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PSYCHOPHYSIOLOGICAL BASIS OF INDIVIDUAL HUMAN BEHAVIORAL REACTIONS

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The aim of the research: *elucidation of autonomic dynamics (according to the electrical resistance of the skin) during functional load, taking into account the individual-typological properties of the nervous system and psychological qualities of the individual.*
Materials and methods. *Determined the functional mobility of nervous processes (FMNP, the method of M. V. Makarenko), electrical resistance of the skin (polygraph study), psychological personality traits (16-factor personality questionnaire by Cattell).*
Results. *The relationship between FMNP, individual parameters of skin galvanic response and some personality traits has been identified. The questions concerning the role of individual-typological properties of the nervous system in the development of autonomic reactivity, their connection with psychological personality traits, prediction of possible behavioural reactions and states are considered.*
Conclusions. *It was found that individuals with high FMNP in terms of sensorimotor response, more likely to have a variant of behavioral response, which is characterized by maximum speed and accuracy of the task, low anxiety. However, there is a risk of overstrain of the autonomic nervous system (according to the indicators of the phase electrical resistance of the skin (ERS)). In the case of low levels of FMNP, a variant of behavioural response with relatively low task efficiency, slow autonomic regulatory processes and a tendency to experience is more common. We claim that FMNP is involved in creating a neurodynamic, autonomic and psychological basis for individual behaviour during sensorimotor response in emotionally stressful conditions. The identified differences can be useful for determining the optimal area of professional activity, settling interpersonal relationships in the team, predicting the limits of acceptable actions and human actions, assessing the likelihood of risks of personal responsibility, the degree of stress, and so on*
Keywords: *functional mobility of nervous processes, psychological personality traits, electrical resistance of the skin*

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1. Introduction

The lifestyle of a person, his social behaviour, spiritual positioning are constantly manifested in numerous combinations of psychophysiological characteristics that form the basis of personality. Every person's life is an endless chain of diverse transformations (biological, psychological, social) that occur in response to the fleeting events of the surrounding world. At the same time, the phenomenon of adaptation, providing physiological and psychological adaptations, has clear individual behavioural manifestations in the ranges of emotional stress, plasticity of brain processes, motor activity, degrees of anxiety, etc. [1, 2]. Significant interest in the disclosure of the biological basis of human behavioural responses is constantly supported by a fairly large practical demand from medicine, physiology, psychology, law, pedagogy, sports [3–5]. Understanding the biological basis of human differences is not possible without taking into account the individual-typological features of higher nervous activity (HNA) [6]. One of the main genetically determined properties of nervous processes is their functional mobility (Holzinger's coefficient varies between 0.61–0.86) [7]. Such circumstances necessitate the elucidation of psychophysiological components of human behaviour depending on the individual properties of HNA, the peculiarities of the systems of regulation of physiological functions, their autonomic manifestations and the psychological structure of personality.

2. Literary review

Every year, the actual information on psychophysiological differences between people, which are increasingly used in the physiology of labour and education [8, 9]. The authors emphasize that the assessment of the functional state of the central nervous system in relation to individual-typological characteristics and the definition of individual psychological determinants of stress resistance is of particular importance [10, 11]. It is emphasized that the identified differences in the state of psychophysiological functions, for example in athletes with varying degrees of extremity of sports, can have prognostic value and be used to optimize sports improvement [12–14].

