

ОСОБЕННОСТИ ПСИХОФИЗИОЛОГИЧЕСКОГО СТАТУСА СУБЪЕКТОВ ЭКСТРЕМАЛЬНОЙ ДЕЯТЕЛЬНОСТИ

¹С. В. Котовская*, ²И. М. Бойко, ³И. Г. Мосягин, ²А. И. Хохрина

¹Государственный гуманитарно-экономический университет, Москва, Россия

²Северный государственный медицинский университет, Архангельск, Россия

³Главное командование Военно-Морского Флота Российской Федерации, Санкт-Петербург, Россия

По мнению многих отечественных и зарубежных ученых, способность человека в экстремальных условиях сохранять профессиональную работоспособность и интегрированное поведение в первую очередь определяют психофизиологические факторы. У специалистов экстремального профиля вследствие сознания угрозы для жизни присутствует постоянная готовность к действиям, не всегда ими осознаваемая.

Цель. В работе представлены эмпирические исследования психофизиологического статуса представителей различных трудных профессий, включающих на содержательном уровне экстремальный компонент (диспетчеров, военнослужащих, военных летчиков и специалистов, занимающиеся переработкой отработанного ядерного топлива — ОЯТ).

Материалы и методы. Психофизиологический статус выявлялся с использованием электроэнцефалографического исследования (ЭЭГ), данных простой (ПЗМР) и сложной зрительно-моторной реакции (СЗМР) и цветового теста М. Люшера в интерпретации И. Цыганок.

Результаты и их обсуждение. Наиболее высокая работоспособность обнаружена у пожарных и военнослужащих, наиболее высокие показатели наличия стрессового состояния, не выходящие за границу коридора нормы, характерны для моряков-подводников и специалистов по переработке ОЯТ. У подводников профессиональная нагрузка отразилась в увеличении индекса альфа-ритма, у военных летчиков уровень операторской работоспособности увеличился за счет активации компенсаторных механизмов.

Ключевые слова: морская медицина, психофизиологический статус, трудные профессии, экстремальный компонент, ПЗМР, СЗМР, ЭЭГ

*Контакт: Котовская Светлана Владимировна, s.marunyak74@mail.ru

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FEATURES OF THE PSYCHOPHYSIOLOGICAL STATUS OF SUBJECTS OF EXTREME ACTIVITY

¹Svetlana V. Kotovskaya*, ²Igor M. Boyko, ³Igor G. Mosyagin, ²Anna I. Khokhrina

¹State Humanitarian Economic University, Moscow, Russia

²Northern State Medical University, Arkhangelsk, Russia

³Chief Command of the Russian Navy, St. Petersburg, Russia

According to many domestic and foreign scientists, the ability of a person to maintain professional efficiency and integrated behavior in extreme conditions is primarily determined by psychophysiological factors. The specialists of extreme profile, due to the consciousness of a threat to life, there is a constant readiness for action, not always aware of them.

Aim. The paper presents empirical studies of the psychophysiological status of representatives of various difficult professions, including at the content level of the extreme component (dispatchers, servicemen, military pilots and specialists engaged in the spent nuclear fuel (SNF) recycling).

Materials and methods. Psychophysiological status was revealed with the use of electroencephalographic (EEG) study, data of simple (SVMR) and complex visual-motor reaction (CVMR) and color test of M. Lusher in the interpretation of I. Tsyganok.

Results. As a result of the study, it was found that the highest efficiency was found in firefighters and soldiers, the highest rates of stress, not going beyond the corridor standards are typical for submariners and specialists in the

SNF recycling. In submariners, the professional load was reflected by an increase in the rhythm index A, in military pilots the level of operator performance increased due to the activation of compensatory mechanisms.

