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Resistant And Plastic EEG Indicators Of Individual Typological Features Of A Person.

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ABSTRACT

The article presents the research results on stable and plastic EEG indicators of individual typological characteristics of a person in 4 measurements on the same subjects. The data obtained indicate that the individual characteristics of a person considered in the work (level of extraversion, neuroticism, properties of the nervous system) differ significantly in terms of severity and correlation of stable (reproducible) and plastic (non-replicating) EEG indicators.

Keywords: EEG, typological characteristics, features, level of extraversion, neuroticism, nervous system

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INTRODUCTION

Studying the fundamentals of the physiological mechanisms of manifestation of certain properties of individuality is extremely important for understanding human behavior. There is evidence of the relationship existing between individual-typological personality characteristics with EEG characteristics of brain activity [1, 2, 3, 4, 5, 6, and many others].It is established that the frequency spectra of the background EEG, in the waking state, recorded on different days, show similarity and repeatability, i.e. they are stable individual characteristics [7, 8, 9].

However, no information was found in the literature about the features (along with the resistant ones) of plastic EEG characteristics of brain activity in the context of individual human characteristics. The identification of stable (reproducible) indicators of individual-typological characteristics of a person will increase the efficiency of predicting the functional support of a particular activity. The study of plastic EEG indicators will allow one to identify the individual characteristics of individual adaptation to new conditions.

In this regard, the purpose of the work was to analyze the stable and plastic EEG indicators of individual-typological features of a person in a state of relative rest.

MATERIALS AND METHODS

In order to determine which of the identified features of the EEG are more dependent on individual characteristics, and which of them depend on external conditions, a study was conducted of the reproducibility of these differences in repeated measurements on the same subjects.

The reproducibility of the differences was evaluated in four measurements, in which 19 subjects aged 19–21 participated.

The electroencephalogram (EEG) was recorded on a 21-channel analyzer of electrical activity of the brain Encephalan-131-03 combined with a computer by “MEDICOM LTD” (Russia). When recording the EEG, the time constant was 0.3 s, the high-pass filter was 30 Hz, the sampling frequency was 160 Hz, and the measurement range of the voltage amplitude was 5 μV to 500 μV.

EEG was recorded from 21 leads, monopolarly, according to the international system 10-20, in a sitting position, in a state of calm wakefulness with open and closed eyes. Reference electrodes were attached to the earlobes. For differentiation of EEG artifacts, electrooculograms (vertical and horizontal), electrocardiograms and electromyograms were simultaneously recorded. Four main ranges of EEG components were recorded: delta (0.3–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz).The EEG recording and pretreatment were performed using software developed for this instrument.

The duration of the analyzed EEG sites was 15-20 seconds. Using the fast Fourier transform on all channels in the range from 0.3 Hz to 30 Hz, with a resolution of 0.3125 Hz, the following characteristics of the electroencephalogram rhythms were determined:

- Amplitude density:an amplitude spectrum with the dimension mkV / Hz;
- Power density:a power spectral density with the dimension mkV2 / Hz;
- Bominant frequency: a frequency with the dimension Hz, which corresponds to the maximum value of the power of a given rhythm.
- Indices (% severity) of alpha, beta, delta, and theta rhythms.

To determine the level of introversion-extraversion and neuroticism, a test questionnaire was used, which had been developed by G. Eysenck and adapted by A. G. Shmelev [10]. Indicators of sincerity, extraversion and neuroticism scales were determined.

The properties of the nervous system were determined using the questionnaire developed by J. Strelau [10]. Strength indicators of the excitation processes, the inhibition processes, the mobility of the nervous processes were determined, and the balance of the nervous processes was calculated.

Statistical processing of materials was carried out using the software package "Statistica v.5.5" and "SSPS v.13". For each parameter considered, the arithmetic average value (M) and the arithmetic average error (m) were calculated. The significance of differences between subgroups was assessed using the Mann-Whitney test, the differences were considered to be significantly significant at $p < 0.05$.

