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Emotional prosody expression in acoustic analysis in patients with right hemisphere ischemic stroke

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ABSTRACT

Objectives: The role of the right cerebral hemisphere in nonverbal speech activities remains controversial. Most research supports the dominant role of the right hemisphere in the control of emotional prosody. There has been significant discussion of the participation of cortical and subcortical structures of the right hemisphere in the processing of various acoustic speech parameters. The aim of this study was an acoustic analysis of the speech parameters during emotional expression in right hemisphere ischemic strokes with an attempt to reference the results to lesion location.

Materials and methods: Acoustic speech analysis was conducted on forty-six right-handed patients with right-middle cerebral artery stroke, together with 34 age-matched people in the control group. We compared the results of acoustic studies between patients with varying infarct locations and the control group.

Results: Variations in fundamental frequency during verbal expression of joy, anger and sadness were significantly smaller in the patient group than in the control group. Cortical lesion caused more restrictions in fundamental frequency variation in the expression of joy and a lower voice intensity in expressions of anger and joy compared to those patients with subcortical lesions.

Conclusions: Cortical lesion was associated with a more impaired expression of emotional prosody than subcortical lesion. The results indicate the leading role of the cortical structures of the right hemisphere in the expression of emotional prosody.

1. Introduction

The right hemisphere plays an important role in verbal communication, as it is mostly responsible for speech prosody and its emotional aspects. The majority of studies have indicated the domination of the right hemisphere in expression of emotional prosody and the superiority of the left hemisphere in the expression of linguistic prosody (functional hypothesis). These functional differences may be connected to the selective dominance of the right or left hemisphere in particular acoustic parameters of speech (physical hypothesis). The right hemisphere predominates in control of the fundamental frequency, the variations of which determine the corresponding levels of

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the expression of emotions [1–9]. The left hemisphere predominates in the control of the duration of speech and pauses, which determine the appropriate structure of the utterance [5,10–15]. The role of the right hemisphere in control of voice intensity in emotional prosody expression remains uncertain. According to Ross [2,16,17] only Fo variation is a sensitive indicator of emotional prosody expression, while the intensity of the voice is less important. Other studies highlight the importance of voice intensity (mean values) especially during the expression of anger [9,18]. Similarly vague is also the influence of the location of damage to the non-dominant hemisphere on emotional expression and maintenance of acoustic parameters of speech, such as Fo, their intensity and duration. Shapiro and Danly [6] showed smaller fundamental frequency variations during emotional expression in patients with vascular damage of the right frontal lobe, compared to the control group of healthy people and patients with damage to the left hemisphere. Blonder et al. [19] evaluated a patient with prosodic impairment caused by an extensive cortico-subcortical right hemisphere ischemic stroke. Ross and Monnot [20] described disturbances of emotional prosody expression in patients with ischemic cortical and subcortical lesion. These abnormalities were more severe in patients with cortical damage. Based on his own results, Ross [21] hypothesized that the functional and anatomical organization of the right hemisphere in terms of emotional prosody is highly similar to the organization of language functions in the left hemisphere. Ross then proposed a distinction of emotional prosody analogous with the classification of aphasia. Therefore, he distinguished, among others, motor, sensory and global aprosodia, combining the types with damage to relevant part of the right hemisphere. However, a verification of Ross's hypothesis gave ambiguous results. Some of the studies confirmed the impairment of the expression of emotional prosody in patients with damage to the right frontal lobe as well as impairment of perception in cases of damage to the right temporoparietal lobe [22–25]. Although other studies did not show such a relationship, in the majority of patients disturbances in prosody could have been related to Ross's classification [26–29]. Other studies revealed the significant role of subcortical structures in prosodic emotional expression and perception. Cancelliere [27] described emotional dysprosody following subcortical damage without respect to cerebral laterality. Starkstein et al. [25] found disturbances in the perception of emotional prosody in patients with damage to the basal ganglia. Van Lancker Sidtis et al. [30] demonstrated reduced F0 variability in acoustic speech analysis of two patients with isolated basal ganglia damage. Moreover, the participation of subcortical structures in the control of prosody seems to be confirmed by disturbances in the melody of speech in other diseases of the extrapyramidal system, such as Parkinson's disease [31–33]. There are several concepts on the pathogenesis of dysprosody in damage of the subcortical structures. Subcortical aphasias are explained mainly by the occurrence of diaschisis, where the subcortical damage causes secondary lesions in the cortical areas responsible for linguistic functions. An analogous mechanism may concern the prosody disorders, where the subcortical focus influences the cortical areas of the right hemisphere in a depressive manner, inhibiting their activity. All this may cause restrictions of the fundamental frequency variations, which is one of the basic elements of dysprosody. Another considered mechanism of subcortical dysprosody relates to the pathomechanism of dysarthria, where the motor coordination of the articulatory apparatus may be impaired. This results in changes in the duration of the verbal sequences and impairment of the coordination of the motor functions of speech. Other authors point out the important role of the corpus callosum in the control of speech prosody, the supplementary motor area and the frontal part of the cingulum of the right hemisphere [34–36]. The damage to the corpus callosum may impair interhemispheric communication, which integrates the prosodic functions, controlled by the right hemisphere, with speech abilities, processed by the left hemisphere [17].

The aim of this study was the characterization of the basic parameters of speech – the fundamental frequency, duration of the test utterance and the intensity during controlled emotional expression in patients with acute ischemic damages to the right hemisphere and in the control group, with reference of the emotional prosody to the location of the stroke.

2. Materials and methods

2.1. *Participants*

Forty-six right-handed patients with right middle cerebral artery stroke, including 16 females (35%) and 30 males (65%), hospitalized in the Department of Neurology, Wroclaw Medical University between October 2003 and December 2008 were evaluated. The average age of the patients was 58 ± 12.31 years old (22–74 years old). The native language of all the patients was Polish. Diagnosis of the ischemic stroke was made based on clinical symptoms and brain CT image. The degree of neurological deficit was evaluated using the National Institute of Health Stroke Scale (NIHSS) on the day of the acoustic speech exam which was performed within 7–14 days after symptoms of the stroke were shown. It was assumed that acoustic speech analysis in an early ischemic stroke can detect potentially reversible emotional dysprosody. The cognitive functions were evaluated with the Mini-Mental State Examination (MMSE) scale, and a result below 24 points was one of the criteria for exclusion from the study. Communicative abilities were assessed with the Goodglass-Kaplan scale. Other excluding criteria were speech disorders hindering verbal communication, both aphasia and dysarthria alike, as well as a history of previous strokes, psychiatric disorders, dementia, Parkinson's disease and acute internal illnesses (circulatory and respiratory failures, renal and liver failures). The patients were divided into subgroups depending on the location of the stroke in the CT image – patients with: cortical stroke (lesion in the cortex or cortex with white matter but without damage to the basal ganglia or the internal capsule), subcortical stroke (lesion in the basal ganglia and/or the internal capsule) and cortico-subcortical stroke. Multifocal ischemic strokes, leukoaraiosis and hydrocephalus were other criteria for exclusion from the study.

The control group consisted of 34 right-handed people, including 12 females (35%) and 22 males (65%), aged 35 up to 81 years old (mean age was 54.7 ± 11.13 years old) and without any clinical symptoms of damage to the central nervous