Key words: marine medicine, psychophysiological status, difficult professions, extreme component, SVMR, CVMR, EEG

*Contact: *Kotovskaya Svetlana Vladimirovna, s.marunyak74@mail.ru*

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Introduction. Professions associated with high energy loads at appropriate levels of mental health on the background of the manifestation of various situation factors (danger, novelty, unexpectedness, uncertainty, high intellectual and psychophysical complexity, etc.) A. G. Maklakov (2004) refers to the category of difficult [10, с. 146]. According to V. I. Lebedev (2001), the threshold separating usual conditions from extremes is such situations when the adaptive barrier is broken, dynamic stereotypes in the central nervous system are «broken», and psychic disadaptation or crisis occurs [8, с. 92]. According to his observations, scuba diver, pilots and astronauts have a constant standby status due to life-threatening condition, which, however, is not always realized by them [9, p. 89]. The concept of extremity, considered by I. L. Napriev, E. V. Lutsenko and A. N. Chistilin (2008), includes environmental, personal and activity aspects [14, p. 62].

Professional activity, including extreme component on the content level, is a special kind of activity, presenting increased physical, psychological and psychophysiological requirements to a person. Registration of them contributes to successful performance of service and labor tasks and prevention of psychosomatic, psychovegetative and pathological organism changes of a subject. Undoubtedly, physiological, psychological and psychophysiological mechanisms determine the success of professional activity, especially for subjects of extreme profile, where the workloads may be prohibitive, and professional activity of specialists is carried out with the mandatory use of functional reserves of the organism [5, p. 82].

The greatest load in maintenance of professional activity of the person is the set of psychophysiological features that are designated in a modern science by the term «functional condition» [18, p. 6].

As numerous studies show, that psychological and psychophysiological factors primarily determine a person's ability to maintain work efficiency and integrated behavior under extreme conditions¹ [7, p. 85; 16, p. 17].

According to observations of V. I. Lebedev (2001), submariners, pilots and cosmonauts due to consciousness of threat to life are in a constant readiness for action which is not always realized by them. Such readiness, accompanied by the corresponding mental tension in an adequate form, is a natural reaction to danger [8, p. 103].

Flying in modern aircraft is accompanied by complex movements of aircraft in space, sharp maneuvers and, as a consequence, the influence of mechanical forces on the pilot, which can cause overloads and changes in the functions of body organs and systems. At the same time a military pilot is in a constant state of mental tension combined with complex coordinated actions under the influence of special environmental factors and extreme time constraints. V. L. Marischuk points out that a quality trained pilot in an environment of increased complexity and attention deficit can be guided by proprioception («body memory»), i.e. he can control based not only on acting but also on «acceleration signals remembered by the body» [11, p. 63].

Sensory stability and speed of sensory development, attentional skills (switchability of attention and its tempo, high concentration of atten-

¹ Chaikina G.V. Decision support System for evaluating the professional health of submarine crews: dis ... cand. techn. sciences. Moscow, 1988 (In Russ.). [Чайкина Г.В. Система поддержки принятия решений при оценке профессионального здоровья экипажей подводных лодок: дис. ... канд. техн. наук. М., 1988].

tion), intelligence are important in professional activity of dispatchers, which cannot be trained.

A fundamental feature of spent nuclear fuel (SNF) reprocessing technology, according to V. A. Kulagin, is its high radioactivity, which requires organization of biological protection for the facilities and a high level of automation and process control. Analysis of accidents with nuclear fuel has shown that it is impossible to create completely safe nuclear facilities, so additional safety measures must be observed: the use of neutron absorbers, restrictions on loads and concentrations of fissile substances, which increases requirements for the reliability of technological and emergency

content level included an extreme component, were examined.

The research was conducted in two stages:

1. In the first stage, psychophysiological data were collected before the impact of professional daily activities;

2. At the second stage, psychophysiological parameters changes after exposure to occupational loads of different duration were studied (flights, commencement of sea passage, fire response, disposal of radioactive substances, etc.).

The division according to the professional duties performed allowed us to distinguish 4 groups (Table 1):

Table 1

Distribution of respondents by professional group

Таблица 1

Распределение респондентов по профессиональным группам

№	Professional group	Number of respondents, n	Sample Percentage, %	Mean age
1.	Aviation dispatcher	Military 24	5,11	41,00±8,75
		Civilian 15		
2.	Servicemen on combat standby duty, guard duty with weapons	76	9,95	32,30±8,22
3.	Military pilots	transport aviation	9	12,30
		fighter aircraft	65	
		ground-based deck-based	20	
4.	Specialists involved in spent nuclear fuel recycling	79	10,34	29,14±6,39

control. SNF is a special type of waste that contains a large number of radionuclides (including highly hazardous radionuclides) with diverse nuclear-physical, radiation, and physical-chemical properties. The problem is that for each of them it is necessary to find a method of handling that would guarantee their safety for the natural environment during the entire period of storage [6, p. 125].