Since a large number of variables were analyzed in the paper, regression equations were calculated, which allowed modeling the effects of one or several independent variables on the dependent variable.

RESULTS

The Figure 1 shows reproducible differences in EEG indices of the rest of the groups being studied, differing in individual features, where their repeatability from one measurement to another is traced. In particular, in the groups of introverts and extroverts, this is the frequency of the alpha rhythm, in groups of subjects strong and weak in relation to the process of arousal – this is the frequency of theta and alpha rhythms, in groups of subjects strong and weak relative to the process of inhibition is the index of theta and alpha rhythm, in inert and mobile subjects -- this is the index, amplitude, and power density of the alpha rhythm.

The results obtained allow us to identify the identified stable (reproducible) differences in EEG-indicators as characteristic of the data on individual typological features, while we consider non-reproducible differences in EEG indicators as related to the situation and reflecting the individual characteristics of the dynamics of the functional state of the brain in response to the influence of exogenous factors, since EEG measurements were performed on different days.

In groups of emotionally stable and emotionally unstable individuals, balanced and unbalanced by the processes of arousal and inhibition of reproducible differences were not found.

In order to find out how certain individual characteristics can be associated with the features of the functional state of the brain, a regression analysis of the relationship of the studied individual characteristics and EEG indicators was carried out. The following equations were obtained:

*Extraversion = - 0.47 * Alpha Amplitude -1.01 * Alpha Frequency + +0,11* Delta Index (1)*
*Neuroticism = 1.85 * Alpha Frequency + 0.01 * Alpha Power +*
+12.32 Beta Amplitude - 0.52 * Beta Power - 0.88 * Theta Frequency(2)*
*SPV = -0.26 * Beta Index + 18.49 * Beta Amplitude -1.5 * Beta Power (3)*
*SPT = 2.75 * Alpha Amplitude - 0.46 * Beta Index + 1.28 * Theta Index (4)*
*PNP = 0.3 * Alpha Index - 0.38 * Beta Index (5)*
*BNP = 0.33 * Alpha Index + 8.92 * Alpha Frequency - 0.87 * Beta Index + (6)*
*+1.57 * Beta Power - 16.24 * Delta Frequency*

As can be seen from the obtained equations, the individual-typological features considered in this work are to a greater extent not related to stable characteristics of brain activity, but to EEG indicators reflecting individual characteristics of the dynamics of the functional state of the brain in response to the influence of exogenous factors.

