

ELECTROENCEPHALOGRAPHIC CORRELATES OF THE SPEED (TIME) OF THE CENTRAL PROCESSING OF INFORMATION BY THE HIGHER PARTS OF BRAIN IN HUMANS WITH THE DIFFERENT INDIVIDUAL-TYOLOGICAL FEATURES OF THE HIGHER NERVOUS ACTIVITY

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Abstract

The speed (time) of the central processing of information (SCPI) by the higher parts of brain and electric activity of the cerebral cortex were studied using the method of electroencephalography (EEG) in humans with the different individual-typological features of the higher nervous activity – functional mobility of the nervous processes (FMNP).

The statistically important differences of indices of the complicated sensorimotor reactions of differentiation, SCPI and EEG powers between the groups of examined were established. The persons with the high FMNP level were characterized with the reliably higher CPI speed and power of α -rhythm of the convexital surface of the cerebral cortex, especially right hemisphere and β -rhythm of EEG ($p \leq 0,001$) comparing with examined persons with the mean and low FMNP levels. The correlative analysis proved the reliability of the connections between FMNP, SCPI and EEG characteristics. We think that the established EEG-correlates of the central processing of information by the higher parts of brain increase the predictability of analysis of typological features of the higher nervous activity and can be useful in the field of professional orientation and selection and also in psychodiagnostics of neurological disorders.

Keywords: central processing of information, functional mobility of the nervous processes, electroencephalography.

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1. Introduction

It is well known, that the speed (time) of the central processing of information (SCPI) by the higher parts of brain is the indicator of psychophysiological difference between humans that are clearly demonstrated in the hourly intervals, quality and quantity of its processing [1–3]. In the modern psychophysiology is accepted that the maximally possible speed of processing of information of the different complexity in the given time limit is presented by the functional mobility of the nervous processes [4]. In the literature is underlined, that the individual temporal characteristics of the processes of information processing and the correspondent decision making are conditioned by the features of the nervous processes of neocortex [5–7]. A. M. Ivanitsky suggests, that each specific complicated act in the brain cortex and subcortical layer corresponds to the specific spatiotemporal net of the excited and inhibited neurons [8]. Obviously there is a connection between the speed and qualitative-quantitative indices of SCPI, FMNP and amplitude-temporal characteristics of EEG. At the same time in the literature can be found only several data about EEG-patterns of information processing by the higher parts of brain [9], most aspects still insufficiently studied and need further researches [2].

2. Aim of research

Detection of the EEG-correlates of speed (time) of the central processing of information by the higher parts of brain.

3. Materials and Methods

The functional mobility of the nervous processes (FMNP) was detected on “Diagnost -1M” apparatus complex using N. V. Makarenko method [10], the speed of simple sensorimotor reactions on the stimuli of aural modality (SSMR) and reactions of the choice of two stimuli of the three ones

(RC_{2,3}), speed of the central processing of information (SCPI) using the original method [11] and spatiotemporal characteristics of electroencephalogram (EEG).

4. Experimental procedures

120 men 18–22 years old were examined. During the testing the norms of bioethics according to the positions accepted for the scientific studies at the university and according to the order of MHP of Ukraine from 13.03.2006 № 66 were observed.

4.1. Testing of the functional mobility of the nervous processes

The studies were started from the determination of the functional mobility of the nervous processes by fixing the speed and quality of information processing in the regime “imposed rhythm”. Before the beginning of research were given the instructions about the methods and were done 3 training tries.

4.2. Testing of sensorimotor reactivity of the different complexity

After familiarization with the task the successive determination of the latent period of the simple reaction and reaction of differentiation – choice of two stimuli of the three ones – was started. For this aim for the work load on information processing was used the 5-minute test on stimuli differentiation in the regime “reverse connection”.

4.3. Determination of the speed of the processing of information by the higher parts of brain

The CPI speed was calculated using the original method [11]. At this calculation were taking into account the results of the latent periods of the simple sensorimotor reactions and differentiation reactions with the choice of two stimuli of the three ones considering the level of the functional mobility of the nervous processes.

