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THE ROLE OF THE MAIN NERVOUS PROCESSES IN FUNCTIONING OF SENSORY BRAIN SYSTEMS

The role of the main nervous processes in functioning of sensory brain systems is investigated. The correlation analysis of evoked brain potential components and the indexes of highly genetically determined features of higher nervous activity – the functional mobility and strength of nervous processes based on the study of processing auditory and visual information is conducted for this purpose. The main nervous processes are considered to be a part of the single physiological mechanism including the early stages of forming brain responses.

Keywords: *the main nervous processes, the functional mobility and strength of nervous processes, sensory processes, visual and auditory analyzer, evoked potentials, electroencephalography.*

Problem definition. Recent studies and publications analysis. It was B.M. Teplov who pointed out the possibility of correlation between special properties of a man and functioning of his analyzers [12]. Some authors stresses the ambiguous role of the main nervous processes (their partiality) in different analyzers [6, 9]. In their opinion, the partiality of nervous system properties may be stipulated by the participation of different nervous structures, the individual degree of excitability of corresponding unconditional centers, methodical approaches to finding neuro-physiological features, the modality of applied stimuli, etc.

The role of nervous system properties in the different structures of holistic brain needs further development since it concerns with both theoretical and practical foundations of many branches of physiology and psychology.

The application of evoked potential method provides high time and space permission and allows obtaining detailed space-time sequence of the electric events arising in the brain in all the periods of performing psycho-physiological task [3].

At present, the authors study mostly the late components of evoked potentials; the initial stages of perception, selection and distribution of material on which further processing of material depends, remain outside of research [14, 16]. The impacts of modality on amplitude-time parameters of evoked potential components, topographic features of their wave development in response to the presentation of sensory irritants are not sufficiently studied.

We suppose that functional mobility of nervous processes as one of the important time characteristics of CNS functioning makes its contribution to the work of analyzer systems, primarily, visual and auditory ones.

It may be possible that in case of correlation between the neuro-dynamics properties of higher parts of central nervous system and the components of brain evoked potentials, such data would be useful in vocational work, the prevention of neurological symptoms.

Object of an article. The goal of the work was to find the features of processing auditory and visual information, to define possible neuro-physiological mechanisms and electro-physiological correlates with highly genetically determined neuro-dynamic properties of higher nervous activity – the functional mobility and strength of nervous processes.

Methods

The evoked potentials (EP) of cerebral cortex, the time of latent periods of different auditory and visual-motor reactions, the properties of the main nervous processes: functional

mobility (FMNP) and strength (SNP) were investigated among the examined 60 men aged 18-20.

The registration of EEG was performed on multichannel encephalograph "Neurocom" XAI Medica with placing electrodes in symmetrical frontal, parietal and occipital leads according to the international system of 10-20.

To register auditory long latent evoked potentials, the standard binaural stimulation with closed eyes in light-and sound-proofed chamber with the duration of 50 ms with sequence period of 1-2 s. was applied. The tone frequency of significant stimulus was 2000 Hz, and insignificant ones – 1000 Hz. The long latent evoked potentials of visual modality were determined with standard photo-stimulation.

To determine the functional mobility and strength of nervous processes, the examined persons performed five-minute tests on processing visual and auditory information in "feedback" regime according to M.V. Makarenko method at computer complex "Diagnost – 1M" [8, 10]. The results were processed with statistic set of Excel-2010 program.

Results and discussion

The investigation results of auditory and visual-motor activity are presented at Fig. 1.