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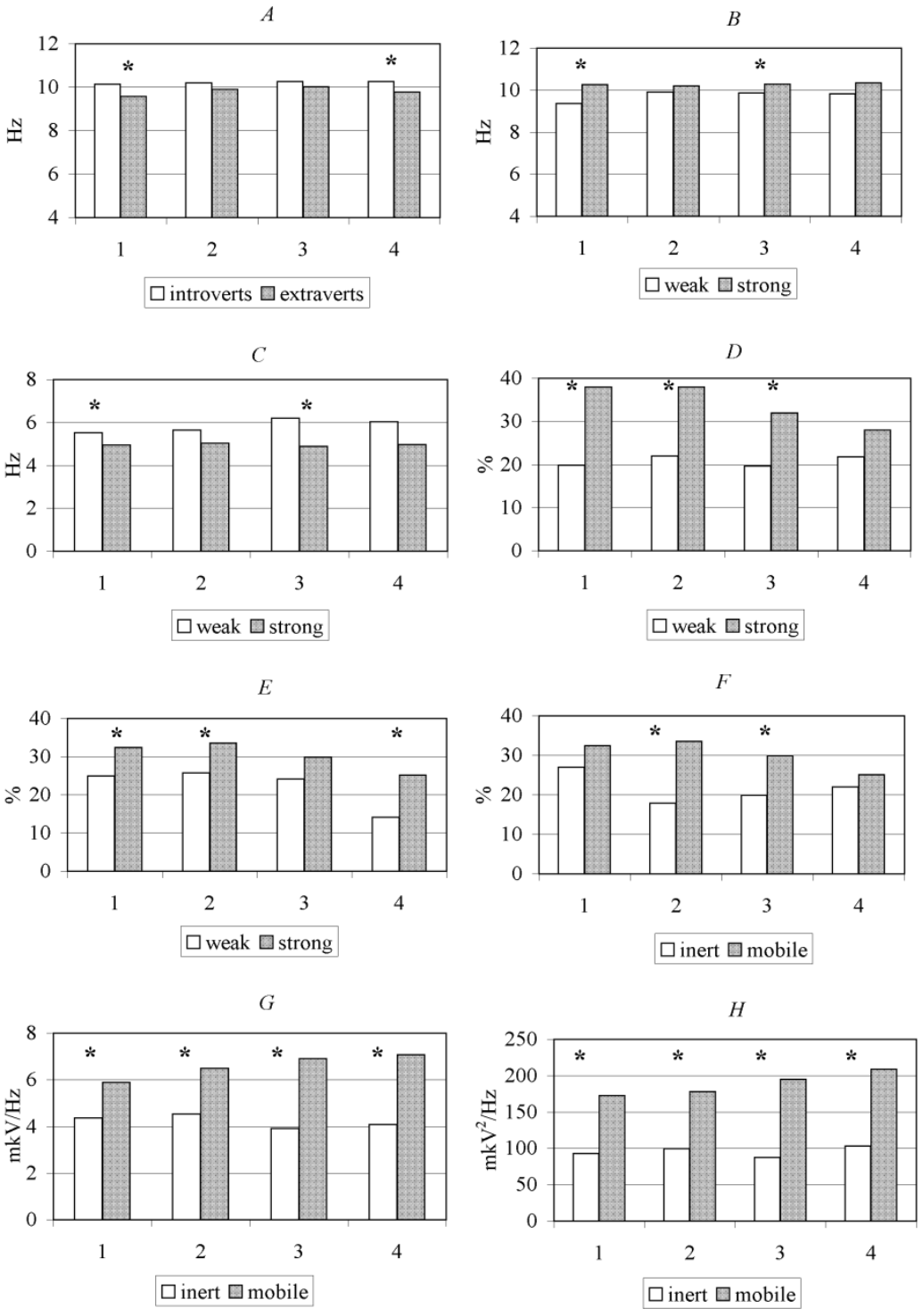

Fig 1: The reproducibility of differences in EEG characteristics in 4 measurements in the studied groups of students (* -p <0.05). A - the value of the frequency of the α-rhythm in the groups of introverts and extroverts; B - the value of the frequency of the α-rhythm in groups with a weak and strong nervous system relative to the excitation; C - the value of the frequency of the ɵ-rhythm in groups with a weak and strong nervous system with respect to excitation; D - the value of the α-rhythm index in groups with a weak and strong nervous system relative to inhibition; E –the value of the ɵ-rhythm index in groups with weak and strong nervous system with respect to inhibition; F — the α-rhythm index value in groups with inert and mobile nervous systems; G - the value of the amplitude density of the α-rhythm in groups with inert and

mobile nervous system; H - the value of the power density of the α-rhythm in groups with inert and mobile nervous system.

DISCUSSION OF THE RESULTS

The individual-typological features considered in this work (properties of the nervous system, the level of extraversion and neuroticism) of the subjects are characterized by features of the brain's bioelectric activity. It is known that there are more or less stable individual differences in the level of activation - this is the level of the functional state that is most often observed in a given individual during wakefulness [7].

Based on the results obtained in this work, in groups of introverts and extroverts, the steady-state EEG is an indicator of the frequency of the alpha rhythm, in groups of strong and weak regarding the excitation process – the frequency of theta and alpha rhythm, in groups of strong and weak relative to the process of inhibition – theta and alpha rhythm, in inert and mobile subjects – the index, amplitude, and power density of alpha rhythm.This is consistent with the results of other authors [7, 11].The alpha rhythm has a thalamic origin [12, 13]. The authors associate theta rhythm frequency with the hippocampus and other structures [12, 14].

