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Features of the influence of working conditions on psychophysiological functions of unmanned aircraft systems operators

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This study was conducted to determine the influence and assess the impact of specific factors of working conditions on the psychophysiological functions of Unmanned Aircraft Systems (UAS) operators. The research involved 41 military personnel (men aged 20-35 years old) who operated the I class "Light" UAS and were engaged in a varied range of professional tasks. The aim was to understand the complex impact of these distinct factors on operators during the execution of their duties. To examine their psychophysiological status, we employed modified methods using the PFI-2 hardware/software complex. The following indicators were determined: accuracy of reaction to a moving object, strength of nervous processes, functional mobility of nervous processes, simple visual-motor reaction, complex visual-motor reaction, orientation in space, and visual memory. The role of climatic and microclimatic factors in professional activity was studied using a questionnaire, where their influence on functional status was assessed on a 100-point scale. To facilitate further theoretical development and practical application, we determined the investigated factors integral impact on shaping operators' subjective perception and specific psychophysiological qualities that are professionally significant for military personnel. The preliminary analysis showed the heterogeneity of feelings the influence of various components of the external environment factor. To correct this heterogeneity, we used the non-linear correction method (logarithmization of analyzed data, when large values of an analyzed parameter could be reduced due to the properties of logarithmic function). Then, a correlation (Spearman correlation coefficient) and regression analysis of studied parameters has been carried out with a preliminary check of the structure of operator perceptions for normality using the Shapiro-Wilk test. As a result, a list of psychophysiological qualities that change under the influence of the external environment factor in individuals with different perceptivity to its components has been selected.

Key words: remote pilots; unmanned aircraft complex; working conditions; occupational suitability; functional state; perception.

INTRODUCTION

In recent years, the development of unmanned aircraft systems (UAS) has undergone significant progress, constantly expanding their capabilities, they are becoming an integral part of modern airspace. Due to their automated capabilities and high efficiency, they have found wide application in various fields, including search and rescue operations, the agricultural sector, scientific research, logistics service, and also have a huge potential in military operations becoming more and more popular and available in various fields of activity [1, 2].

However, with the growing role of UAS in various spheres of activity, there is a need to study the impact of working conditions on the psychophysiological functions of operators who manage these systems [3, 4]. Since UAS can carry out missions in dangerous, hard-to-reach and remote areas, operators are in different working conditions than those associated with conventional piloting [5]. Such conditions can affect the physical and psychological condition of operators, as well as their cognitive abilities and decision-making [6, 7].

Among the factors that researchers pay a lot of attention to, one can highlight the level of stress, the length of the working day, fatigue, and monotony of work. Undoubtedly, these factors can affect the mental state of operators, as well as their cognitive and psycho-motor abilities [8, 9]. In addition, the increased load on the visual and cognitive human systems can lead to a decrease in work quality and an increase in the error risk [10, 11].

The influence of individual parameters of working conditions and their complex effect on the psychophysiological functions of UAS operators in the process of performing their occupational duties remains insufficiently studied. In this article, we will consider the results of research on the influence of environmental factors on the functional state of UAS operators, the assessment of the degree of influence of the components of the external environment on their emotional state, and the level of connection between the evoked emotions and certain occupationally important psychophysiological qualities. In addition, a comprehensive understanding of these mechanisms can help to develop new possible approaches to occupational selection and measures that will help reduce the negative impact of working conditions and improve the work of UAS operators.

METHODS

41 servicemen, men aged 20-35 years old, who had experience in managing I class UAS "Light" and were involved in the performance of a wide range of occupational tasks, have been studied. Using a specially developed questionnaire that included questions about the influence of climatic and microclimatic factors on occupational activity, their perceptions of functional status were assessed on a 100-point scale. The questionnaire took into account 13 main climatic and microclimatic factors that may affect the reliability of the functional duties performance of UAS operators.

To study the psychophysiological status of UAS operators, modified methods have been used using the PFI-2 hardware and software complex [12]. With its help, the following indicators were determined: the accuracy of the reaction to a moving object (RMO), the strength of nervous processes (SNP), the functional mobility of nervous processes (FMNP), simple visual-motor reaction (SVMR), complex visual-motor reaction (CVMR), orientation in space (OS), visual memory (VM). In order to take into account the possible influence of different experiences of using the computer keyboard on the results of the study, we applied the same technique of performing simple motor actions while solving tasks that differed in tempo and content. This allowed us to assume that the reaction of the research participants depends mainly on the component related to the perception and processing of information. Thus, we excluded the possible influence of computer keyboard skills on the obtained results.

At the Ukrainian Military Medical Academy, the materials of this research were reviewed by the ethics commission. These materials do not pose a high risk to the research participants and were conducted in accordance with the ethical norms and standards for conducting research, Protocol dated 06.11.2021 No. 212. The Spearman correlation coefficient was applied, as well as regression (the Shapiro - Wilk test was applied) and factor analysis using the STATISTICA 13.3 software package, license AXA905I924220FAACD-N [13].

RESULTS AND DISCUSSION

First of all, it should be emphasized that the perception of the external environment is a complex systemic process. This system consists of many components: the state of the human body, the emotional state of a person and its perceptivity to the influence of harmful external environmental factors, and the structure and level of harmful environmental factors. From this thesis, it can be concluded that the influence of environmental factors on the human body consists of several important components: the level of influence on the emotional state of a person by the components of the external environment and the level of connection between the evoked emotions and certain occupationally important psychophysiological qualities of servicemen.

Data on the impact of various hygienic factors on the functional state of UAS operators were previously published in [14]. In this work, the proposition about the heterogeneity of the perception of certain external environment factors by different groups of operators has been substantiated. A group of conditionally "hypo-perceptive" and a group of "hyper-perceptive" operators to the action of harmful factors of the external environment have been identified. However, in order to carry out further theoretical developments and practical application, it is necessary to determine (perhaps with less accuracy) the integral influence of the studied factors on the corresponding subjective formation of operators' perceptions and its effect on certain occupationally important psychophysiological qualities of military personnel.