The interaction of the organism and the environment causes individual differences between people, which are manifested in a complex interaction between genetically determined and acquired during life psychophysiological properties. In the literature, there are experimental data that confirm the importance of the properties of HNA (strength, mobility, balance of nervous processes) in the development of various behavioural strategies that unfold under certain conditions of existence or activity [7]. It is proved that the spectrum of behaviour of each person, which is manifested in ability to work, the effectiveness of the work, style, volume, pace, especially in terms of time constraints or increasing the complexity of the task, depends on the degree of development of major nervous processes [6]. Individual psychological determinants related to stress resistance of athletes have been identified [15]. The results of the study indicate that the structure of stress resistance is balanced and contains such qualities as strength, stability, properties for self-regulation of behaviour and features of the nervous system that characterize the body's susceptibility to external events (emotional stability or neuroticism) [16]. Other researchers pay attention to the predisposition of a person to the development of somatic diseases depending on its individual psychological and neurodynamic properties [17]. Non-compliance of a certain set of psychophysiological properties with professional requirements leads to a violation of health. Researchers draw attention to the existence of individual differences in the autonomic and general reactivity of the body of students to the information load [18, 19]. There is an active search for ways to avoid states of excessive stress, which is based on established correlations between physical, neurodynamic and psychological components of personality [20, 21]. Nowadays, research related to the refinement of the criteria for polygraphic assessments and prediction of human functional states is gaining importance [22]. However, knowledge about the dependence of human behaviour on the psychological components of personality and their autonomic manifestations at present remain limited. Problems in elucidating the neurodynamic mechanisms of mental phenomena, their role in behavioural responses, the effects of living conditions on purposeful behaviour, and the autonomic characteristics of stress are still awaiting resolution. The different directions of scientific research are complementary, as they agree with the leading role of the neurodynamic basis for the development of behavioural response. At the same time, the results of complex studies that would take into account the level of major nervous processes, the range of autonomic response and psychological personality traits, obtained through the use of objective hardware methods are scarce. The scarcity of research is manifested by the lack of development of modern optimal methods for studying the reactivity of the organism and the assessment of individual psychophysiological characteristics of man. Taking into account the psychophysiological potential is extremely necessary for the development and individualization of modes of study, training, work, rehabilitation and correctional measures. It is possible that to determine the criteria for the individuality of behavioural reactions may be useful to study the variability of the autonomic reactivity of the electrical activity of the skin of persons with different properties of HNA, which will take into account the most stable personality traits.

The aim of the work is to determine the dynamics of autonomic parameters (electrical resistance of the skin) during functional load, taking into account the individual-typological properties of the nervous system and psychological qualities of the individual.

3. Research methodology

176 students aged 18-21 of Cherkasy National University named after Bohdan Khmelnytsky (2016–2018) were examined. From them 43 persons were selected (with high and low level of FMNP) and 2 groups of participants were formed: I group n=22, II group n=21 people, respectively with its high and low level. In groups of people with different FMNP, electrical resistance of the skin (ERS) was examined and psychological personality traits were tested. All individuals agreed to participate in the study, which was conducted in accordance with the provisions of the Declaration of Helsinki (1975, 1996–2013). This was confirmed by the Law on Bioethical Expertise No. 1 of 02.03.2021 of Cherkasy National University named after Bohdan Khmelnytsky (order on the establishment of a commission on bioethics No. 291 from 22.12.2015).

FMNP studies were performed on the computer system “Diagnost – 1M” (Ukraine) in the “feedback” mode according to the method of M. V. Makarenko [23]. The mobility of nervous processes was assessed by the time (seconds) of the test task for differentiation of 120 signals of sound modality. Pure sound signals with tones of 300, 600 and 1000 Hz were used. Two of them (300 and 1000 Hz) were positive, during their presentation the subjects had to press the appropriate keys with their left or right hand, and one brake (600 Hz), the presentation of which did not require pressing any of them. The faster the subject performed tasks related to the differentiation of auditory signals, the higher the ability of nervous processes he had. The use of “feedback” mode allowed the subject to adjust the supply of auditory signals at the optimal rate (the rate of stimulus varied within ±20 ms, depending on the erroneous reactions: in case of error, it decreased, and after the correct answer – increased).

As a functional load, the subject on the same device was offered to perform a test for sensorimotor response to a moving object [24]. Performing the test required pressing the right or left button. At the touch of a button, the subject should try to stop a moving object moving at a constant speed on a computer monitor in front of the cursor. The moment of movement of the object was set by the program, as well as the interval between individual launches, which varied in the range of 0.5–2.5 s. The number of tests was 30. The best result was chosen (from three series of tests).

Individual adaptive mechanisms of the organism were evaluated by the parameters of the skin galvanic reaction. To do this, during sensorimotor response to a moving object, ERS was recorded using a computer polygraph “Axciton” (USA) [25]. ERS reactivity was determined by the difference between the indicators of the skin galvanic reaction obtained in the background and the indicators recorded in situations

of false reactions. All subjects had approximately the same body area.

The study of psychological personality traits was performed on a 16-factor personality questionnaire Cattell [26]. The motivation for the successful implementation of sensorimotor response was to obtain additional points for the semester test.

Statistical processing of the obtained data was carried out by parametric statistics with significant differences in the obtained data by Student's t-test. It is necessary to indicate the names of the methods. Differences between groups and the presence of correlation were considered significant at $p<0.05$.