The studying of the psychophysiological status of a professional, especially in conditions of extreme activity, with possible risk for life in hysteresis (a property of an organism consisting in an instant response to the impact, depending on the current state and its past development) is now actual but underestimated direction of research in national and foreign psychology [13, p. 126].

The purpose of this study was to identify the characteristics of psychophysiological status in individuals whose professional field included an extreme component on a substantive level.

Materials and methods. To implement the goal of the study, 764 male subjects of different professional groups, whose daily activities on the

1. Aviation military (n=24) and civilian (n=15) dispatcher (n=39; average age 42.00 (35.00–49.00));

2. Servicemen on combat standby duty, guard duty with weapons (n=76; average age 31.00 (26.00–39.75));

3. Military pilots of transport (n=9) and fighter aircraft of ground (n=65) and deck (n=20) base (n=94; mean age 33.00 (29.00–37.00));

4. Specialists involved in SNF recycling (n=79; average age 28.00 (24.00–33.00)).

The subjects were examined by several methods after signing voluntary informed consent:

1. Evaluation of the functional state of the central nervous system (CNS) on the basis of simple visual motor reaction (SVMR) [12, p. 18].

2. Evaluation of the level of operator performance based on the complex visual motor reaction (CVMR) [12, p. 24].

3. Study of Brain Wave Activity (EEG).

4. Color test by M. Lucher [19, p. 168].

The results were processed on a PC using standard statistical methods Windows Millen-

nium Edition; Exel 1997 for Microsoft Office; SSPS 11.5, as well as standard calculation methods. The results are presented as median (Md), 25th (Q1) and 75th (Q2) percentiles (Md (Q1–Q2)). Statistically significant differences were recognized as $p \leq 0.05$ [16, p. 176; 17, p. 49].

Results and discussion. Interpreting the results of the eight-color subtest according to the methodological recommendations of I. Tsyganok (2007), it can be stated that dispatchers, servicemen, pilots, firefighters and specialists in the recycling of SNF are autonomous, active, initiative, independent, inclined to dominate, seeking self-assertion and success (statistical significance $p \leq 0.05$). Soldiers and combatants took an interest in the environment as an object of influence or a source of assistance and did not focus on their own problems. Doctors and combatants have a balanced personality that forms a holistic complex. The highest work efficiency was found in firefighters and soldiers. The highest indicators of stress conditions not going beyond the norm were found in sailors-submariners and specialists in the recycling of SNF.

Specialists involved in SNF recycling showed an increased level of mental tension and decreased nervous and mental stability. Their potential for expedient activity was reduced, which encouraged them to do things forcibly. Volitional self-control was presented constantly, but it was regularly depleted, and as not being connected with direct satisfaction from the process and results of activity, it further increased mental fatigue. Intensive and long work of doctors and specialists involved in the recycling of SNF required a lot of stress from the nervous system and the psyche. Productivity of work and quality of its performance were not equal in different time periods. The general emotional tone was characterized by increased excitability, anxiety and uncertainty. In a stressful situation, there was probably a disturbance of activity.

Dispatchers, servicemen, sailors — supermariners, sailors — submariners, combatants, pilots, fishermen and firefighters showed an average level of unproductive tension. They coped with their duties within the limits of social demands. In a familiar environment, having enough time to switch over, they went from work to rest and back, from one activity to another without any significant difficulties. If necessary, they are able to overcome fatigue by force of will, but after that, the ability to work for a long time decreased.

Sailors — supermariners, sailors — submariners, doctors, fishermen and firefighters found the installation to optimize the use of force. There was a moderate need to restore strength and rest. Their energy potential is low, but sufficient for successful activity in the usual quiet conditions. Temporary effective mobilization is possible in the face of danger, which was reflected in an extreme situation as a delay in orientation and decision-making.

The least cohort including dispatchers, servicemen, combatants, pilots and specialists in the recycling of SNF showed psychophysiological mobilization and attitude to activity. They have optimal readiness to apply physical and mental forces, moderate active excitement. These subjects were not afraid of encountering difficulties and felt able to overcome a lot. In an extreme situation, a high speed of orientation and decision making, expediency and success of actions are likely.