The graph regarding the average group effect of individual factors of the external environment on the body of UAS operators is presented in Fig. 1. It should be specified here that the effect of each studied component was very different from each other and did not exceed 45% of the possible maximum effect of this component on the operator's body. The greatest impact can be seen in the presence of a thunderstorm. Perhaps such a phenomenon was caused by many reasons, among which it was necessary to note the increased risk of destroying the drone and harming the operator's health, as well as a complex of meteorological phenomena accompanying a thunderstorm.

The second place in terms of the intensity of negative emotional shifts in the operator, which exceeds 40%, was the "level of exposure to polluted air." This phenomenon interfered with the accurate performance of a combat mission, as this requires good visibility of surveillance objects. The third most important, in terms of negative impact on the human body, was the impact of low temperatures on it, the average estimate of which reaches 40%. The intensity

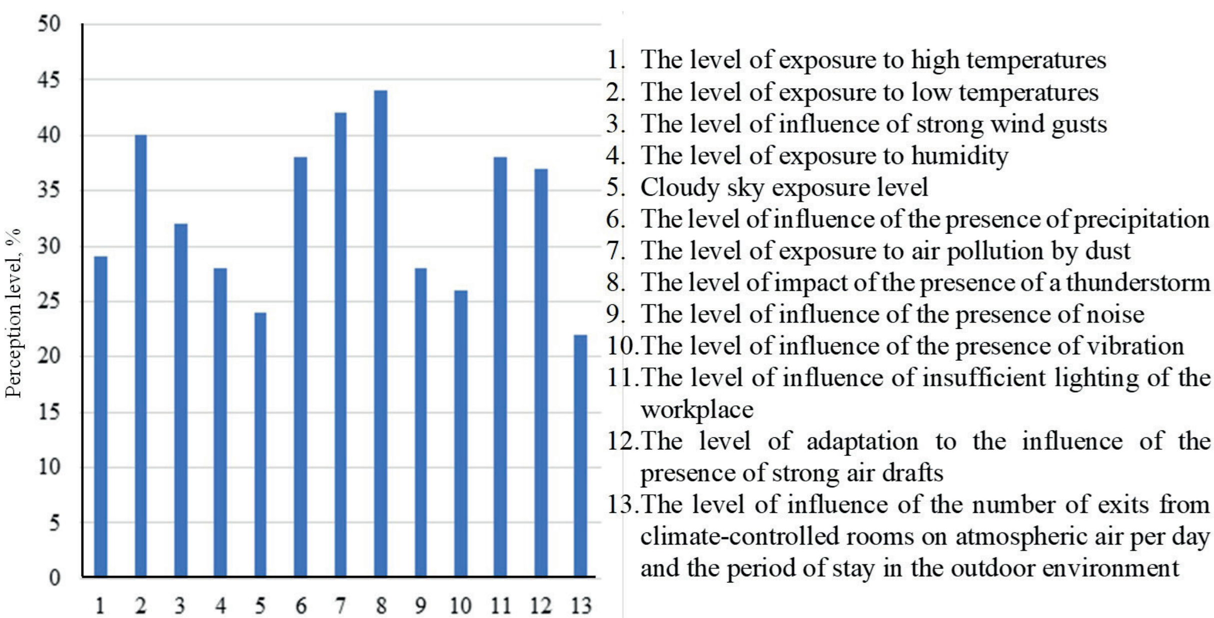

Fig. 1. Perceptions of the external environment factors' components among UAS operators (in % of the possible maximum effect of this component influence on the human functional state)

of the effect of this component of the environmental factor indicated the insufficiency of the available clothing to ensure comfortable work in the natural environment.

The following three factors affected the operators' perception of somewhat weaker, the intensity of their influence varied between 35-40%. These included the following components: "level of influence of precipitation", "level of influence of insufficient lighting" and "level of adaptation to air drafts". From the listed factors, it was clear that weather conditions were the biggest obstacle when the "operator-drone" system performed combat missions.

The intensity of other perceptions from the influence of the components of the external environment factor was also sufficiently large, which emphasized the importance of their research for the development and implementation of measures to rationalize the process of using drones in combat conditions.

Additional valuable information was contained in the parameter of variation of indicators of perception intensity in operators from the influence of the external environment. The diagram containing this information is presented in Fig. 2. The fact was that the investigated group of operators (as emphasized earlier) was not homogeneous. The dispersion of each of the studied indicators allowed us to roughly estimate the degree of heterogeneity of each of the studied indicators, which allowed us to see the degree of instability of the operators' perceptions from the action of each studied component of the external environment factors.

The indicator of perception from the thunderstorm turned out to be the most unstable. It exceeded 1000 u.o. It can be assumed that the complex of dangers caused by the factor of the thunderstorm presence had great importance for some operators and lead to the collision of two behavioral strategies: to quickly hide from the thunderstorm in a dangerous place or to perform the assigned task in these dangerous conditions. As a result of the collision of these opposite strategies, high neuro-emotional tension was formed, and occupational efficiency decreased, which was the basis for the emergence of a circle of feedback loops that increased and continuously maintained a high level of this tension.