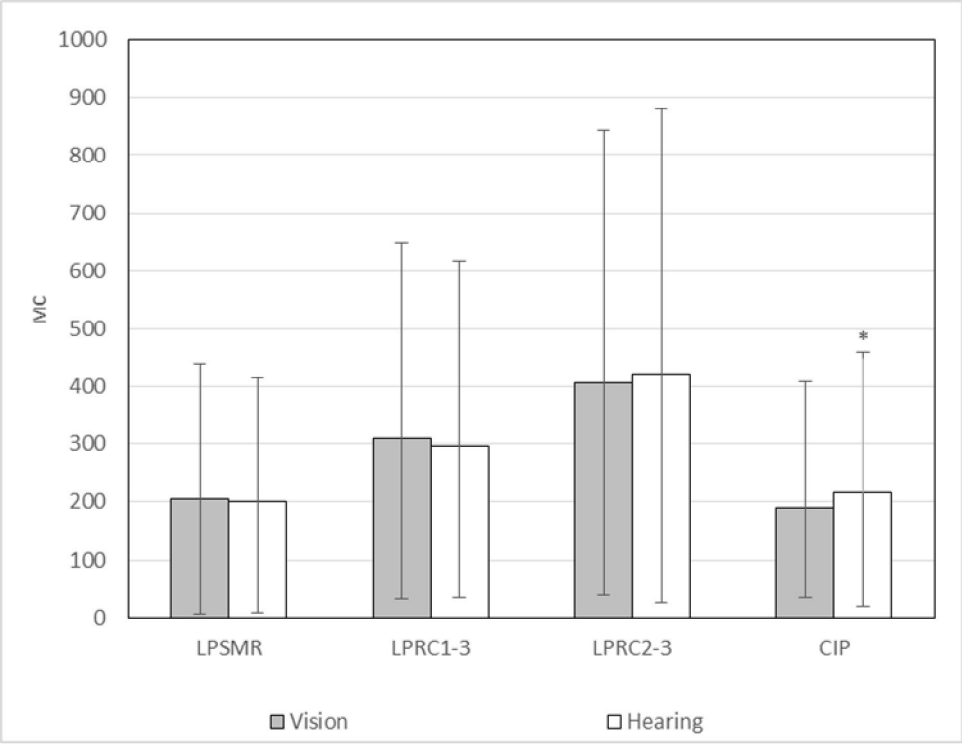

Fig. 1. Medians (1st and 3rd quartiles) of latent periods of varying complexity and central information processing (ms); probability of distinctions * - P<0.05

It shows that there are no significant differences between latent reactions being different according to modality (sight and hearing) and to difficulty degree (simple – latent period of simple motor reaction (LPSMR), with one choice – latent period of reaction with one choice ($LPRC_1$-$_3$) and two choices ($LPRC_2$-$_3$). At the same time, the index of central information processing (CIP) as time difference between the reaction with two choices and simple sensory-motor response was significantly less in work with the stimuli of visual modality ($p<0.05$).

Correlation analysis shows reliable correlation between functional mobility of nervous processes and CIP time ($r = 0.67$, $p<0.001$), and between FMNP and the number of processed

irritants in both modalities (r=0.67, p<0.001).

The following data may show intra-individual variations in the excitability of corresponding unconditional centers. Therefore, we compare the options reflecting FMNP and SNP in processing auditory and visual information (Fig.2).

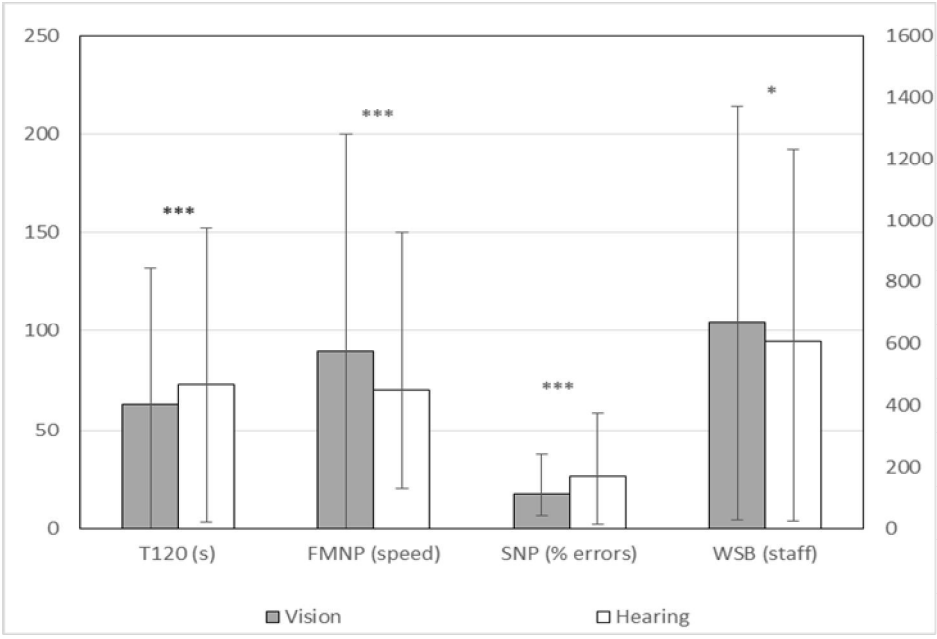

Fig. 2. Medians (1st and 3rd quartiles) of main nervous processes (the right scale concerns to parameters WSB); probability of distinctions * - P<0.05, *** - P<0.001

The Fig.2 shows that the indexes of mobility of nervous processes and the efficiency of the cerebral cortex in processing visual information are reliably better if compared with analogical indexes obtained in work with auditory irritants.

Previously, the similar data were found in the investigation of monkeys' mobility in visual and auditory analyzers in favor of the first one [1]. It was hypothesized as to the possible differences in the efficiency of cortical elements of the investigated analyzers at these animals. It is possible that certain analyzer is able to play a "leading" role participating in the organization of an animal's behavioral reactions. Probably, both a man and an animal have similar relations between different analyzer systems; since already proved analogies (e.g. of memory: visual, auditory, motor, tactile) indicates this fact.