According to the CVMR data, the margin of safety for dispatchers, servicemen, pilots, and SNF recycling specialists was above 50%, and it was prevailed among the military. Dispatchers and specialists in SNF recycling had reduced quality of the test execution but their reaction rates was higher than average, and the level of operator efficiency was reduced (Table 2).

The military was characterized by a high rate of CVMR with low test quality. Unstable, impulsive responses to stimuli were observed. There was a pronounced focus on speed to the detriment of error-free action. The level of operator performance was low. Pilots had test quality and reaction speed above average and the level of operator performance was high. The average time of the CVMR for the soldiers was assessed as high, while in other groups it was above average.

Analysis of the EEG showed that the EEG pattern of dispatchers (group 1) and Sailors — supermariners (group 3) was dominated by alpha rhythm (the index reached 70–75%) with reduced amplitude characteristics and smoothness of zone differences. The data of the EEG can be attributed to type I–II of the EEG according to E. A. Zhirmunskaya classification (Table 3).

According to SVMR the level of activation of CNS of military pilots did not change after exposure to occupational loads and corresponded to the average one. Stability of reactions improved from above average to high. The level of sensorimotor reaction increased (average and high correspondingly). Before exposure, the quality of test

Table 2

Psychophysiological status of persons of extreme professions before professional loads exposure according to CVMR, Md (Q1–Q3)

Таблица 2

Психофизиологический статус лиц экстремальных профессий до воздействия профессиональных нагрузок по данным СЗМР, Md (Q1–Q3)

Criteria	Professional group			
	Dispatcher	Servicemen	Military pilots	Specialists in spent fuel recycling
CVMR integrated reliability index, %	55,14 (37,17–62,86) [×]	60,46 (53,18–68,57) ⁺	59,16 (54,28–67,70) [‘]	55,07 (46,46–62,08) [*]
CVMR net error	3,00 (1,00–5,00) [^]	5,00 (2,75–8,25)	3,00 (2,00–7,00)	4,00 (1,75–8,50) [*]
CVMR error-free level	2,00 (2,00–4,00) [^]	2,00 (1,00–2,25)	2,00 (1,00–3,00)	2,00 (1,00–3,25) [*]
CVMR average reaction time, msec	433,00 (398,00–493,00) [^]	404,00 (372,50–436,25) ⁺	419,50 (375,00–448,50) [‘]	436,50 (409,00–476,50) [*]
CVMR level of performance	4,00 (3,00–5,00) [×]	5,00 (4,00–5,00) ⁺	4,00 (4,00–5,00) [‘]	4,00 (3,00–4,00) [*]

* – Statistically significant differences ($p < 0.05$) in the data H – Kruskal–Wallis criteria for 4 independent groups;

[^] – Statistically significant differences in the data U – Mann–Whitney criteria for dispatchers and servicemen;

[×] – Statistically significant differences in the data U – Mann–Whitney criteria for dispatchers and pilots;

⁺ – Statistically significant differences in the U data – Mann–Whitney criteria for servicemen and specialists in spent fuel recycling;

[‘] – Statistically significant differences in the U data – Mann–Whitney criteria for pilots and specialists in spent fuel recycling.

execution and reaction rate were above average (Table 4). The level of operator performance in military pilots according to CVMR was high. After exposure, the reaction rate was evaluated as high with reduced test quality. Unstable, impulsive reactions to stimuli were observed. The speed was set to the detriment of faultlessness of actions. The level of operator performance was reduced. The level of CVMR stability changed statistically significant, but it was within the range of above average level (Table 4).

In researches of Kulagin V.A., Lebedev V.I., Marischuk V.L., Oboznov A.A. it is affirmed, that in conditions of partial or full isolation the person is exposed to certain factors which cause a condition of mental tension, and at their intensive or long term influence lead to stress. In the psychophysiological status there are significant changes in the alpha rhythm frequency, the efficiency of thought processes decreases, there is a feeling of anxiety, worry, depression [6, p. 125; 11, p. 63]. The results of our research confirm the data obtained by the above-mentioned authors.