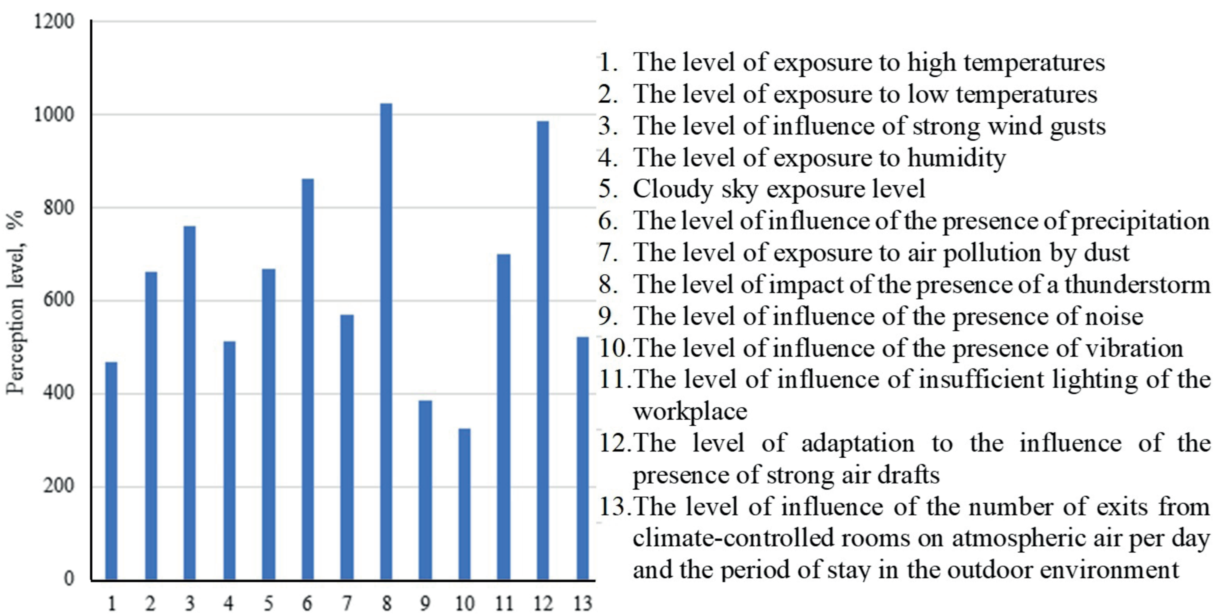

Fig. 2. Dispersion of perceptions due to the influence of the components of the external environmental factors on the UAS operator (in % of the possible maximum effect of this component on humans)

The level of adaptation to air drafts was also the source of the appearance of high heterogeneity of perceptions in the studied group. One got the perception that the operator's adaptability to the action of this external environment component largely depends on his personal perceptivity, which differed significantly among different people. Weather conditions had a considerable influence on the quality of the drone's flight. This was due to the relatively small size and low power of aircraft of this class. However, the skill of the operator significantly affects the quality of the combat mission. Therefore, a possible double source of the appearance of high variability of the impact of precipitation on the operator's performance was the weather conditions during the flight and the skill of the operator's occupational activity. For the same reasons, there was a fairly significant variability of operators' perceptions of the effect of other weather components: "level of influence of strong wind", "level of influence of cloudy sky" and "level of influence of insufficient lighting".

Here, it was appropriate to discuss three analyzed parameters, which had a high level of perceptions of their action and a high level of variability: "level of influence of thunderstorms", "level of influence of precipitation" and "level of adaptation to air drafts". In this phenomenon, a big role was played by "hyper-perceptive" operators, which made the distribution structure of each among these significantly asymmetrical perceptions. It could be thought that the presence of such operators in the group significantly reduced the quality of the performance of combat tasks, possibly due to their low stress resistance and impulsivity. However, this hypothesis needs to be carefully examined.

The conducted analysis once again showed the presence of heterogeneity of perceptions to the action of various external environment factors' components. A particularly important role of this heterogeneity was played by "hyper-perceptive" individuals, who distorted the structure of the distribution of many components of the environmental factors. This significantly complicates the search for correlations between the components of the working environment and the psychophysiological qualities inherent in each operator due to the formation of the so-called "false correlation". To eliminate this shortcoming, it makes sense to formulate a hypothesis according to which the perception of the external environment factors' components in "hyper-perceptive" persons is overestimated, which does not reflect the real state of affairs. In order to "linearize" the operators' perceptions, it was necessary to reduce the level of detection of the perceptions of "hyper-perceptive" persons by applying the techniques of non-linear correction of their values. One of the popular methods of such "linearization" is the logarithmization of the analyzed data, when large values of the analyzed parameter will be reduced due to the properties of the logarithm function. Thus, each of the analyzed parameters was changed according to the formula $y_i = \ln(x_i)$, where i = 1,2,3,... This transformation gave hope to correct the structure of each indicator and made it "normal".

Subsequently, a correlation (Spearman correlation coefficient) and regression analysis of each studied parameter was carried out with a preliminary check of the structure of the operator's perceptions for the "normality" of the distribution structure using the Shapiro-Wilk test. As a result, the following correlation pairs were selected.

Elevated temperatures (according to the criterion of normality of the structure of their distribution Shapiro-Wilk $P = 0.00006$) determined the effect on FMNP by $d = 11.6\%$ ($P < 0.05$). The constructed regression line based on these data had the following form (Fig. 3). It can be seen that an increase in the temperature of the external environment contributed to the deterioration of the number of completed tasks when testing FMNP in individuals who were characterized by hyper-perceptivity to the effect of this characteristic of the external environment. Therefore, it can be assumed that increased perceptivity to the action of high temperatures was somehow correlated with human reactions to the appearance of excitatory and inhibitory stimuli.

The following correlation of the influence of the level of human perceptivity to elevated ambient air temperatures was found with the indicator of orientation in space – the delay time (the coefficient of determination shows what proportion of the variance of the resulting characteristic is explained by the influence of another variable – d = 10.8%; $P < 0.05$). The constructed regression line based on these data had the following form (Fig. 3). In this case, increasing the level of perceptivity to the temperature of the external environment contributed to the deterioration of the indicator of orientation in space - the delay time. That was, the accuracy of the response to a moving object decreased, which lead to a more noticeable chaos of the operator's corresponding reactions.

Another significant correlation of the influence of the level of human perceptivity to elevated temperatures was found according to the indicator of orientation in space, namely the anticipatory time (d = 20.9%; $P < 0.05$). The constructed regression line based on these data had the following form (Fig. 3). That was, an increase in the level of human perceptivity to elevated temperatures of the external environment contributed to an increase in the delay of the indicator of orientation in space – the anticipatory time. In the described case, the accuracy of responding to a moving object decreases. Taking into account the previously presented information about the decrease in the level of the anticipatory time of reaction with increased perceptivity to the effect of high temperatures