Summarizing the above, we can conclude that the differences between the individual-typological features of a person can be determined by the specificity of the functioning of the brain structures, which is expressed in the characteristic for each type of picture of the resting EEG. These differences may be due both to the influence of external factors, which is expressed in plastic (non-reproducible) patterns of the background EEG, and internal features of the functioning of certain structures of the nervous system, which manifested themselves in a stable from measurement to measurement trend of reproducibility of features of the background EEG.

As follows from the results of the regression analysis, the studied individual characteristics were associated with both reproducible and non-reproducible EEG characteristics. Apparently, in the regulatory mechanisms that ensure the individual characteristics of the current functional state of the nervous system, stable and mobile components can be distinguished. The first ones allow one to maintain gomestatic constants of the functional state, the latter – to adapt to new external conditions.

This is consistent with the views of N. P. Bekhtereva on the principle of "individually emerging brain systems", according to which the implementation of the same mental activity can be provided by topographically different brain systems in which the neurophysiological mechanisms consist of "hard" and "flexible" links [15].

Similar views were expressed by G. M. Edelman and G. Tononi, according to which the same groups of neurons can participate in different brain operations, and at the same time, different groups of nerve cells can perform similar functions [16]. Consequently, individual characteristics of the functional state of the brain must have both stable and variable characteristics.

As can be seen from the regression equations, the functional state of the brain, correlating with individual-typological features, is primarily related to alpha and theta rhythms. The lower the amplitude and frequency of the alpha rhythm, the higher the severity of the delta, that is, the lower the level of activation of the cortex, the higher the level of extraversion. The higher the frequency and power of the alpha rhythm and the amplitude of the beta rhythm, and the lower the beta power and frequency of the theta rhythm, the higher the emotional instability. The higher the amplitude of the alpha and the severity of the theta rhythm and the lower the severity of the beta, the higher the strength of the process of inhibition. The higher the severity of the alpha rhythm and the less pronounced the beta, the higher the mobility of the nervous processes. The higher the severity and frequency of the alpha rhythm and the power of beta, but the less pronounced the beta and frequency of delta, the higher the balance of the nervous processes.

G. G. Knyazev et al. believe that the delta and theta oscillatory systems can be correlated with stem and limbic structures, and alpha and beta oscillations – with thalamo-cortical neural networks [12].

There are many assumptions regarding the functional role of the alpha rhythm [6, 17, etc.]. In particular, it is assumed that the alpha rhythm reflects the reverberation of excitations that create the optimal

background for receiving and processing the incoming signals. Theta rhythm is closely associated with emotional and mental stress, with short-term memory and emotions [18, 19]. When performing mental tasks, both delta and theta activity may increase [20]. Strengthening is associated either with emotionality or with the search for a correspondence between an external stimulus and some internal pattern.

This explains, on the one hand, the presence of stable and plastic EEG indicators of the functional state of the brain, and, on the other hand, the individual characteristics of the severity and correlation of these characteristics.

CONCLUSION

The data obtained indicate that the individual-typological features of a person considered in the work significantly differ in the severity and correlation of resistant (reproducible) and plastic (non-replicating) EEG indices. The results of the work allow us to draw the following conclusions:

1. Sustained EEG parameters were found in the groups of introverts and extroverts, strong and weak relative to the process of excitation, strong and weak relative to the process of inhibition, in inert and mobile subjects. In groups of emotionally stable and emotionally unstable individuals, balanced and unbalanced by the processes of arousal and inhibition of reproducing differences, it was not found. Thus, it is not possible to speak about the prediction of the functional support of a particular activity for all individual-typological characteristics of a person.

2. The individual-typological features considered in this work were to a greater extent associated with the plastic characteristics of brain activity, reflecting individual characteristics of the dynamics of the functional state of the brain in response to the influence of exogenous factors.

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