

## VEGETATIVE CORRELATES OF COGNITIVE PROCESSES IN STRESS SITUATION

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### Abstract

In this series of experiments we investigated the relationship between the structure of the behavioral activity of a person in a virtual computer environment, and the structure of physiological reactions in the context of legitimate and random dynamics of informative images. In the experiments was implemented the technology of integrated monitoring of the functional state and event of context in conditions of a natural human activity in a virtual computer environment.

AIM: To study of autonomous components of a functional system, providing purposeful behavior of the person in stress information contexts.

METHODS: Sixty healthy subjects and fifty addicted patients (age or gender difference is not taken into account) participated in the study. Heart rate measurement was performed with the help of the system of the telemetry wireless registration of the heart rhythm. During the experiment we recorded face of the subject and the content of his computer screen.

CONCLUSION: The operational management of heart rhythm is agreed with the level of uncertainty of information image.

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**Keywords:** Stress, autonomic regulation, cognition functions, emotion state

### Introduction:

The relevance of this work is determined by the high social importance of the research devoted to the development of knowledge about the dynamics of human functional state in the conditions of daily life. In today's reality, most human diseases are the results of excessive loads of different nature. The major problem is the search for methods of early detection of dangerous status in order to prevent the risks of health disorders. Therefore, questions about the presence of markers of excessive arousal, resource depletion, energy depletion, stress are very important.

The stress is the most wasteful mode for the body. The reaction of stress is a non-specific systemic defensive reaction to the damage or its threat. The factor of the launch of this reaction is an information parameter. This information parameter is the signal of excessive disagreement of two images: the current and required ones. Based on the theory of functional systems by P.K. Anokhin, stress factors can be divided in the dependence of the functional systems block, which includes disagreement: informational factor; physical factor; affective factor. Thus, the task of finding specific for different functional states markers include monitoring of all the variables that are involved in the formation of the state, exogenous context (object environment and its dynamics), endogenous context (status options «up» and their dynamics). Still in the research practice, the functional state of the person is assessed by measurement in laboratory conditions, which includes hard monitoring of the status of the subject (while sitting or lying) and the absence of external stimulus. However,

this approach greatly narrows the range of techniques, because management modes of the physiological system of the person are associated with the target function and vary widely in accordance with the meaningful context. The studies of physiological signals in laboratory conditions don't allow to predict the characteristics of physiological reactions in the conditions of daily life.

According to modern notions, autonomic regulation of heart rate reflects the activation level and voltage systems of the body. The experience of the studies of 1960-s regarding HRV as a set of characteristics of the system of regulation demonstrates the sensitivity of this parameter to any changes in mental or physiological states of the living object, which is consistent with the original idea of neocortex-heart links by Claude Bernard. This fact is confirmed by empirical studies devoted to the measurement of HRV in the contexts of information, physical and integral loads [Taelman et al., 2011] and targeted researches of the linkage parameters of HRV with the activity of various neuronal structures using the method of neuroimaging (fMRI, PET) [Critchley, 2003; Whalen et al., 2004; Holland and Gallagher, 2004; Gianaros, 2004; Belova et al., 2007; Napadow et al., 2008; Johnson et al., 2009; Whalen and Phelps, 2009; Lane, 2009; Ahs et al., 2009; Ruiz-Padial et al., 2011]. Modern studies provide a broad base of results of measurement of HRV in different groups of subjects: patients with depressive disorders, postinsult patients, suffering from diabetes and other disorders [Hanson, 2001; Collins et al., 2005; Melillo et al., 2005; Samen et al., 2007; Chandola et al., 2008] and under different experimental laboratory contexts: fatigue, overexertion, different types of stress: an examination, work, etc. [Carney et al., 2009; Nikolova et al., 2007,2011; Taylor et al., 2009,2011]. Thus, we can make a conclusion about the non-specificity of changes of HRV under the influence of exogenous and endogenous factors, which confirms the hypothesis of informative markers of stress (nonspecific reaction of the organism) in the dynamics of HRV.

The development of methods for mathematical processing of cardiointervalogramme led to the discovery of a large number of indicators (statistical, geometrical, frequency), which, on the one hand, are closely correlated with each other, making the entire set excess, and on the other one - suitable for interpretation and evaluation of cardio-signal in stationary conditions.

The influence of activity of the stress-regulatory systems (sympathoadrenal (SAS), hypothalamic-pituitary-adrenal (HPA), the endogenous opioid (EOS)) on the vegetative regulation of cardiac rhythm was investigated independently, i.e. there are separately shown the effects of activation SAS, HPA, EOS in the dynamics of HRV [Lishmanov et al, 1995; Maslov et al, 1995; Ardashev et al, 1995; Kus et al., 1995; Chao et al., 1999; Huangetal, 2008; Yehetal, 2008; Coruzzi et al., 2003]. Knowledge about identification of the signs of sequential change of dominance and joint impact of these systems on the dynamics of the autonomic regulation extremely is limited.

