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FEATURES OF EVOKED BRAIN ACTIVITY NEURODYNAMICS UNDER CONDITIONS OF DIFFERENTIATING VISUAL STIMULI IN PEOPLE WITH HEARING DEPRIVATION

Introduction. *There are no investigations of brain processes in adults with the lack of hearing using EP methods and in complex with neurodynamic study. We suppose that integrative neurophysiological and neurodynamic approach will help to deepen our understanding of activating and regulating systems of brain under the conditions of processing visual information in the investigated persons with hearing deprivation.*

Purpose. *In this regard, the goal of the research is to find out the features of the evoked activity of the brain and neurodynamics under the conditions of differentiating visual irritators in persons with hearing deprivation.*

Methods. *The evoked activity of the brain is investigated according to the indicators of long latent (cortical) visual evoked potentials (LVEP); and neurodynamic characteristics – under the conditions of differentiating visual information. 30 healthy individuals aged 21-25 (control group) without hearing problems and 30 individuals of the same age with hearing deprivation are investigated. The registration of LVEP is performed with the help of computer complex "Nerocom" XAI Medica, in the screened sound- and light-isolated chamber in a sitting position with photo-stimulation of the right and left eye with eyes closed. Non-artifact is analyzed. While analyzing the obtained LVEP curves, the latent periods of P_1, P_2, P_3 wave peaks are considered. The investigation of neurodynamics properties are performed on computer system according to the developed method and program "Diagnost-1". The statistical analysis of the obtained results was carried out by the methods of mathematical statistics using Excel software package.*

Results. *The number of processed irritators during the reaction of differentiation was reliably higher in the investigated individuals with normal hearing compared with the individuals with auditory deprivation function ($p<0.05$). The time of reaching minimum signal exposition and the minimum time of reaction was reliable longer in the investigated individuals with auditory deprivation ($p<0.05$-0.01); it indicated lower speed characteristics of neurodynamics. To understand the features of cortical activity during the differentiation of visual information, the results of the evoked activity of the deaf persons' brain was compared to the data of the investigated individuals with normal hearing. It was found that the latency of early components of visual EP in the persons with auditory system deprivation was less than in the investigated individuals with normal hearing. The obtained data show quicker perception of a signal and higher reactivity of cortical cells in the deaf persons at the first stages of information processing that occurs via the rapid sensory fibers of lemniscus projection systems, thalamus-cortical structures and the acquired cross-modal reorganization of the cortex due to the compensatory response of the brain to cell destruction. Besides, the given results confirm the existence of powerful reorganizational compensatory changes of the occipital cortex area of the brain in the deaf persons of the investigated age. The correlation analysis shows the relationship between the indicators of the number of the processed irritators, the time of minimum signal exposition and the duration of the latent period of P_2 component of EP ($p<0.05$). Concerning the latent period of P_3 component, it was found that cortical activity in response to light flashes was reliably lower in the investigated persons with auditory deprivation ($p<0.01$).*

Originality. *According to EP, the weak part of the brain mechanisms of processing visual information in the deaf individuals is the information stage which the final formation of corresponding reaction depends on.*

Conclusion.

1. The correlation has been found between the neurodynamic indicators of the processed stimuli number, the time of signal minimum exposition and the duration of P_2 latent component of EP.

2. The initial stages of the evoked brain activity are characterized with the high level of neocortex cell reactivity in the subjects with the deprivation of auditory function.

3. Significantly lower reactivity of the brain mechanisms, which provide the final response stage of differentiation, has been found in the deaf individuals compared to the persons with normal hearing.

Key words: *the evoked brain activity, neurodynamics, hearing deprivation.*

Topicality of Research. The diagnostics of sensory dysfunctions and the study of psycho-physiological mechanisms of their formation is an urgent problem of neurophysiology. Nowadays, great attention is paid to the clarification of cognitive disorders under the conditions of sensory deprivation [1, 2]. Authors point out that the violation of sensory function causes psychic and behavior disorders.

An objective method of studying central nervous system in the individuals with hearing deprivation is the investigation of bioelectric activity of the brain with the evoked potential method which can find the opportunities of brain cortical activity according to the overall reactions of neuron population in response to artificial irritators [3]. It is proved that the amplitude of the early waves of the evoked potential (EP) reflects sensory sensitivity, and the amplitude of late waves is associated with decision criterion [4]. However, there are still contradictory views whether the components of sensory coding correlate with physiological content or they are only links of spatially organized sensory conductivity [5, 6].

The results obtained by neurodynamic investigation on the basis of processing information with differentiating irritators, are equally important [7]. Processing information requires the participation of various links of perception, the identification of an irritator, comparison, analysis and synthesis operations, memory, generalization and forming the programs of an answer.