4.4. Electroencephalography

At the beginning was recorded the background EEG using electroencephalographic complex “Neurocom” (XAI – Medica, Ukraine) at the state of rest with eyes closed. Then using the same equipment EEG was fixed at the work load on information processing carried out by examined person. Electrodes were placed according to the international scheme 10–20. EEG records were carried out in the screened light- and soundproof chamber equipped according to the sanitary-hygienic requirements. The combined aural electrode was used as the referent one.

4.5. Statistical processing of the data

All obtained material was processed using the methods of parametric and non-parametric statistics using the Microsoft Excel – 2010 program package.

5. Results

The “Results of research” and “Discussion of results” are the two different sections.

The examined persons were divided into three gradations by the method of signal deviations according to FMNP: with the high, middle and low levels. Between these groups was carried out the comparison of the mean SCPI values. The differences of the temporal SCPI characteristics of examined with the different FMNP level are presented in the **Table 1**.

It was established that the LPSSMR indices alongside with the minimal exposition of the signal in persons with the high, middle and low FMNP did not reliably differ ($p \geq 0,05$). But the persons with the high FMNP level were characterized with the shorter LPRC_{2,3} comparing with the persons with the other FMNP levels ($p \leq 0,05$). SCPI was reliably higher in patients with the high FMNP level comparing with the middle and the low ones ($p \leq 0,05$).

The comparison of LPSSMR of persons with the middle and low FMNP did not also reveal the reliable differences ($p \geq 0,05$). The comparison of LPRC_{2,3} indices fixed its predominance in examined with the low level of the studied typological feature ($p \leq 0,05$, $p \leq 0,01$). The minimal exposition of signal was reliably lower in persons with the middle FMNP level comparing with the

indices of examined with its low level ($p \leq 0,05$). The reliably much time was spent for CPI by the persons with the low FMNP level comparing to the ones with the middle level ($p \leq 0,05$).

Table 1

The speed (time) of the central processing of information in persons with the different level of the functional mobility of the nervous processes (median, first and third quartile)

FMNP Level	LPSSMR (ms)	LPRC2-3 (ms)	Information processing level (ms)	Minimal signal exposition (ms)	SCPI (ms)
High	204.1 (195.5; 211.75)	408.2*## (385.5; 428.2)	80.1*# (70.1; 78.2)	24.6# (21.7; 26.6)	194.5*## (173; 222.7)
Middle	201.1 (185.5; 208.3)	423.2^ (409.1; 435.2)	65.3^ (60.1; 70.1)	26.4^ (25.2; 28.3)	217.1^ (208.1; 237.3)
Low	206.3 (194.5; 241.3)	464.5 (421.2; 478.3)	50.2 (47.1; 50.3)	31.5 (30.4; 36.9)	242.5 (211.3; 261.2)

Notes: * – the reliable differences of indices in persons with the high and middle FMNP level, $p \leq 0,05$; ## – the reliable differences of indices in persons with the high and low FMNP level, $p \leq 0,05$, $p \leq 0,01$; ^^ – the reliable differences of indices in persons with the middle and low FMNP level, $p \leq 0,05$, $p \leq 0,01$

The used correlative analysis revealed the connection between the FMNP, SCPI and EEG characteristics (**Fig. 1**).

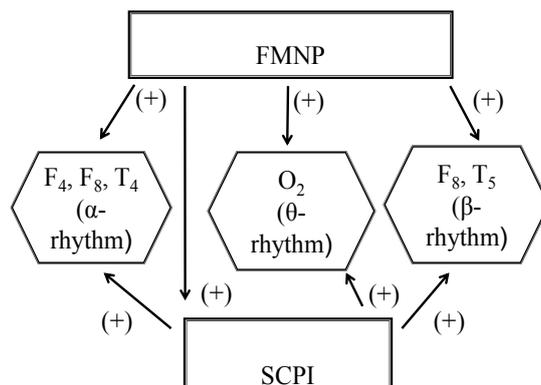


Fig. 1. The correlations between FMNP, power of EEG rhythms and CPI; only reliable connections are presented ($p < 0,05 - 0,001$)

For specification of the results of correlation between the CPI speed and EEG characteristics we compared the indices of the wave power in the interested brain zones during the processing of information in examined with the different FMNP levels (**Fig. 2**).

In all examined persons was fixed the rise of the power of EEG-oscillations in θ -diapason comparing with the state of rest ($p \leq 0,05$, $p \leq 0,001$).

