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METHOD OF REGISTRATION OF ALTERED STATES OF CONSCIOUSNESS OF OPERATORS OF DIFFICULT ERGATIC SYSTEMS

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Abstract: *A new method of registering an altered state of consciousness of the human operator of complex control systems is considered. The method is implemented by a complex assessment of the stability of homeostasis of the body using the Shannon's entropy determination. It is shown that the maximum human psycho-emotional stability is achieved when the level of chaos and order in the structures of the body is in the proportion of the golden section.*

Key words: *altered states of consciousness, ergatic system, operator.*

I. Introduction

Successful operation of complex ergatic system depends on the efficiency and safety of the work of operators. The most difficult types of operator activity are the control of dynamic objects, particularly aircraft, air traffic control, manned space stations and space ships control.

Our own conducted studies suggest a high degree of probability of occurrence of an altered state of consciousness of operators of complex ergatic systems in extreme situations. In this case, fully appears so-called "human factor". The operator (pilot, air traffic controller, etc.) can make fatal errors leading to

serious accidents and disasters, but he also can show the unique ability to make the right decision in a very short period of time. The cost of a human error in extreme situations in the aviation and aerospace industry is especially high. To prevent air and space accidents and improve level of flight safety it is essential not only to have high quality personnel recruitment, but also the existence of methods of objective control of psycho-physiological state of a person and forecast of its behavior in extreme situations.

This all adds actuality to the task of development of methods that allow

to make an objective assessment of the external factors impact on the human psyche that determines human's behavior in complex emergency situations that can call an altered state of consciousness (ISC).

In the modern science of consciousness, more and more attention is focused on the study of the theoretical fundamentals of an altered state of consciousness and its applied aspects. As you know, ISC appear: from various factors impact to human (stress, sensory deprivation, intoxication, psychedelic effects, hallucinations, etc.) from hyperventilation or if respiratory arrest occurs, in hypnosis and meditation, etc.

Solving the problem of explanation of the ISC is not only important in psychology (general, medical, transpersonal, psychology of personality), but also in psychiatry. The research process of ISC brings together dozens of sciences - from genetics to philology. At the same time, each discipline considers its own aspect, which makes it difficult to build a common theoretical base and conduct applied research, particularly in such an important area as the development of objective methods of ISC registration. The term "ISC registration" shall mean the registration (measurement of parameters) of the relevant correlates to adequately characterize the state of the person at ISS.

II. METHODOLOGY

Let's analyze the problem in the most general form. Imagine the

human body as a biosystem - the "black box", at whose input disturbance comes (verbal and non-verbal environmental impact).

For the most complete and adequate assessment of the impact of external factors on the person it is proposed to analyze the degree of uncertainty in operation of the homeostatic control systems of the body from the synergistic approach. As you know, a number of homeostatic and adaptive mechanisms operate in the human body. At that, the leading role of hemostasis in preserving homeostasis should be highlighted. The system of hemostasis is usually considered as the collection and interaction of the components of blood, walls of vessels and body organs involved in the process of circulation of blood. Hemostasis largely determines the information processes in the homeostatic control systems, reflects the regulatory processes of the recovery of mass balance, energy and information. In consequence of the spatial orientation of blood components external electromagnetic fields can change the basic characteristics of blood, particularly it's viscosity.

The method of objectification of external influences on human [1 - 3] is realized through a comprehensive assessment of stability of homeostasis by examining the dynamics of central and regional hemodynamics taking into account the rheological characteristics of the blood and the elastic properties of the various segments of the walls of blood

vessels. Using received parameters it was determined the degree of uncertainty of the functioning of biosystem with the help of Shannon's definition of entropy.

It was determined the maximum (H_{max}), the actual (current) (H_t) and relative value (H_0) of the biosystem's entropy:

$$H_t = -\sum_{i=1}^N P_i \cdot \log(P_i)$$

$$H_t = -\sum_{i=1}^N (m_i / n) \cdot \log(m_i / n)$$

$$H_{max} = -\log(2 \cdot T_\beta \cdot \frac{S_x}{\sqrt{N}})$$

$$H_0 = H_t / H_{max}$$

where N - the total volume of the analyzed selection;

P_i - the probability of acceptance of the i -th state of the biosystem;

m_i - the number of entering of the analyzed parameter values into the

i -th interval;

n - the size of the analyzed interval;

S_x - the mean square deviation of the analyzed selection;

T_β - Student's coefficient at probability belief β .

For completeness of assessment of external influence it is introduced the relative (R_0) and absolute (R_{abs}) measure of organization of the biosystem:

$$R_0 = 1 - H_0 \quad (0 \leq R_0 \leq 1);$$

$$R_{abs} = H_{max} - H_t \quad (0 \leq R_{abs} \leq H_{max}).$$

In the behavior of biosystem it can be distinguished two of its edge (extreme) states:

1. The system is completely disorganized (ultimate chaos), the uncertainty in the system is maximal, the entropy of the system is maximal. The system is characterized by the following parameters: $H_t = H_{max}$, $H_0 = 1$, $R_0 = 0$, $R_{abs} = 0$.

2. The system is completely deterministic ("absolute" order), the uncertainty in the system is absent, the entropy of the system is minimal. The system is characterized by the following parameters: $H_t = 0$, $H_0 = 0$, $R_0 = 1$, $R_{abs} = H_{max}$.