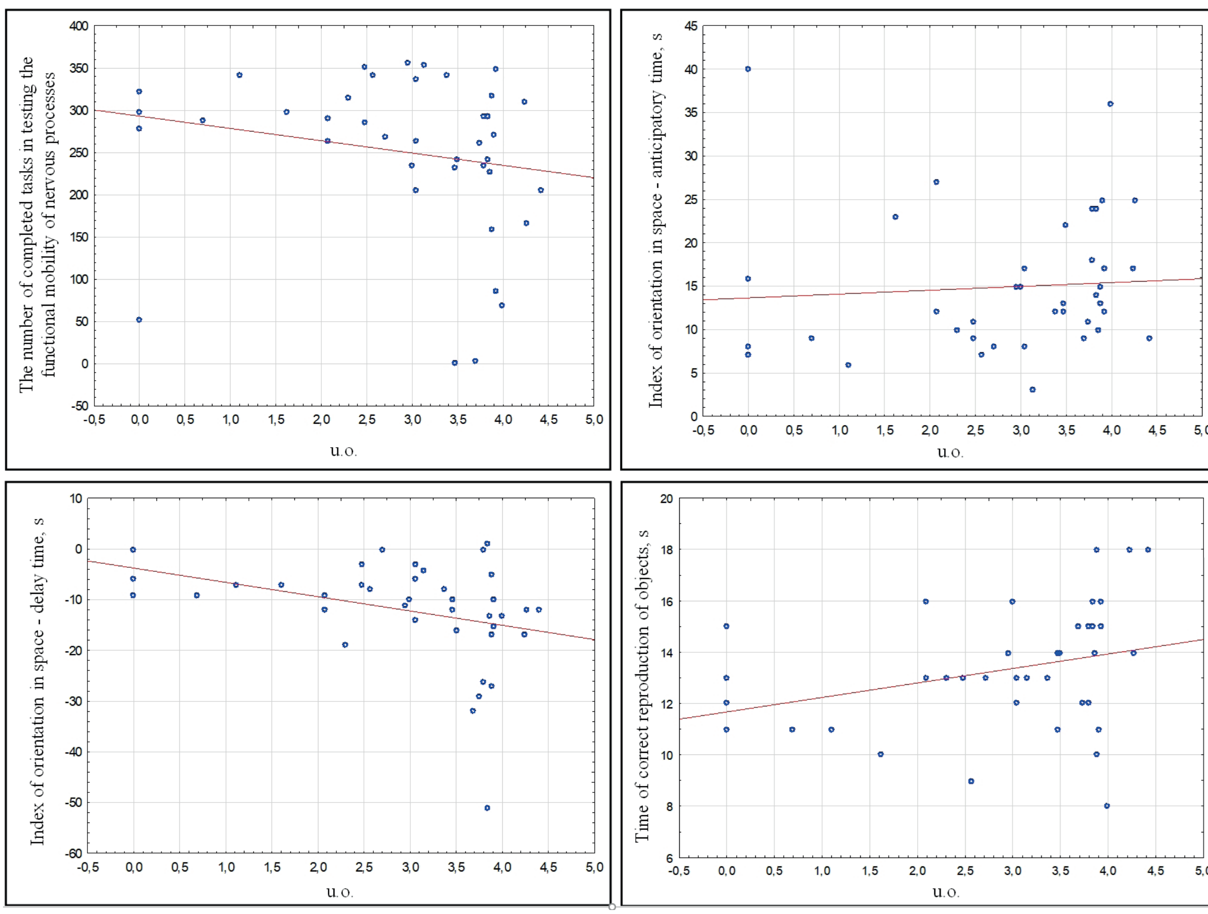

Fig. 3. Regression lines of psychophysiological indicators depending on the individual perceptivity to elevated air temperatures of the external environment. Along the abscissa axis is the logarithm of perceptions from the level of human perceptivity to elevated air temperatures of the external environment, u.o.

and the ascertained increase in the delay time of the discussed reaction in these conditions, the conclusion was suggested that the increased perceptivity to the effect of high temperatures in the operator's working area caused a significant decrease in the reliability of his occupational activity, namely contributed unpredictable decrease in the accuracy of his reactions.

Another significant correlation of the increased perceptivity effect from environmental high temperature was found with the short-term memory indicator, namely the time of correct pointing (d = 12.1%; P < 0.05). The constructed regression line based on these data had the following form (Fig. 3). In this case, it could be seen that perceptivity increasing among operators to the high temperature of the external environment entailed a deterioration of the quality of short-term memory and increasing the object reproduction time.

Reduced temperatures (according to the criterion of normality of the structure of their distribution, Shapiro-Wilk P = 0.00002) determined the effect on SVMR by d = 10.5% (P < 0.05). The regression line based on these data had the following form (Fig. 4). That was, reduced levels of the external temperature contribute to the deterioration (increase in the level) of the SVMR. This indicated the deterioration of the operator's reactions to different signals and the appearance of different color signals.

The comfort of work was also transformed at low temperatures if it was evaluated by the index of orientation in space (time of delay) d = 18.3% (P < 0.05). The regression line based on these data had the following form (Fig. 4). That was, reduced levels of the temperature of the external environment contributed to the deterioration (increase) of the delay in determining the sides of the world when testing orientation in space. This indicates the deterioration of the quality of the operator's orientation in space (one of the key indicators of task performance).

The work of the operators was influenced not only by the temperature factor. This state was additionally influenced by the presence of wind gusts. This state was additionally influenced by the presence of wind gusts. By its nature, it had both a direct effect on the operator's body and a side effect, due to the difficulty of controlling the drone in conditions of strong gusts of wind. Since this mode of drone operation is not unique but occurs quite often, the determination of the effect of this factor on the operator's psychophysiological functions seems very relevant. Significant wind gusts (according to the criterion of normality of the structure of their distribution Shapiro-Wilk P = 0.001) determined