There are researches using multi-channel EEG registration, visual and auditory evoked potentials and the comparison of the obtained data with behavioral reactions in the sphere of studying the features of interactive activity of human brain with violations of analyzer systems [1, 8]. There are no investigations of brain processes in adults with the lack of hearing using EP methods and in complex with neurodynamic study. We suppose that integrative neurophysiological and neurodynamic approach will help to deepen our understanding of activating and regulating systems of brain under the conditions of processing visual information in the investigated persons with hearing deprivation.

In this regard, the goal of the research is to find out the features of the evoked activity of the brain and neurodynamics under the conditions of differentiating visual irritators in persons with hearing deprivation.

Research Organization and Methods. According to the goal set, a complex of instrumental methods of investigation is used. The evoked activity of the brain is investigated according to the indicators of long latent (cortical) visual evoked potentials (LVEP); and neurodynamic characteristics – under the conditions of differentiating visual information. 30 healthy individuals aged 21-25 (control group) without hearing problems and 30 individuals of the same age with hearing deprivation are investigated.

The registration of LVEP is performed with the help of computer complex “Nerocom” XAI Medica, in the screened sound- and light-isolated chamber in a sitting position with photo-stimulation of the right and left eye with eyes closed. LVEP is registered in response on photo-stimuli for 5 mc with alteration period of 1s ± 15%. Flash intensity does not exceed generally accepted in clinic 0.24-0.35 kJ. The time interval of 300 ms to the emergence of the LED flash is also analyzed. The number of averaging for significant stimuli is within 50-70. Non-artifact is analyzed. While analyzing the obtained LVEP curves, the latent periods of P_1, P_2, P_3 wave peaks are considered. The biopotentials taking from the occipital region are analyzed. Ear ipsilateral electrodes are used as referent.

The investigation of neurodynamics properties are performed on computer system according to the developed method and program "Diagnost-1" [9]. Geometric figures (circle, square and triangle) are applied as visual loading to differentiate information. 5-minute differentiation of stimuli in "feed-back" regime is applied as test loading; it helps the investigated individual to adjust the flow of visual stimuli to the pace optimal for him (the speed of stimuli pace ranges within ± 20 ms depending on the made mistakes: it decreases in case of a mistake, and it increases in case of a correct answer). The total number of the processed visual stimuli, the time of reaching minimal exposition, the minimal time of response, and the number of false responses are determined.

The statistical analysis of the obtained results was carried out by the methods of mathematical statistics using Excel software package. The reliability of changes and differences between comparable values was assessed by the criterion of authenticity difference (t) by Student's table, nonparametric criterion of "U" Wilcoxon-Mann-Whitney.

Results and Discussion. Neurodynamic characteristics were analyzed to find the features of brain mechanisms of differentiating visual stimuli in the investigated individuals with normal hearing and deaf ones (Table 1).

The number of processed irritators during the reaction of differentiation was reliably higher in the investigated individuals with normal hearing compared with the individuals with auditory deprivation function ($p<0.05$). The time of reaching minimum signal exposition and the minimum time of reaction was reliable longer in the investigated individuals with auditory deprivation ($p<0.05$-0.01); it indicated lower speed characteristics of neurodynamics.

Table 1.

Dynamics Characteristics under the Conditions of Differentiating Visual Information in the Investigated Individuals with Different State of Hearing Function

Investigated groups	Investigated indicators of neurodynamics			
	Number of processed stimuli	Time of signal minimum exposition (ms)	Minimum time of reaction (ms)	Number of false reactions (%)
Normal hearing	738±40.2	121±6.2	30.034±5.0	46,13±4.3
Deaf	638±60.4	266±4	47.83±3.2	65.4±3.7
Reliability of differences	$p<0.05$	$p<0.001$	$p<0.05$	$p<0.05$

Better quality of processing information was demonstrated by the investigated individuals with normal hearing who had less false reactions ($p<0.05$).

To understand the features of cortical activity during the differentiation of visual information, the results of the evoked activity of the deaf persons' brain was compared to the data of the investigated individuals with normal hearing. It was found that the latency of early components of visual EP in the persons with auditory system deprivation was less than in the investigated individuals with normal hearing (Fig. 1). In particular, the latency of P_1 components of the investigated persons in both groups was minimum and did not reach the level of reliability and was less in the deaf individuals ($p<0.05$). It is known that early components (P_1 and P_2) are the result of unconscious identification and the initial stages of specific information processing [1, 3, 5]. The obtained data show quicker perception of a signal and higher reactivity of cortical cells in the deaf persons at the first stages of information processing that occurs via the rapid sensory fibers of lemniscus projection

systems, thalamus-cortical structures and the acquired cross-modal reorganization of the cortex due to the compensatory response of the brain to cell destruction [5, 10]. Besides, the given results confirm the existence of powerful reorganizational compensatory changes of the occipital cortex area of the brain in the deaf persons of the investigated age [2, 8].