In the group with the middle FMNP level the power in α -diapason at the processing of information decreased in the right parietal-occipital zone and raised in the frontal parts of cortex comparing with the state of rest ($p \leq 0,05$, $p \leq 0,001$). In the persons with the low FMNP level the power of α -rhythm decreased more often in the central parietal-occipital zones excluding the right temporal lobe where it raised ($p \leq 0,05$, $p \leq 0,001$). Persons with the high FMNP level were characterized with the total rise of the indices power in the whole cortex that was more significant in the cortex areas of the right hemisphere ($p \leq 0,001$).

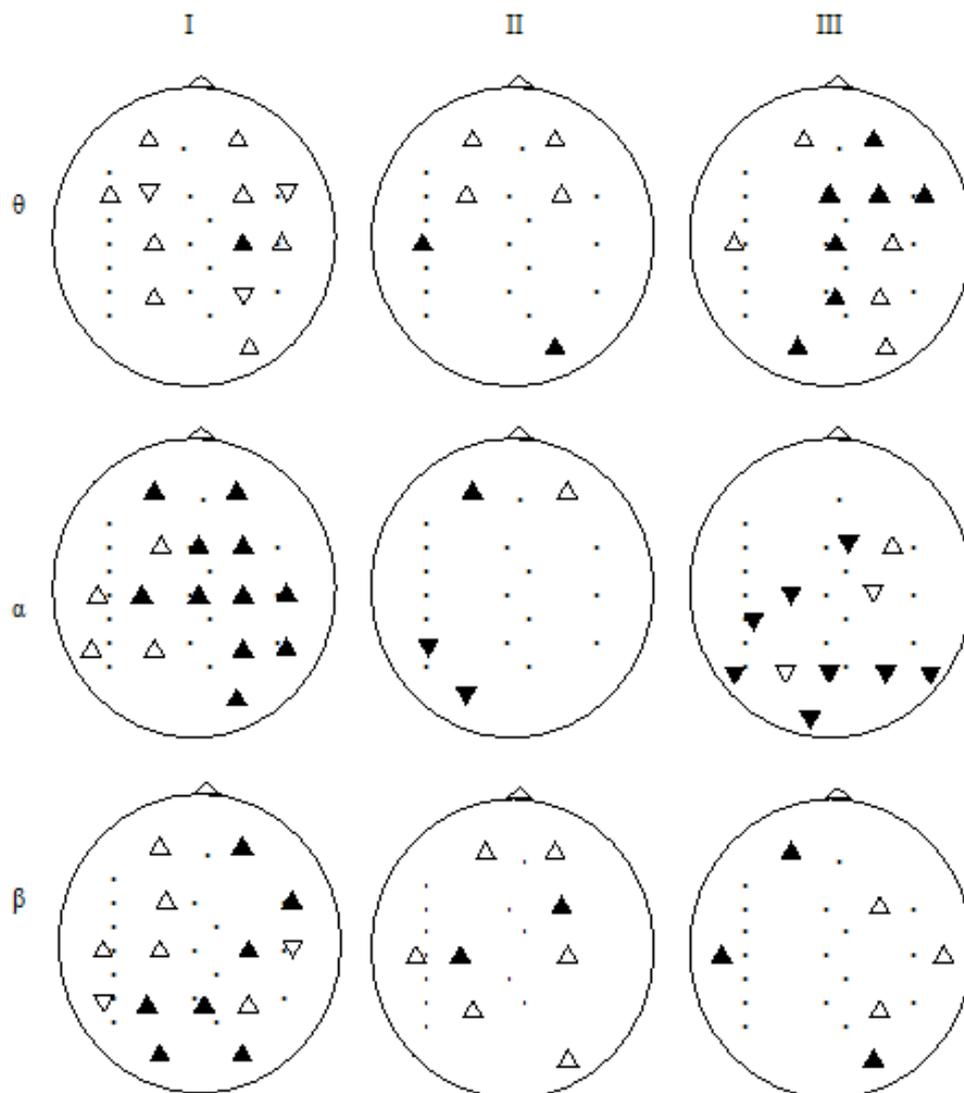


Fig. 2. The change of the power of EEG-oscillations at the processing of information comparing with the state of rest in examined with the high (I), middle (II) and low (III) FMNP level
Notes: ∇ Δ \blacktriangledown \blacktriangle decrease (rise) of the power comparing with the state of rest, $p \leq 0,05$, $p \leq 0,001$

In all examined at the processing of information was fixed the rise of the power of EEG-oscillations in the β -diapason comparing with the state of rest. Persons with the high FMNP level were characterized with the rise of the power on the whole scalp ($p \leq 0,05$, $p \leq 0,001$), excluding the right parietal zone and left parietal-occipital one ($p \leq 0,05$). In persons with the middle and low FMNP level was fixed the less generalized rise of the power in the β - diapason comparing with the state of rest.

