CENTRAL MECHANISMS OF VOWEL PERCEPTION, CATEGORIZATION AND IMITATION

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ABSTRACT

Cerebral lateralization of speech processing depending on the type of the task presented, type of answering-vocal or manual, side of stimulation, etc. was examined. Dominance for different aspects of speech and complex non-speech sounds perception is shown. The paper presents the results of monaural testing in normal listeners, the stimuli being amplitude-modulated noise and tones and CVC syllables with native and foreign vowels.

1. INTRODUCTION

Speech processing involves rapid decoding and construction of meaning from a transitory acoustic signal. The necessary linguistic skills are usually associated with the functions of the left hemisphere (LH). The last decades undoubtedly proved the fact of the right hemisphere (RH) involvement in speech processing - both perception and production. It was shown that LH mechanism provides for correct phonetic analysis, enabling to reduce sound continuum to functionally relevant segments, while the role of the RH is to realize global template recognition, discriminate the pitch, individual voice qualities, prosodic features. Our research shows that LH mechanisms secure accuracy of processing unfamiliar, novel material, while RH provides for quick orientation in familiar information. We have also shown the difference in hemispheric involvement in the perception and production of native and foreign languages. It is important to mention that both hemispheres can use various cognitive strategies depending on a number of factors including individual differences caused by genetically programmed lateralization of cognitive functions as well as those formed as a result of some specific training - language background including. Recent data show that predominant LH or RH influence on information processing is determined by the task factor - either experimental or real and consequently the necessity of cognitive style choice: analytic for one class of tasks versus holistic, Gestalt for the other. It is crucial that not all the stages of speech processing imply hemispheric involvement, i.e. higher cortical functions - lateralization can be the result of sensorimotor resolution capacities.This paper demonstrates the research in cerebral dominance for different types of information processing: detection, imitation and categorization of speech and complex non-speech samples.

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2. METHODS

2.1. Experiment I

The subjects were 24 normal listeners between 20-50 years of age, all native speakers of Russian, right-handed. The stimuli sets were CVC syllables made up of natural speech sounds produced by a male Russian-French bilingual. Russian stop consonants were used to construct syllables on a computer and record the set. The resulting tape consisted of 24 trials with 3-sec.interval which permitted subjects to record their responses manually or vocally. The stimuli were presented monaurally to the right or the left ear in turn. Reaction time and type of answer were registered automatically. All possible combinations of hands and ears were used. Subjects were asked to give simple vocal or manual response, to imitate the stimulus most accurately, to produce or write the Russian syllable similar to the target one.

2.2. Experiment II

49 normal subjects between 24 and 36 years of age were tested. The stimuli were amplitude-impulse-modulated sounds of different durations. Sounds were noise (frequency range 350-3000 Hz), sustained tones (250, 800, 1000 and 4000 Hz) and linearly frequency modulated tones with rising and falling frequency changes (from 400 to 700 and from 700 to 300 Hz). The duration of a sequence of pulses was 0.08-3.2 sec., impulses being linearly rising or falling. The rythm was 5-80 pulses per second (medium - 30 pulses per second). Subjects were asked to classify the stimuli according to two possible perceptual parameters - speech-like and moving in space (approaching or moving away). The stimuli were presented monaurally to the left and right ears in quasirandom order. Subjects were instructed to respond monaurally (left or right in different sessions). Reaction time was automatically registered.

3.RESULTS

Subjects turned out to be grouped in two extremes the remaining arranged in between as to their psychophysiological organization. The comparison of the group differences reveals (i) the "reciprocal" character of one of them, i.e. sharply different latent times depending on the stimulation sides, the parameters of the stimuli being identical and (ii) the "synaergic" group demonstrating ap-

proximately the same reaction time irrespective of the stimulation side and other conditions; subjects of this group make significantly less mistakes compared to those of the first one. Exploratory analysis reveals groups of subjects characterized by different hemispheric involvement in processing native and foreign language material - both vocal and manual reactions show it definitely.

3.1.Experiment I

The data provided evidence of reaction time hierarchy in different task types. The first range is the time needed just to hear the stimulus and start reacting manually; the second - to decide which of the stimuli was presented and the third - to simulate articulation movements of the stimulus without phonation. The greatest reaction time was registered when the stimuli were presented to the left ear, while the response was given by the left hand; the least - when the stimuli were presented to the right ear and the response was given by the right hand. It must be noted that though individual reaction times may vary around the measured value the relation between the ranges remains stable. Vocal responses also show hierarchy of latent times. It should be mentioned that processing of native versus foreign syllables seem to be controlled by different cerebral structures: "foreign" need mostly left hemisphere mechanisms - both for imitation and categorization;- (probably it is caused by the necessity of phonemic coding), while native syllables can involve both (right and left) hemispheres.

3.2.Experiment II

The data showed three discrete ranges of stimuli durations revealed in classification tasks of amplitude-impulse-modulated targets according to their perceptual parameters: 0.08-0.2 sec.; 0.2-0.6 sec.; 0.6-3.2 sec. The subjects used these ranges to identify the stimulus as hoarse, speech-like (consonant-like with noise carrier and accent-like with tone carrier) or moving in space (approaching with rising amplitude and moving away- with falling one). It was shown that classification task is being solved within the same time limits irrespective of the stimulus acoustic parameters - rythm of pulses, duration, carrier frequency, amplitude shifting, the side of stimulation etc. - in the average-latent time was 1.5 sec. However, it should be emphasized that the usage of "speech-like" criterion increases by 30 per cent when the signal is being addressed to the right hemisphere, i.e. to the left ear. The findings suggest that classification procedure in the given experiment was based on dealing with individually formed functionally relevant template recognition. Opposite to it, experiments with amplitude changes identification show basic importance of (a) stimulus presentation side and (b) the use of the right versus left hand for the response. The maximum differences were examined in the range of "speech-like" durations revealed in classification experiment. The data demonstrate two main types of sensory-motor organization of subjects, the dependence of lateralization on the experimental conditions - side of stimulation, type of task, type of answer (vocal/manual), ear/hand combinations,etc.

The results have basically revealed that classification and imitation procedures involve different hemisphere mechanisms depending on individual characteristics of subjects.

4. CONCLUSION

We put forward a suggestion that in central regulation of speech all high level processing of new and complex information seems to be the function of LH, while familiar information engages both or RH preferably. Speech processing, therefore, most probably uses higher levels in interpreting lower levels of perception. LH provides for phonemic enooding and structural analysis of complex acoustic stimuli both in perception and imitation using short-term memory; RH realizes global template recognition. It should be emphasized that perception is language specific and depends on individual acoustic and language background. The data demonstrate different types of organization of subjects irrespective of the type of experiment, which is of importance in interpreting mean or normalized data.

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