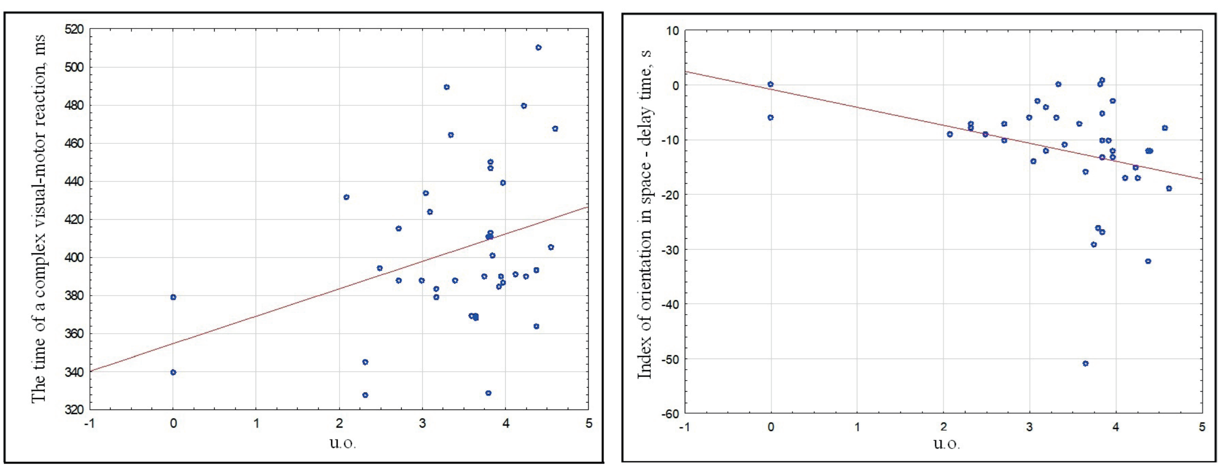

Fig. 4. Regression lines of operators' perceptivity to reduced temperatures of the external environment with separate psychophysiological indicators. Along the abscissa axis is the logarithm of the perceptivity to reduced temperatures of the external environment, u.o.

the influence on the SVMR by d = 17.1% ($P < 0.05$). The regression line based on these data had the following form (Fig. 5).

Strong gusts of wind also affected the number of completed tasks when testing FMNP (d = 12.7%; $P < 0.05$). The direction of the shift of the regression line shows (Fig. 5) that as the operator's perceptivity to the action of strong wind gusts increases, the number of completed tasks decreases. Such an effect indicated a decrease in the concentration of attention and speed qualities of operators' responses.

High humidity also affected the operators' performance. Such humidity (according to the criterion of the normality of their distribution structure Shapiro-Wilk $P = 0.00021$) determined the effect on the SVMR by d = 13.7% ($P < 0.05$). The regression line based on these data had the following form (Fig. 5).

It can be seen from the figure that with an increase in perceptivity to air humidity, an increase in the level of SVMR was observed, which indicated a decrease in the speed capabilities of the operator in the conditions of a changing modality of his response.

It was established that the discussed indicator of perceptivity also affected the psychophysiological indicator of short-term memory – the time of correct reproduction of the information memorized during testing. Significant air humidity determined the effect on short-term memory (time of accurate information reproduction) by d = 11.4% ($P < 0.05$). The regression line based on these

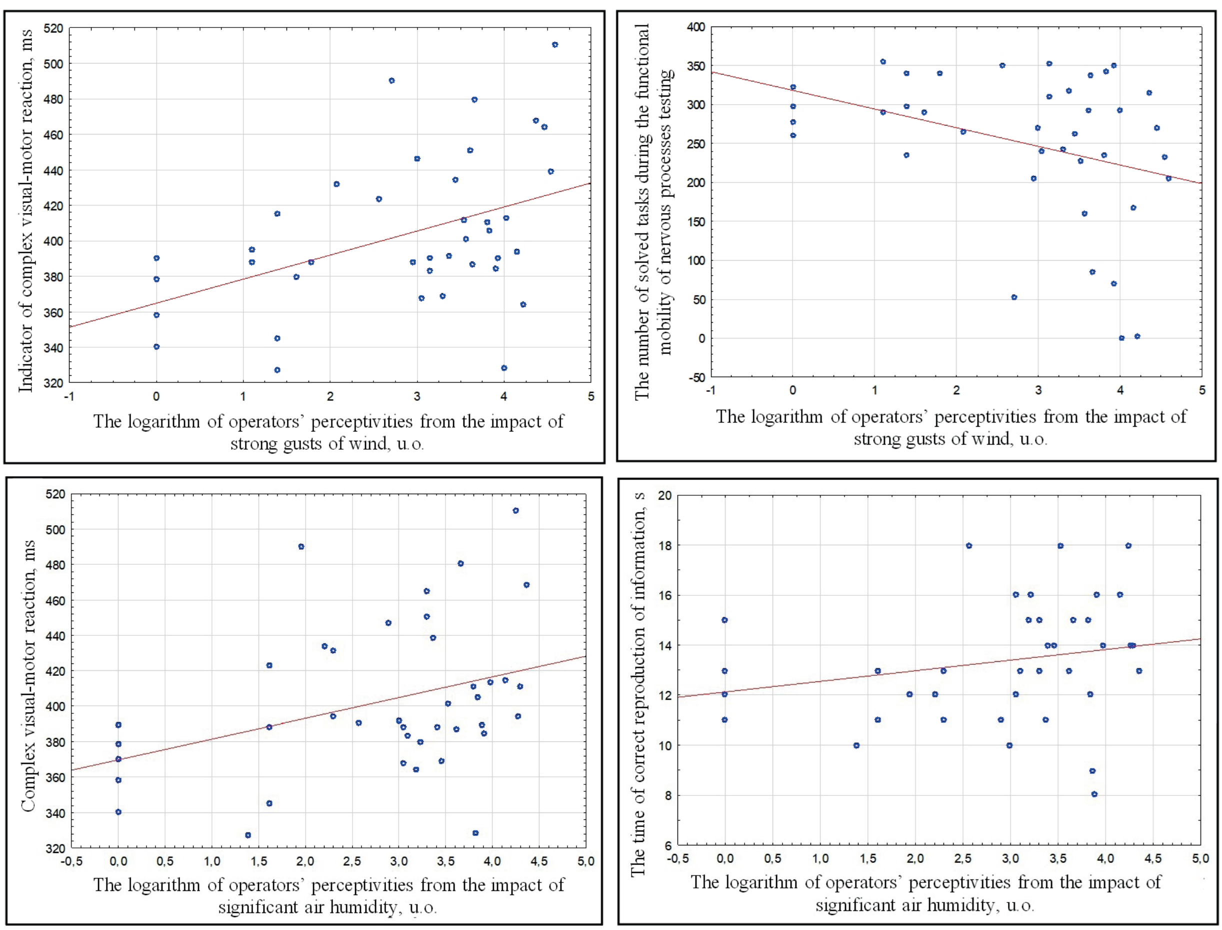

Fig. 5. Regression lines of the perceptivity level of operators to the wind factor with separate psychophysiological indicators

data had the following form (Fig. 5).