M. Wertheimer [2] explained the availability of such fluctuations in the psycho-physiological characteristics of sense organs by the possibility of countervailing fluctuations of excitability of cortical areas of corresponding analyzers, namely, the index of their functional independence. On the other hand, such differences in functioning of analyzers may be connected with those processes that take place in receptors directly (shift differences of the sensitivity of different modalities) [9].

To determine the process taking place in perception apparatus and in cortical parts of investigated analyzers we apply the method of evoked potentials. The previous investigations show that the sources of early components (to 15 ms after stimulus) are extra-cerebral, extra-cortical factors and afferentiation. The components ranging 20-40 ms are stipulated by the transmission of impulses in high-speed lemniscus system. Later (40-100 ms) components of EP are the reflection of afferent feed which passes through the striatal complex and association nuclei of the thalamus. The components ranging 100-300 ms are the result of non-specific afferentiation from reticular formations of the thalamus and the limbic areas of the cortex of the frontal and temporal parts [3, 4].

The form, amplitude and latent period of long-latent EP oscillations are known to depend on modality and the individual features of a person [11].

The registration results of evoked potentials of different modality are given in Table 1 and 2.

Table 1

Medians (1st and 3rd quartiles) of latent components of evoked potentials of the investigated persons

P_1 (s/d)	N_1 (s/d)	P_2 (s/d)	N_2 (s/d)	P_3 (s/d)
Sight (photo-stimulation, withdrawal P_3, P_4)				
3 (31; 0) 4 (35; 0)	35 (67; 21) 47 (62; 15.5)	94 (112.5 ;74) 98 (119.5; 83)	135 (180.5; 127) 174 (199; 134)	213 (230; 167) 285 (363.5; 188)
(withdrawal O_1, O_2)				
4 (14.0; 0) 3 (39; 0)	21 (56; 14.5) 56 (67.5; 44)	98 (117; 87) 96 (11.1; 87.5)	196 (253.5; 139) 151 (200; 127)	296 (336; 164) 164 (353; 143)
Hearing (tone-stimulation , withdrawal C_3, C_4)				
22 (28; 13) 31 (28; 31)	74 (20.5 ;39) 76 (14.5; 41)	166 (10.5; 8) 177 (9.5; 21.5)	180 (45; 20) 186 (32; 15.5)	400 (77; 224) 206 (414; 155.5)
Reliability (sight P_3, P_4 – hearing C_3, C_4)				
$p>0.05$	$p>0.05$	$p<0.01$	$p>0.05$	$p>0.05$
Reliability (sight O_1,O_2-hearing C_3,C_4)				
$p>0.05$	$p>0.05$	$p<0.01$	$p>0.05$	$p>0.05$

Table 2

Medians (1st and 3rd quartiles) of amplitude components of evoked potentials of the investigated persons

P_1-N_1 (s/d)	N_1-P_2 (s/d)	P_2-N_2 (s/d)	N_2-P_3 (s/d)	P_3-N_3 (s/d)
Sight (photo-stimulation, withdrawal P_3, P_4)				
4.71 (5.9; 2.8) 3.54 (6.5; 2.5)	5.84 (10.8;3.9) 6.47 (9.7;3.7)	5.58 (11.2; 3.1) 6.62 (15.3;4.1)	7.5 (8.64; 5.51) 8.88 (15.0; 6.5)	6.12 (12.6; 2.4) 8.4 (15.5; 4.6)
(withdrawal O_1, O_2)				
4.42 (7.5; 3.1) 3.81 (7.2; 2.3)	6.47 (8.0; 4.35) 6.82 (8.0; 5.2)	6.1 (13.7; 4.7) 6.8 (11.7; 4.9)	8.42 (16.7; 5.0) 9.73 (12.4; 2.6)	7.1 (14.0;5.1) 4.9 (8.2;2.9)
Hearing (tone-stimulation , withdrawal C_3,C_4)				
0.85 (0.62;0.53) 1.4 (0.5; 0.6)	9.6 (0.99; 2.0) 8.62 (0.53; 1.11)	0.1 (1.97; 0.07) 0.1 (2.47; 0.08)	6.67 (2.53; 1.4) 7.57 (1.05; 2.3)	8.46 (1.7; 3.43) 7.83 (6.48; 1.6)
Reliability (sight P_3, P_4 – hearing C_3, C_4)				
$p<0.05 – 0.01$	$p>0.05$	$p<0.01$	$p>0.05$	$p>0.05$
Reliability (sight O_1,O_2-hearing C_3,C_4)				
$p<0.05$	$p>0.05$	$p<0.01$	$p>0.05$	$p>0.05$

Reliably shorter latency of the component of P_2 evoked potentials and higher inter-peak amplitude of P_1-N_1 and P_2-N_2 evoked potentials were found to the action of visual stimuli relatively the similar data obtained to the stimuli of auditory modality ($p<0.05 – 0.01$). The amplitude characteristics had been found to be characterized with the activity of non-specific ascending systems of the brain and to reflect the current neuro- and psycho-physiological state of a man [13].