6. Discussion

As we know from the literature, the CPI represents the speed, quality of information processing, it is the consequence of analytic-synthetic activity of the cerebral cortex and other cerebral structures and also contains the individual characteristics of HNA [2, 8, 12, 13].

According to the received data, activation of the certain zones of the cerebral cortex, speed of appearance, distribution and switching of the nervous processes in the cortical links condition the individual differences of the SCPI of examined.

Analysis of the EEG dynamics at the processing of information allow separate the plastic transformations of the functional activity of the cortex zones that were dependent on the FMNP level as the response on the offered activity.

The received results complement the existed neurophysiological data about the mental activity provision [5, 14].

It was revealed that the transformation of the aural information by the persons with the high FMNP level was attended with the most rise of the power of α - и β -diapasons among the other groups of examined. Such predominance of the rhythms in EEG pattern obviously provided the facilitation of the sensor stimuli processing in the cortical parts of the auditory analyzing system.

Taking into account the modern ideas about the organization of the cerebral processes and the obtained amplitude dynamics, the results of correlative analysis, we think, that their efficiency was provided by activization of the frontal and parietal parts of the cortical system of attention on the base of the internal and inter-hemisphere interaction [13, 15–17].

In the persons with the middle FMNP level the power indices of α - and β -waves were higher than in examined with its low level and lower than in persons with the high gradation of this neurodynamic feature.

The established correlation between FMNP, SCPI and the spatiotemporal EEG characteristics confirms that the processing of brain information is the complicated analytic-synthetic activity and FMNP is involved in its structural-functional organization. On the other side, the obtained results indicate that the provision of the information processing is carried out by the cerebral mechanisms in which the synergism of the neurodynamic and neurophysiological functions is demonstrated.

The revealed differences in the speed of information processing between the groups of examined represented in the correspondent EEG patterns allow thinking, that they were conditioned by the different FMNP level that provided the dynamism of the work substrates and cortical structures [4, 6]. It is also obvious, that the ensembles of neurons that provide the information processing can differ by content and degree of differences of the temporal characteristics [18], variability of discriminatory power and activization of operative memory [2].

We think, that the revealed EEG-correlates of the central processing of information by the higher parts of brain will increase the predictability of analysis of the typological features of information processing and will be useful in the field of professional orientation and selection and also prophylaxis and diagnostics of the neurological disorders. Many researchers confirm this demand [9, 19, 20].

At the same time the obtained and presented results on detection of EEG-correlates of the speed (time) of the central processing of information by the higher parts of brain cannot pretend to be the full elucidation of the question of the features of processing and differentiation of the offered material as psychophysiological base of individuality; they are only an attempt to approach to the understanding of regularities of the brain informational abilities. Undoubtedly, the solving of this fundamental problem depends on the further complex elaboration of neurophysiological aspects of the complicated behavior reactions and the other directions of the study of the cortical modules of cerebral activity.

7. Conclusions

1. The examined with the high FMNP level had the shorter $LPRC_{2,3}$ comparing with examined with the middle and low FMNP level. SCPI in persons with the high FMNP level had the less temporal indices comparing with the low and middle levels.

2. Examined with the high FMNP level at the information processing were characterized with the total rise of the power of α -waves on the whole cortex and it was more significant in its right hemisphere zones ($p \leq 0,001$), and also β -waves on the whole scalp (excluding the right parietal zone and the left parietal-occipital one) comparing with the middle and low levels.

3. The established EEG-correlates of SCPI allow thinking, that activization of the certain zones of the cerebral cortex, the speed of appearance, distribution and switching of the nervous processes in the cortical links condition the individual-typological differences of the informational features of the brain work.

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