Analysis of the figure shows that an increase in perceptivity to air humidity corresponds to an increase in the time of correct reproduction of memorized information. It is possible to think that the uncomfortable working conditions associated with high air humidity indirectly have a negative effect on short-term memory.

It was unlikely that the cloudiness of the sky significantly affected the functional state of the operators. However, apparently, the corresponding cloudiness of the sky could strongly influence the flight parameters of the drone, which significantly worsened the quality of the combat mission, which contributes to the development of stress in the operator controlling the drone. Significant cloudiness of the sky (according to the criterion of normality of their distribution structure Shapiro-Wilk $P = 0.0018$) determined the effect on the number of tasks in the assessment of FMNP by $d = 13.8\%$ ($P < 0.05$). The regression line based on these data had the following form (Fig. 6). Here it could be stated that with the increase of the operator's perceptivity to the overcast sky, the number of solved tasks in the implementation of the FMNP assessment decreases, which indicated a decrease in the speed of multimodal information processing, including both excitatory and inhibitory processes occurring in the operator's body.

Probably, the presence of precipitation further interferes with the flight of the drone, disrupting the quality of its control by the operator. Thanks to this, the informational and emotional load on the operator greatly increases.

Assessment of the impact of the fact of precipitation by the logarithm of its impact on the effect of this harmful factor according to the criterion of normality of the structure of its distribution Shapiro-Wilk $P = 0.00006$. That was, such a distribution of perception levels in the group should be considered normal. The correlation of this indicator with SVMR has been established. It was established that the mutual determination of these indicators was $d = 20.9\%$ ($P < 0.05$). The regression line from the analyzed data had the following form (Fig. 6).

It can be seen here that with the increase in the perceptivity of the operator to the presence of precipitation, the level of the SVMR indicator increased, which indicates a decrease in the speed of multimodal information processing.

Since 80% of persons perceive information with the help of vision, any deterioration in the ability to see well, in particular, when the air is polluted with dust, causes a permanent deterioration of working capacity. Therefore, the presence of air pollution with dust can affect certain operator's psychophysiological qualities. In the considered case, the assessment of the impact of the presence of air pollution with dust (by the logarithm of perceptions from the action of this harmful factor) corresponded to the criterion of normality of the structure of its distribution (Shapiro-Wilk $P = 0.000001$). That was, such a distribution of impression levels in the group should be considered normal. The correlation of this indicator with the indicator of short-term memory – the time of false reproduction has been established. It was established that the mutual determination of these indicators was $d = 12.1\%$ ($P < 0.05$). The regression line from the analyzed data has the following form (Fig. 6).

It can be seen from the figure that as the operator's perceptivity to the presence of air pollution with dust increased, the level of the short-term memory indicator increased, namely the time of false reproduction, which indicated a decrease in the reliability of short-term memory use.

The fact that the presence of a thunderstorm did not correlate with a change in any psychophysiological qualities of the operator was also interesting. This was probably due to the fact that drone flights did not take place in these cases. Otherwise, if the task must be performed under these conditions, experienced stress-resistant operators were assigned to control the drone.

Noise is an integral part of aircraft operation, especially in combat conditions. Therefore, it is necessary to take into account its effect