In real existing biosystems these parameters take on intermediate values [1-3]. Each level of organization of biosystem has the appropriate value of entropy. During the process of system development its entropy decreases - organization grows. However, this process does not have to exceed some certain limit, when excessive organization will cause excessive tightening of the structure and rigid centralization of subsystems functioning. In this case it is difficult to further improve the system, in the extreme case - the impossibility of perfection (the inability of evolution). Progress can not be stopped. Therefore in one moment of time for further movement (evolution) it is required a sharp transition - jump to the next level, with a large number of qualitative differences. Such a jump is also possible only at a certain balance of chaos and order. If the internal state

of the biosystem is too chaotic (high entropy), the jump is not possible from the lack of organization. If the control organization of the biosystem is too rigid, the system "overorganized" (low entropy), the jump is not possible because of retardation in the perception of external information and, in the extreme case, absence of the perception of information. Thus, the biosystem should have an optimal ratio between the levels of order and disorder, in which, on the one hand, it maintains sufficient stability and certainty, and, on the other hand, it has a fairly high level of variation and uncertainty, leaving the possibility for change and maintaining the necessary pace of development. Determinism ("order"), and stochasticity ("mess") in the system should be in harmony.

Reception and processing of information by the person is executed with a help of the universal code of p-proportions (Fibonacci p-codes), which is based on the parameters of the "golden ratio". With this code it is provided optimal parameters of body systems responsible for information processing. Thus, the level of the harmonious functioning of biosystem should be assessed using the parameters of the "golden section". So, it is postulated the following statement: "In general the maximum (H_{max}) and the current (H_t) values of the biosystem entropy should correlate to each other in through invariants of the "golden section". If assume values of the "golden section" in the form of real roots X_1, X_2, \dots ,

X_{p+1} ($p > 0$) of the equation: $X^{p+1} + X^p = 1$, then the ratio between the maximum and the current value of the entropy is expressed as:

$$H_t = \mathfrak{R}(X_1, X_2, \dots, X_n) H_{max},$$

where \mathfrak{R} - operator on the set of solutions of the original equation.

In the simplest case ($p=1$), you can use the following values of the parameters of the "golden section": 0,618 and 0,382.

Studies conducted in Gurzuf central sanatorium of Ukraine have shown that the entropy parameters of the human body have stochastic nature and fluctuate relative to some constant. After the proper statistic analysis it was shown that the parameters of the "golden section" act as such constant

Thus, within the previously defined restrictions, it is postulated the following statement: "in a harmoniously functioning biosystem in the simplest case, the share of chaos (disorder) should be 0.382 of the maximum entropy value and the share of orderliness - 0.618".

A more formal definition: "the relative entropy of the system and the relative organization of the system at the optimal functioning of biosystem are defined by some function of the parameters of the "golden section". Therefore, I postulate that the development of the system (in terms of its evolution), the stability of its functioning in difficult stressful situations is possible when the level of chaos and order in the system

governed by the law of harmony, more specifically it is located in the "golden section" proportion. This is the most general principle. A special case of its demonstration:

$$\mathbf{H}_t = \mathbf{0.618} \cdot \mathbf{H}_{\max} , \quad \mathbf{H}_0 = \mathbf{0.618}, \\ \mathbf{R}_0 = \mathbf{0.382}$$

The degree of deviation of a real functioning biosystem from its harmonious state is proposed to estimate using index of information balance (S):

$$\mathbf{S} = \mathbf{1} - \mathbf{ABS}(\mathbf{H}_0 - \mathbf{0.618}) / \mathbf{0.618} \\ (\mathbf{0} \leq \mathbf{S} \leq \mathbf{1}), \mathbf{S}_{\max} = \mathbf{1}, \text{ with } \mathbf{H}_0 = \mathbf{0.618}$$

The intensity of the absolute (\mathbf{U}_{abs}) and relative (\mathbf{U}_0) information influence is proposed to determine by the formulas:

$$\mathbf{U}_0 = (\mathbf{H}_0^{(\mathbf{K})} - \mathbf{H}_0^{(\mathbf{H})}) / \mathbf{H}_0^{(\mathbf{H})} ; \\ \mathbf{U}_{\text{abs}} = (\mathbf{H}_{\text{abs}}^{(\mathbf{K})} - \mathbf{H}_{\text{abs}}^{(\mathbf{H})}) / \mathbf{H}_{\text{abs}}^{(\mathbf{H})} ,$$

where the indices \mathbf{K} and \mathbf{H} , characterize respectively the final and the initial value of the system entropy (before and after influence).

This approach can be successfully used as a method of complex evaluation of psychophysiological parameters of the person, for the purpose of objectification of his behavior in extreme situations [4, 5].

The proposed method of the ISC registration was tested during the study of ISC which was induced by influence on the brain of light impulses modulated at a frequency of alpha- and tetra-ritma of the brain,

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together with impact of low-frequency mechanical vibrations to whole human body. It was shown the possibility of application of the reviewed method of evaluating the effectiveness of treatment with alpha camera (vibratory stimulation in conjunction with aromatherapy with music background) and with photostimulator RelaxEase (music therapy with low-frequency photostimulation of the eye's retina) [6, 7].

III. CONCLUSION

Conducted experiments fully confirmed the legitimacy of the above assumptions and postulates. On the basis of the research it can be concluded that the entropy-informational method of ISC registration is accurate and sensitive enough. The proposed method allows us to estimate the impact of external factors on the person and can be successfully used for efficient diagnosis of psycho-emotional stability and determination of the adequacy of his behavior under extreme conditions. Entropy-informational method of ISC registration can be successfully used for the development of optimal schemes of rehabilitation and prevention of mental and emotional state of the operators of complex ergatic systems.

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