It was proved that the processing of sensory information might be estimated by analyzing the amplitudes and latent periods of EP consecutive components [15]. Thus, N_1 and

P_2, reflect earlier stages of information processing – the initial selection and recognition of stimuli and the beginning of their classification process [14, 16].

The investigation found the correlation between FMNP and P_1-N_1 and N_1-P_2 inter-peak intervals of both modalities ($r = 0.32$-0.34, $p<0.05$) of the right hemisphere. The obtained data show that the sensory system forms the final result of information processing starting with receptor part, obviously, on the basis of the integration effect of many infra-cortical brain structures participating in reception, transmission, decoding, analysis, synthesis, providing appropriate tonus and other numerous functions of dynamic character in which FMNP plays a leading part.

Although the excitation of primary cerebral cortex neurons is not a sufficient condition for the emergence of full sensation, however, it is an obligatory and necessary element for further formation of response and creates conditions for special organization and interaction of brain structures [5]. The discovered connection between the amplitude characteristics of EP and FMNP proves the participation of the main nervous processes in the deployment of responses in the sensory areas of the brain.

On the other hand, on the initial stages of reception, the modality of stimulus participates in future response; however, it is presented in implicit form [6]; but it is possible that the specific character of physiological processing mechanisms and corresponding morpho-functional features of a definite analyzer may stipulate the difference on effector.

Besides, a distinction threshold is found to be mostly a constant and is characterized for each analyzer by relative quantity: it is 1/1000 for visual one, it is1/10 for auditory one [7]. We are inclined to believe that the obtained reliably shorter latency and higher inter-peak amplitude of early components to the stimuli of visual modality is rather connected with higher threshold of sensitivity in the given analyzer but not with its functional independence. In fact, the obtained connection between FMNP and P_1-N_1 and N_1-P_2 inter-peak intervals in both modalities shows the common physiological mechanism of their work.

Thus, the main nervous processes as an integral functional component of cerebral organization provide the activity of generally activated non-specific system and corresponding dynamic activity of the investigated sensory brain systems.

Conclusions

1. The main nervous processes are the component of the single physiological mechanism of sensory response starting with the early stages of its formation.
2. The correlation between FMNP and P_1-N_1 and N_1-P_2 inter-peak intervals was found.
3. Reliably shorter latency of P_2 evoked potential component and higher inter-peak amplitude of P_1-N_1 and P_2-N_2 evoked potential components to the action of visual stimuli were found.
4. The obtained results may be useful in labour physiology, sensory systems, age physiology, the prevention and treatment of the organs of sight and hearing.

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Аннотация. Юхименко Л.И., Лизогуб В.С., Хоменко С.Н. Роль основных нервных процессов в функционировании сенсорных систем мозга. *Исследовали роль основных нервных процессов в функционировании сенсорных систем мозга. С этой целью проводили корреляционный анализ компонентов вызванных потенциалов мозга и показателей высоко генетически детерминированных особенностей высшей нервной деятельности – функциональной подвижности и силы нервных процессов на основе изучения переработки слуховой и зрительной информации. Показано, что основные нервные процессы являются частью единого физиологического механизма, включая ранние этапы формирования ответных реакций мозга.*

Ключевые слова: *основные нервные процессы, функциональная подвижность и сила нервных процессов, сенсорные системы, зрительный и слуховой анализатор, вызванные потенциалы, электроэнцефалография.*

Аннотація. Юхименко Л.І., Лизогуб В.С., Хоменко С.М. Роль основних нервових процесів у функціонуванні сенсорних систем мозку. *З'ясовували особливості переробки слухової та зорової інформації, виявляли можливі нейрофізіологічні механізми та електрофізіологічні кореляти з високо генетично детермінованими нейродинамічними властивостями вищої нервової діяльності – функціональною рухливістю та силою нервових процесів. На основі отриманих компонентів викликаних потенціалів мозку та встановлених зв'язків доведено, що основні нервові процеси є складовою єдиного фізіологічного механізму починаючи з ранніх етапів формування мозкових відповідей.*

Ключові слова: *основні нервові процеси, функціональна рухливість і сила нервових процесів, сенсорні системи, зоровий та слуховий аналізатор, викликані потенціали, електроенцефалографія.*

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