleus Caudate, internal capsule
MIT	56	right-handed	3	Left Sylvian region with Basal ganglia involvement

Control subjects. The control group was composed of twelve female subjects ranging from 37 to 67 years in age (mean: 57. 1) who did not have any vocal complaints, laryngeal pathology, hearing disorder or history of neurological damage. All were native speakers of Serbian. The two groups were comparable with regard to age. No significant differences were found ($p>0,05$).

Procedure

At first, all patients were examined by clinical aphasiologist. After that, they were examined by an otorhinolaryngologist and there was no evidence of laryngeal pathology. After both examinations, a voice recording was made. Multi-dimensional voice program, model 4300; Kay Elemetrics corp., Lincoln Park, NJ and Computerized Speech Lab hardware for signal-acquisition analysis and interpretation of data were used. The research was carried out individually while the subject seated in a quiet room. Digital voice recorder WS 2105 was placed at 5,0 cm distance from the patient's mouth. The patients were instructed to attempt to sustain the vowel /a/ at the optimal pitch level several times. As the patients became more skilled at pitch-level control and vocal pitch level became habitual, recording started. Each group repeated the sustained vowel /a/ at their habitual pitch and

loudness level for at least three times, the token with median value being considered relevant for the analysis. Acoustic voice parameters were recorded and saved as digital file, on a laptop.

RESULTS

The mean values and SDs of the acoustic voice parameters in the aphasic subjects and in the control group are presented in Table 2.

The obtained values in the aphasic subjects were higher than in the control group. These groups differences were statistically significant for the all parameters ($P < 0,05$). A minimal value of jitter was 1.890 and maximal value was 5.120. For shimmer, these values were 2.120 and 8.182. In the control group, the minimal value for jitter was 0.290 and the maximal value was 0.780, and for shimmer, the values were 1.125 and 2.132 respectively.

Table 2 – Mean acoustic voice parameters of aphasic subjects and control group

Acoustic Voice Parameters	Aphasic subjects (n=12)		Control Group (n= 12)		Difference
	Mean	SD	Mean	SD	Probability (P)
F0 (Hz)	185.676	14.019	243.727	0.645	0.01
Jitter (%)	2.692	3.233	0.359	0.156	0.05
Shimmer (%)	6.534	2.470	1.998	0.546	0.05
HNR	0.282	0.134	0.112	0.014	0.05

DISCUSSION

Considering that Broca's aphasics frequently show complete inability of speech production in the acute phase, and that with improvement of speech abilities clinically are observed some voice variations, the main focus of this study was to collect acoustic analysis of voice in post-acute period.

Our results suggested that voice quality is impaired in patients with Broca's aphasia. Higher mean values of all parameters were present in the aphasic subjects than in the control group. Increased values of jitter and shimmer are associated with changes in dysphonia and various laryngeal pathologies (Titze and Liang, 1993). Jitter refers cycle-to-cycle, short-term perturbation in the fundamental frequency of the voice, and describes how much a given pitch period differs from one or several pitch periods that immediately precede or follow it (Key Elemetrics corporation, 1993). On the other side, shimmer values are related to waveform amplitude perturbation (Huang et al., 1995).

Acoustic analysis of sustained vowel phonation showed higher habitual F_0 values (200.015) compared with a standard male voice. Increased values of jitter (3.796) and shimmer (3.647) are evidence of unperiodical vocal fold vibrations. The differences in values for harmonic-to-noise ratio compared with controls suggest that Broca's aphasics have an insufficiency of glottal closure. In the absence of any laryngeal pathology detected by an otorinolaryngologist, it can be presumed that the higher F_0 frequency is due to the neurological damage.

It was shown that anterior aphasics have deficits in laryngeal control for voicing (Baum et al., 1990), and deficits of laryngeal timing or coordination with the supralaryngeal vocal tract (Kurowski et al, 2003). Classical approaches have generally characterized phonetic/articulatory impairments as occurring in patients with lesion involving both cortical and

subcortical structure that are suprasylvian and anterior to the central sulcus (Damasio, 1991). The presence of both cortical and subcortical lesions in patients who participated in this study perhaps could explain increased values of jitter and shimmer.

CONCLUSION

Results of this study have showed that patients with Broca's aphasia have increased values of all examined voice parameters. Therefore, this results suggest that variations in quality of voice, at least in some stages, may be an integral part of clinical picture of Broca's aphasia, wich has to be considered during evaluation of speech production deficits.

In order to reveal the nature of voice imapirments in patients with Broca's aphasia, it is necessary to investigate precize correlation analyses of site and extent of brain lesion versus deviations of vocal parameters, which wasn't conducted in present study.

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