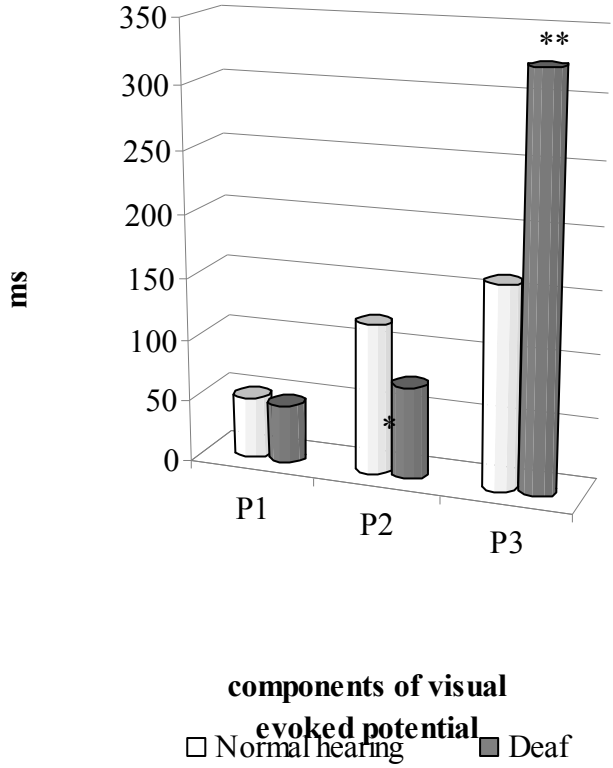

Fig.1. Latency of wave components (median) of visual evoked potentials of the subjects with different state of auditory function; * - difference reliability $p<0.05$ and **- $p<0.01$ relatively to the subjects with normal hearing.

The correlation analysis shows the relationship between the indicators of the number of the processed irritators, the time of minimum signal exposition and the duration of the latent period of P_2 component of EP ($p<0.05$).

Concerning the latent period of P_3 component, it was found that cortical activity in response to light flashes was reliably lower in the investigated persons with auditory deprivation ($p<0.01$). P_3wave is considered to be an indicator of the activity of the brain processes occurring in the primary and secondary areas of the cerebral cortex of the brain [5, 11 12, 13]. The higher latency of this component in the investigated persons with auditory deprivation confirms the idea that sensory deficit forms the limited circuit of central connections [1], delays the conductivity and transformation of information, causes incomplete analysis and synthesis, complicates the determination of spatial and temporal relationships [6, 14].

The overall response time of the brain in the investigated persons with normal hearing was within the generally accepted clinical standards (to 180-200 ms). The total latency of the analyzed peaks LVEP in the deaf subjects exceeded its by almost 2 times. Probably, reliably longer latent period of P_3 component of LVEP in the deaf subjects shows the insufficient number of the formed synaptic connections, the low speed of information transmission, the imperfection of neurotransmitter systems and brain mechanisms in general, that would allow to show better performance of information processing.

According to modern concepts, late components of the evoked brain activity are associated mostly with nonspecific nuclei of the thalamus, reticular formation systems, limbic complex, and other polysynaptic nonspecific systems, functional activity of which is insufficient for the deaf persons [2, 15].

Thus, for the deaf individuals, the analysis of primary EP peaks with short latency enables to state about the high speed of visual stimuli perception and identification due to compensatory reorganizational reconstructions in the occipital cortex area of the brain. The long latency of late peaks demonstrates "emergency operation" of the formed neuron networks, which are rapidly depleted and do not reach the required level of performance compared to healthy people.

Thus, according to the characteristics of both LVEP and neurodynamics, the auditory deprivation is reflected with low speed characteristics of all the parts of visual analyzer system. At the same time, according to EP, the weak part of the brain mechanisms of processing visual information in the deaf individuals is the information stage which the final formation of corresponding reaction depends on.

Conclusions

1. The correlation has been found between the neurodynamic indicators of the processed stimuli number, the time of signal minimum exposition and the duration of P_2 latent component of EP.
2. The initial stages of the evoked brain activity are characterized with the high level of neocortex cell reactivity in the subjects with the deprivation of auditory function.
3. Significantly lower reactivity of the brain mechanisms, which provide the final response stage of differentiation, has been found in the deaf individuals compared to the persons with normal hearing.

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Анотація. Лизогуб В.С., Юхименко Л.І., Хоменко С.М. Особливості викликаної активності мозку та нейродинаміки за умови диференціювання зорових подразників у осіб зі слуховою депривацією. *За даними викликаної активності мозку та властивостей нейродинаміки досліджували мозкові механізми диференціювання зорових подразників у глухих. Встановлений зв'язок між показниками кількості перероблених подразників, часом мінімальної експозиції сигналу та латентністю компоненту P_2 викликаних потенціалів. Виявлено, що особи з депривацією слуху характеризуються низьким рівнем диференціювання інформації та високою реактивністю клітин неокортексу на початкових етапах викликаної активності мозку.*

Ключові слова: *викликана активність головного мозку, нейродинаміка, депривація слуху.*

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