Of interest for discussion is the comparison of the results of the work with studies of the psychophysiological features of specialists in difficult professions, which include an extreme compo-

nent at the content level, conducted by other authors in different years.

N. Y. Vlasenko et al. in their study of the SVMR found that the values of mean reaction time (MRR) and standard deviation (SD) at the beginning of the shift in the firefighter-rescuers of the studied groups corresponded to the average level and had no statistically significant differences. This combination of rapidity and stability indicated a steady state of regulatory mechanisms. The high level of error-free performance at the beginning and at the end of the shift testified to the reliability of their CNS functional state [2, p. 230]. In our study, the level of activation of the CNS of military pilots after exposure to occupational loads did not change and corresponded to the average. At the same time, the stability and the level of sensorimotor reactions changed to high.

According to Y. P. Ignatova et al. the high level of SPMR stability characterizes a stable level of activity, preservation of high working capacity for a long time in extreme conditions [4, p. 40].

A. A. Zemskova and N. A. Kravtsova showed on the example of cadets of Russian Emergency Ministry that the brightest indicator of CVMR turned out to be stability. In extreme labor conditions the high level of stability of adaptive reactions is char-

Table 3

Psychophysiological status of persons of extreme professions before professional loads exposure according to EEG, Md (Q1–Q3)

Таблица 3

Психофизиологический статус лиц экстремальных профессий до воздействия профессиональных нагрузок по данным ЭЭГ, Md (Q1–Q3)

Параметры	Профессиональные группы			
	Dispatcher	Servicemen	Military pilots	Specialists in spent fuel recycling
α -rhythm F1 lead average frequency, Hz	10,05 (10,00–0,25)*	9,80 (9,50–10,100)	10,05 (9,70–10,20)	10,10 (9,57–10,57)
α -rhythm F3 lead average frequency, Hz	10,00 (9,82–10,17)*	9,80 (9,50–10,10)	10,10 (9,70–10,22)	9,95 (9,60–10,37)
α -rhythm P3 lead average frequency, Hz	10,20 (9,85–10,57)*	10,00 (9,70–10,30)	10,20 (9,97–10,42)	10,30 (9,77–10,50)
α -rhythm P3 lead maximum frequency, Hz	10,00 (10,00–11,10)*	10,00 (10,00–10,00)	10,00 (10,00–11,10)	10,00 (10,00–11,10)
α -rhythm P4 lead average frequency, Hz	10,45 (10,07–10,67)*	10,00 (9,80–10,20)	10,20 (9,90–10,40)	10,10 (9,77–10,42)
α -rhythm P4 lead maximum frequency, Hz	10,55 (10,00–11,10)*	10,00 (10,00–10,00)	10,00 (10,00–11,10)	10,00 (10,00–11,10)
α -rhythm Q1 lead average frequency, Hz	10,15 (9,87–10,55)*	10,00 (9,90–10,40)	10,20 (10,10–10,50)	10,35 (9,65–10,55)
α -rhythm Q2 lead average frequency, Hz	10,30 (10,05–10,47)*	10,00 (9,70–10,30)	10,20 (10,00–10,50)	10,05 (9,70–10,52)

* – Statistically significant differences ($p \leq 0.05$) according to Kruskal–Wallis H-criterion for 4 independent groups.

Table 4

Dynamics of psychophysiological status of military pilots, Md (Q1–Q3)

Таблица 4

Динамика психофизиологического статуса военных летчиков, Md (Q1–Q3)

Criteria	Exposure to professional load	
	Before exposure	After exposure
SVMR average reaction time, msec	216,50 (203,00–231,50)*	217,50 (202,00–227,50)
SVMR standard deviation, msec	41,50 (30,00–58,25)*	35,00 (27,25–42,25)
CVMR response stability assessment	0,24 (0,07–0,60)*	0,55 (0,26–0,81)
CVMR total error rate	3,00 (2,00–7,00)*	2,00 (1,00–4,00)
CVMR average reaction time, msec	419,50 (375,00–448,50)*	367,00 (337,50–407,50)
CVMR standard deviation, msec	83,00 (69,25–100,75)*	69,50 (61,25–86,25)

* – Statistically significant differences ($p \leq 0.05$) from the data of the Wilcoxon criterion for two related samples of groups. CVMR – complex visual motor reaction, SVMR – simple visual motor reaction.

acterized by a stable level of activity and interaction of functional systems, the preservation of high efficiency over a long period of time [3, p. 48–49]. In our studies in the group of military pilots, the index of the stability level of CVMR changed statistically significantly, but at the same time, it was within the limits of above average level.