4. Research results

Analysis of sensorimotor response to a moving object in individuals with different levels of FMNP found that subjects with high levels were characterized by an average value of reactions that did not exceed 15.8±0.07 ms and allowed the least number of all deviations in advance or delay reactions. In all 3 series of tests, subjects with low FMNP levels showed significantly higher sums of all deviations, ranging from 41.2±0.06 ms and indicated a significantly lower accuracy ($p<0.05$).

It is known that the performance of any motivated task always contains a certain emotional component due to the participation of the autonomic nervous system in the regulation of behaviour [25]. The subject's attempt to make as few errors and inaccuracies as possible during the sensorimotor response, of course, required high concentration, concentration, accuracy, agility and speed, which activated the central and autonomic nervous system, increasing stress. Let us emphasize the well-known fact that in the conditions of excitement and activity ERS decreases [12].

It was found that during the errors (during the series of sensorimotor tests) there was a decrease in ERS in both groups. However, the extent of ERS reduction in the subjects of each group differed significantly. In Fig. 1 presents the differences in mean ERS values in groups of individuals with different levels of FMNP between the values recorded at rest and during erroneous reactions. All situations of erroneous reactions of the subjects in all series of the study were taken into account. Individuals with high FMNP were characterized by more rapid changes in the phased electrical response of the skin ($p<0.05$) during the sensorimotor test compared to those subjects who had a low gradation.

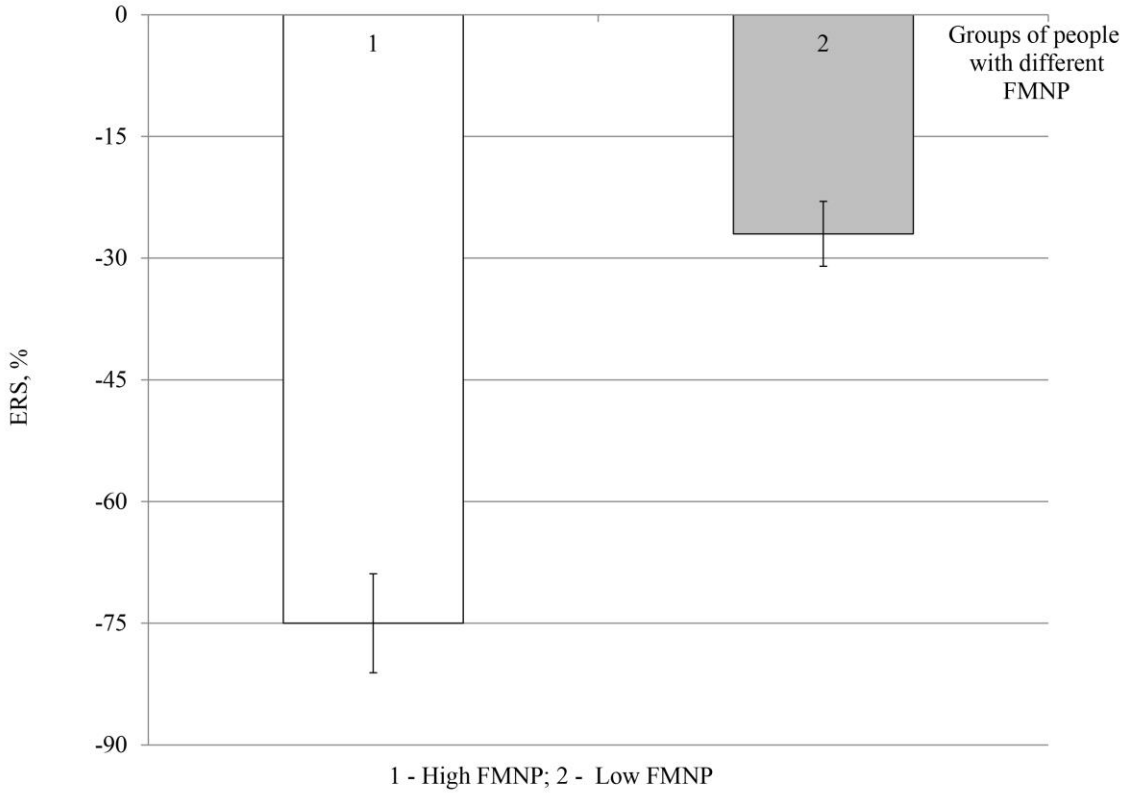

Fig. 1. ERS reactivity of persons with different levels of FMNP; * – the significance of differences $p<0.05$ relative to the low level of FMNP. Background indicators of the respondents are taken as 100 %.