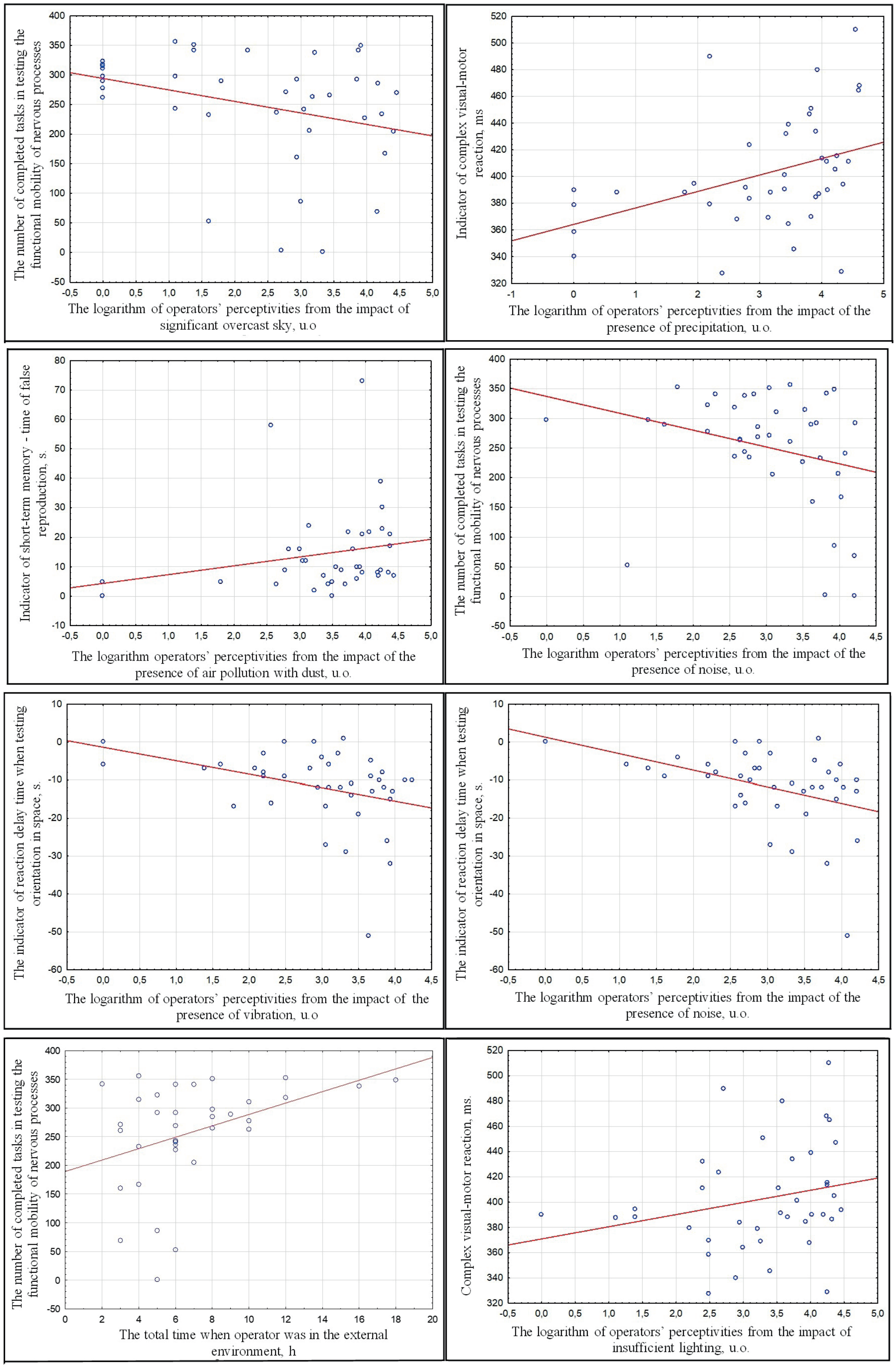

Fig. 6. Regression lines of operators' perceptivity levels to climatic factors depending on other psychophysiological indicators

on the functional state of the operator. It was previously shown that drone operators had a rather uneven attitude to noise in the course of their occupational activities.

In order to "linearize" of the perceptions the operators from the effect of noise, as in previous cases, the levels of the strongest perceptions were "muted" by logarithmizing the perceptions data.

The distribution of the obtained results was close to normal - the structure of the obtained distribution according to the Shapiro-Wilk criterion P = 0.00941. Further correlation analysis revealed the existence of a reliable correlation between the level of noise exposure with the indicator of the number of solved tasks when testing FMNP (d = 11.2%; P < 0.05). The regression line constructed from the analyzed data had the following form (Fig. 6).

It can be seen from the given figure that the increase in perceptions from the effect of noise was accompanied by a decrease in the number of tasks that were performed during the fixed time of testing the FMNP. The presence of this regularity indicated a decrease in the operator's concentration of attention and a decrease in his ability to make quick decisions when processing signals of various modalities.

The presence of noise caused negative changes in another psychophysiological indicator. This was the delay time reaction when testing orientation in space. The coefficient of determination, which shows the explanatory power of this relationship d = 18.3% (P < 0.05). The regression line describing the obtained relationship is presented in Fig. 6. The given figure illustrates a regularity: an increase in the level of perceptions from noise exposure corresponded to an increase in the delay reaction time when testing the operator in three-dimensional orientation. The invented feature can be interpreted as follows: an increase in perceptivity to noise caused an increase in the braking properties of the operator's nervous system.

Further analysis shows that the operator's perceptivity to the influence of vibration (the structure of the obtained distribution according to the Shapiro-Wilk criterion P = 0.0005) also leads to negative changes in some psychophysiological functions of the operator, in particular, the delay time when testing the operator for successful orientation in space. At the same time, the coefficient of determination, which shows the explanatory power of this connection, was d = 19.1% (P < 0.05). The regression line describing the obtained relationship is presented in Fig. 6.

This figure shows that when the perceptivity of the operator to the effect of noise increases, there is a simultaneous increase in the delay time of his reaction during orientation in space, which indicates a decrease in the level of activation of the central nervous system.

An important parameter of the surrounding work environment is the level of insufficient lighting. As was shown earlier, the level of insufficient lighting has a strong impact on the operator's performance. The study of this phenomenon shed light on the source of the indicated deterioration of working capacity. Linearization of the perception level from insufficient lighting was carried out by logarithmizing the initial data (the structure of the obtained distribution according to the Shapiro-Wilk criterion P = 0.00099). It was found that the logarithm of perceptions from insufficient lighting was reliably correlated with an indicator of psychophysiological function - SVMR (the coefficient of determination, which shows the explanatory power of this relationship d = 9.9%; P < 0.05). The regression line describing the obtained relationship is presented in Fig. 6. It can be seen from the figure that the increase in the level of perceptions due to the effect of insufficient lighting contributes to the deterioration of the CVMR, i.e. complications in the operator's work caused by the deterioration of the lighting reduce the operator's speed capabilities in developing reactions to multimodal signals.

It was established that the number of hours of the operator's working time in the external environment was reliably correlated with the psychophysiological indicator of the number of completed tasks when testing FMNP (the coefficient of determination, which shows the explanatory power of this relationship d = 13.6%; $P < 0.05$). The regression line describing the obtained relationship is presented in Fig. 6.

The analysis of this figure shows that an increase in the number of hours of drone control in the external environment contributed to the activation and mobilization of the operator's body, which caused an increase in the number of performed tasks when performing the FMNP testing. This was the only indicator among studied that improves operator performance. However, this improvement could only occur within certain operating hours. An excessive increase in working time will necessarily cause the formation of an overfatigue state, which, in turn, will have a negative, harmful effect. Another explanation for the described effect is that operators who worked a lot with drones had better occupationally important qualities, in particular, as a result of their increased training.

Summarizing the obtained results, it should be noted that in most cases, various components of the external environment, which were evaluated subjectively and reflect the feelings (perceptions) of the action of these components by the operators, worsen the manifestation of some psychophysiological functions: CVMR, the number of tasks (when testing FMNP), delay time (orientation in space). This small number of psychophysiological indicators reflects the speed characteristics and the level of attention concentration. Sometimes the listed indicators were supplemented with the following characteristics: anticipatory time (orientation in space), time of correct reproduction (operational memory), and time of false reproduction (operational memory). As could be seen, these indicators were related to the speed of information processing. A small list of psychophysiological parameters, which were related to feelings from the action of the working environment, possibly shows that these characteristics reflect the process of stress formation in operators. Here it is necessary to pay attention to the fact that stress reactions are non-specific and increase the perceptivity of people to the influence of harmful environmental factors.

Of course, when carrying out the professional activities of drone operators, they are always affected not only by one factor but also by a whole set of harmful factors. This was due to different weather conditions, the specifics of the combat mission being performed, etc. Therefore, in each case, objectively, there was a specific set of active harmful factors of the external environment. To determine such an external load on the operator, it is necessary to carry out appropriate calculations each time, which is quite a difficult task in field conditions. A palliative way out of this situation is to determine the upper limit of the indicated load. This operation can be carried out in the following way.