In works of some authors it has been established that the structure and level of tension of components of functional systems depends on type of carried out sensorimotor reaction (SMR). At realization of CVMR the frontal cortex is in-

cluded in functional system constantly, and at SVMR this link is curtailed. Performance of SMR is connected with certain volitional efforts. These studies have shown a reliable dependence of the temporal parameters of perception and sensorimotor response on the characteristics of brain electrical activity. According to the authors, only the peak (energy-dominant) frequency in the alpha-rhythm range, which determines the speed of SMR, is most likely related to the origin of the «central delay» in SMR (the difference between the time values of simple

and complex SMR) [20, pp. 2832, 2834]. In our studies, no statistically significant differences were found in the EEG pattern in all groups.

Comparing our EEG results with those of Butova O.A. and Grishko E.A., we can clearly see the predominance of alpha-band waves in the total spectral power of the rhythm in persons with difficult occupations, in contrast to those of conscripts of the Defense Ministry. The prevalence of fast-wave processes, mainly due to beta-rhythm (β), over the expression of alpha-band waves was found in them, which indicated their stressful state [1, p. 5].

Thus, the results of our studies confirm the data obtained by other authors that the speed and accuracy characteristics of SMR are not stationary values but fluctuate in the presence of external disturbing influences on the CNS and depend on the type of professional activity, work

experience, stability of attention, and level of mental tension [20, p. 2832, 2834].

Conclusion. As a result of the study it was found that according to psychophysiological features the specialists involved in the recycling of SNF show an increased level of mental tension. The highest work efficiency was found in firefighters and servicemen. The highest stress indicators, which are not beyond the norm limits, were found in sailors-submariners and specialists in recycling of SNF. Before the military pilots' professional load, the level of operator efficiency was higher than that of servicemen, in our opinion, due to their acquired skills. The submariners' professional load was reflected in an increase in the A Rhythm Index, while the military pilots' operating efficiency increased due to the activation of compensatory mechanisms.

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Авторство:

Вклад в концепцию и план исследования — И.Г.Мосягин. Вклад в сбор данных — С.В.Котовская. Вклад в анализ данных и выводы — С.В.Котовская. Вклад в подготовку рукописи — И.М.Бойко, А.И.Хохрина.

Authorship:

Contribution to the concept and plan of the study — I.G.Mosyagin. Contribution to data collection — S.V.Kotovskaya. Contribution to data analysis and conclusions — S.V.Kotovskaya. Contribution to the preparation of the manuscript — I.M.Boyko, A.I.Khokhrina.

Сведения об авторах:

Котовская Светлана Владимировна — кандидат биологических наук, доцент, заведующий кафедрой педагогики и психологии федерального государственного бюджетного образовательного учреждения инклюзивного высшего образования «Государственный гуманитарно-экономический университет», г. Москва, ул. Лосиноостровская, д. 49; e-mail: s.marunya74@mail.ru;

Бойко Игорь Михайлович — кандидат медицинских наук, доцент, доцент кафедры мобилизационной подготовки здравоохранения и медицины катастроф федерального государственного бюджетного образовательного учреждения высшего

образования «Северный государственный медицинский университет»; 163000, г. Архангельск, Архангельская обл., Троицкий пр., д. 51; e-mail: imboyko@mail.ru;

Мосягин Игорь Геннадьевич — доктор медицинских наук, профессор, начальник медицинской службы Главного командования Военно-Морского Флота, 191055, Санкт-Петербург, Адмиралтейский проезд, д. 1; e-mail: mosyagin-igor@mail.ru;

Хохрина Анна Игоревна — аспирант кафедры семейной медицины и внутренних болезней федерального государственного бюджетного образовательного учреждения высшего образования «Северный государственный медицинский университет»; 163000, г. Архангельск, Архангельская обл., Троицкий пр., д. 51; e-mail: anna.boyko@mail.ru.

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