For greater clarity of the individual differences of ERS established by us, we present the average values of galvanic activity of the skin of the examined K and C, which turned out to be the most pronounced in comparison with other persons (Fig. 2). The examined K had a high FMNP, and the examined C – its low level. The average values reflecting the background ERS of each subject are calculated from data recorded at rest in all 3 series of the study. The average values of galvanic activity of the skin, reflecting the fluctuations of its electrical resistance during the error, take into account all cases of erroneous reactions in these series of studies.

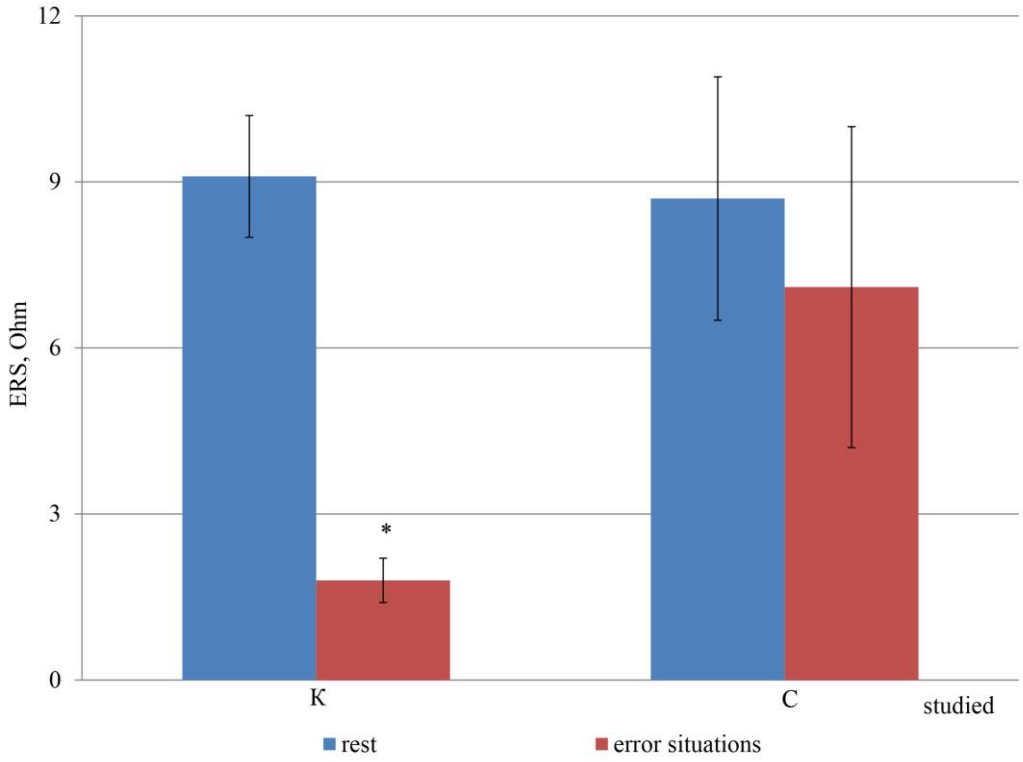

Fig. 2. The dynamics of the average values of ERS in the subject with high (K) and low (C) FMNP during sensorimotor response; * – the significance of differences p<0.05 relative to the low level of FMNP.

In order to assess the dynamics of ERS, the differences between the background indicators of the subjects and the indicators recorded in error situations in all series of studies were analyzed. It was found that the changes in the ERS of the examined K during the sensorimotor response to a moving object was 80.3 %, and the examined C only 17.1 %. Thus, the changes in the ERS of the examined K were almost 5 times more pronounced compared to the examined C. Similar differences in the autonomic reactivity of the ERS were observed between other individuals with high and low levels of FMNP.