First, it is necessary to aggregate the characteristics of the operators' perceptions under the influence of all investigated components of the external environment factors. Such assessment will provide information on the maximum harmful effect that all components of the environmental factor can have at the same time. This procedure can be carried out using factor analysis. The performed factor analysis (method of principal components) made it possible to single out only one factor, which explains 52.8% of the variance of the initial data. The peculiarity of the connections of individual indicators with this factor was that the vast majority of them were very strongly related to the selected factor. Factorial values of each investigated operator can be used as integral estimates of the power of this factor.

Secondly, to identify the list of psychophysiological qualities that change under the influence of the environmental factor in individuals with different perceptivity to its components. To specify this list under the influence of all studied components, a step-by-step multiple correlation analysis was applied. With the help of this analysis, a list of psychophysiological qualities was obtained, which correlates with the integral factor of perceptivity to the influence of components of the external environment factor (R = 0.77; P = 0.0314). This list included: number of correct answers (short-term memory), reaction accuracy time (RMO), anticipatory time (orientation in space), number of correct marks (corrective test of attention), the critical flicker fusion frequency (both eyes), time of correct reproduction (short-term memory), FMNP, testing time (corrective test of attention), time of incorrect reproduction (short-term memory), number of incorrect answers (short-term memory). The given list of psychophysiological qualities does not include some of them, which are separately correlated with the corresponding components of perceptivity to the influence of the external environment. But this list reflects the influence of the maximum possible number of these components and therefore reflects a completely different picture of the interaction of perceptivity to the action of the working environment and psychophysiological qualities of operators. A different set of components of the working environment will give different psychophysiological qualities and a different degree of their determination.

Thus, it must be stated that the conducted analysis showed the presence of heterogeneity of perceptions to the effect of various components of the external environment factor. A particularly important role in the emergence of this heterogeneity was played by “hyper-perceptive” individuals, who distorted the structure of the distribution of many components of the environmental impact factor. It was found that increased perceptivity to the action of components of the external environment factor increased the negative impact of these components on the psychophysiological functions of operators. Therefore, it can be assumed that the extremely high perceptivity to the effects of the factors of the working environment can serve as a sign of the occupational unsuitability of the UAS operators. It has been established that the profession of the UAS operator is burdened by the action of a large complex of various components of the external environment, which causes certain negative shifts in the psychophysiological, occupationally important qualities of these operators. The list of these psychophysiological qualities was small, related to the speed characteristics and concentration of attention of UAS operators. Moreover, the harmful effect of these components of the external environment determined the change in psychophysiological qualities in the range from 9.9% to 20.9%. The maximum integrated effect of all investigated components of the environmental factor (the integral factor explains 52.8% of the data on the perceptivity of operators to the influence of all components of this factor) reached D = 59.6%, i.e. it was much greater than the determination of individual components.

CONCLUSIONS

1.The list of psychophysiological qualities that vary under the influence of the environmental factor in persons with different perceptivity to its components has been highlighted.

2. It was shown that an increase in the level of perceptions due to the action of insufficient lighting reduced the operator’s speed capabilities when emerging reactions to multimodal signals.

3. It was revealed that increased perceptivity to the level of the external environment temperature in the operators’ working area correlated with their reactions to the appearance of exciting and inhibitory stimuli, contributed to the deterioration of the short-term memory quality and caused a significant decrease in the reliability of their occupational activity.

4. It was established that an increase in the level of noise exposure was accompanied by a decrease in the operators’ concentration of attention, a decrease in their ability to make quick decisions when processing signals of various modalities, and a decrease in the level of activation of the central nervous system.

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ОСОБЛИВОСТІ ВПЛИВУ УМОВ ПРАЦІ НА ПСИХОФІЗІОЛОГІЧНІ ФУНКЦІЇ ОПЕРАТОРІВ БЕЗПІЛОТНИХ АВІАЦІЙНИХ КОМПЛЕКСІВ

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Для виявлення впливу та оцінки питомої ваги окремих параметрів умов праці та їх комплексної дії на психофізіологічні функції операторів безпілотних авіаційних комплексів (БпАК) у процесі виконання ними своїх професійних обов'язків обстежено 41 військовослужбовців – чоловіків віком 20–35 років, які мали досвід управління БпАК І класу «Легкі» та залучалися до виконання широкого спектра професійних завдань. Для вивчення їх психофізіологічного статусу були використані модифіковані методики з використанням програмно-апаратного комплексу «ПФІ-2». Були визначені такі показники: точність реакції на рухомий об'єкт, сила нервових процесів, функціональна рухливість нервових процесів, проста зорово-моторна реакція, складна зорово-моторна реакція, орієнтація в просторі, зорова пам'ять. Роль кліматичних та мікрокліматичних факторів у професійній діяльності вивчено за допомогою анкетування, яке містило питання щодо оцінювання їх впливу за 100-бальною шкалою на функціональний стан. Для здійснення подальших теоретичних розробок та практичного застосування визначено інтегральний вплив досліджуваних факторів на формування відповідного суб'єктивно забарвленого відчуття впливу на організм операторів та його дію на окремі професійно важливі психофізіологічні якості військовослужбовців. Попередній аналіз показав наявність неоднорідності відчуттів до дії різних компонентів фактора зовнішнього середовища. Застосовано прийоми нелінійного виправлення їх значень тобто логарифмування аналізованих результатів, коли великі значення аналізованого параметра будуть зменшені завдяки властивостям функції логарифму. Потім було проведено кореляційний (коефіцієнт кореляції Спірмена) та регресійний аналіз кожного досліджуваного показника з попередньою перевіркою структури вражень оператора на «нормальність» структури розподілу з допомогою критерію Шапіро-Уілка. В результаті за допомогою кореляційного аналізу виділений перелік психофізіологічних якостей, які змінюються під впливом фактора зовнішнього середовища у осіб з різною чутливістю до його складових.
Ключові слова: зовнішні пілоти; безпілотний авіаційний комплекс; умови праці; професійна придатність; функціональний стан; відчуття впливу.

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