It should be noted that the individual dynamics of ERS features of the regulatory mechanisms of the autonomic nervous system during sensorimotor response errors suggest that higher levels of FMNP may be accompanied by more pronounced phase changes in the skin galvanic response. Apparently, the perception, processing of information and issuance of the effector command in a person with high FMNP in a situation of erroneous reaction initiated the activation of the sympathetic nervous system. This was manifested by a significant decrease in ERS and may indicate the deployment of a less effective version of individual adaptive-regulatory regulatory autonomic mechanisms. In the case when the FMNP of the subject (which provides the speed and accuracy of sensorimotor response) [7] had a low gradation, the functioning of the regulatory mechanisms of the central nervous system was at a relatively lower level. Under these conditions, the erroneous response, although accompanied by an increase in emotional stress of the subject, but did not lead to a significant decrease in ERS and significant activity of the autonomic nervous system, which can be regarded as a better option for adaptive behavioural response.

The study of indicators of psychological traits of the subjects found some differences between individuals with high and low levels of FMNP on Catell's factors. Factors *H* (resistance to stress) and *G* (moral norms) were probably higher in the subjects with high FMNP, and the factor F_1 (anxiety) was the lowest (p<0.05). Subjects with low levels of FMNP were characterized by higher values of factor O (expectation of trouble), (p<0,05). Other psychological factors of both groups were within normal limits and did not differ statistically (p>0.05). Thus, the obtained indicators of psychological factors of subjects with a high level of FMNP indicated a greater ability to discipline, moral control of behaviour, lack of complexity, sufficient resistance to stress and less anxiety. At the same time, subjects with low FMNP levels looked more anxious and prone to trouble. In particular, most researchers believe that complex forms of behaviour and, especially, their component – anxiety, are largely determined by the individual-typological properties of HNA [2, 9, 27]. The authors emphasize that a number of components of anxiety (internal tension, insecurity, frustration) are the initiators of further reduction of stress resistance, which can be reflected in the nature of nervous processes that accompany active activities and may contribute to mental disorders [17].

The applied correlation analysis between the studied neurodynamic property of HNA, skin-galvanic parameters obtained in the conditions of false reaction and psychological factors of Cattell subjects indicated the existence of a connection between FMNP, ERS and factor F_1, (r=0.35–0.43, p<0.05), which characterizes the level of anxiety (high-low). Higher FMNP corresponded to lower levels of ERS and anxiety as a persistent personality trait.

5. Discussion of the research results

Thus, studies indicate that there is a link between individual typological properties of HNA, autonomic reactivity and psychological personality traits, which indicates the involvement of the studied psychophysiological characteristics in the development of individual style of human behaviour. Some of our data are consistent with the results of other authors obtained in athletes [16]. However, we emphasize that the results obtained by us in the imaging study can not claim to solve all aspects of the problem of psychophysiological basis of individual behavioural responses, although to some extent complement the information about the mechanisms of development of skin galvanic response in individuals with different FMNP and features of stable psychological personality traits. Moreover, our results indicate the existence of "points of intersection" of biological, psychological and social determinants of man, their involvement in the formation of the strategy of individual behavioural reactions.

Study limitations. It should be noted that the study of individual and typological properties of the higher parts of the central nervous system and their relationship with psychophysiological features of personality is not limited to clarifying only the problems of modern physiology HNA, labour, sports, but also touches on many aspects of medicine, pedagogy, psychology, sociology, ergonomics, etc.

Prospects for further research. The next task of the research of psychophysiological bases of individual behavioural reactions can become the analysis of their ontogenetic features. The accumulation of such data will contribute to the formation of theoretical and practical basis for career guidance work, identification of personality accentuations, prediction of deviant behaviour, interpretation of its autonomic manifestations.

6. Conclusions

1. It was found that people with high FMNP under conditions of sensorimotor response are more likely to develop a variant of behavioural response, characterized by maximum speed and accuracy of the task, low anxiety, but the threat of overexertion of the autonomic nervous system (according to phase ERS). In the case of a low level of FMNP, a variant of behavioural response with relatively low efficiency of task performance, slow autonomic regulatory processes and a tendency to experience is clearly manifested.

2. Based on the established dynamics of individual autonomic reactivity and identified correlations, we claim that FMNP participates in creating a neurodynamic, autonomic and psychological basis of individual behaviour during sensorimotor response in emotionally stressful conditions.

3. The established differences can be useful for determining the optimal sphere of professional activity, settling interpersonal relationships in the team, predicting the limits of acceptable actions and human actions, assessing the likelihood of risks of personal responsibility, the degree of stress and so on.

Conflict of interests

The authors emphasize the absence of conflict of interests.

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