Therefore, it is important to use instrumental methods of registration of biophysical signals, providing personalized monitoring and remote diagnostics without restrictions on the length of the recording, distance to the signal source and mobility, the development of non-linear non-stationary methods of mathematical treatment of signals corresponding to the real natural activities in diverse stimulus environment, research of dynamic characteristics of participation stress regulatory systems in the regulation of a cardiac rhythm.

## I.

The time sequence of sensory signals activates imprint of real events with complex cognitive, vegetative, motor and emotional components in the memory of a man ensuring the optimization of life in the real physical environment. It is obvious that the information images as well as the real objects are able to induce physiological reactions, but these reactions are deprived of the biological viability for acting in virtual computer environment. In this series

of experiments we investigated the relationship between the structure of the behavioral activity of a person virtual computer environment, and structure of physiological reactions in the context of legitimate and random dynamics of informative images. In the experiments were implemented using the technology of integrated monitoring of the functional state and event of context in conditions of a natural human activity in a virtual computer environment [Polevaya et al., 2013].

The estimation of biological activity of information images was conducted in three virtual contexts of different degree of complexity: 1. The elementary information context; 2. The complex dynamic informational context; 3. The context of elementary cognitive loads. The data array included the written sequence of R-R intervals, the video of the man's face in various information contexts, a video monitor showing the dynamics of the information images in a virtual computer environment for each subject. On the basis of the tracks of video surveillance there were developed individual chronogram events in virtual reality.

In the elementary information context, there was found a direct relationship between the level of uncertainty of information image and the level of disorganization of the heart rhythm. The indicator of disorganization of the heart rhythm (RRmax-RRmin) was significantly higher in the context of uncertainty compared with a context of clarity ( $p < 0,05$ ). Found effects can be associated with the activity of the operational management of heart rhythm (cortical circuit regulation), consistent with the level of uncertainty of information image.

In most participants (86%) of the research there was observed a mobilizing action of discordance and error management of information images, manifested in the increase of sympathetic activation - sharp increase in the power of oscillations in low-frequency (LF) (1 phase of stress) in the context of computer games (the complex dynamic informational context). Transition physiological system in high-energy mode supports protective reactions in extreme situations with the threat to life. Sympathetic activation in this context devoids of biological viability and leads to the unjustified reduction of the physiological system.

The dynamics of HRV during functional testing ensuring the mainstreaming of a primary cognitive functions and measurement errors motor displaying elementary sensory signals was investigated in the two groups of subjects (healthy, drug-addicts). The analysis of variance showed the presence of the factor (cognitive tests) on HRV parameters ( $p < 0,01$ ). Evaluation results showed that the autonomic provision of cognitive function has the property of adaptability: the modes of HRV are specific to the nature of the cognitive load. The suppression of the regulatory function of the EOS reduces the adaptability of the autonomic regulation (Fig.1.).

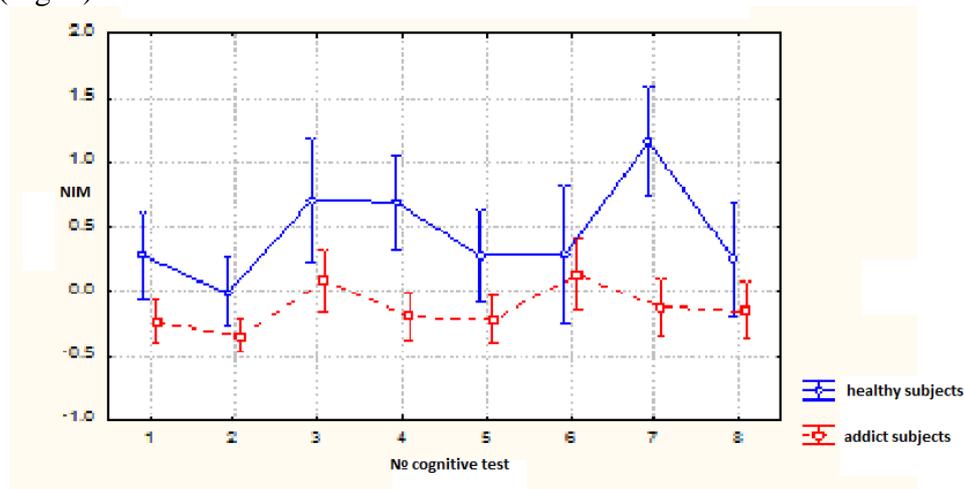


Fig.1. The dynamics of parameters of HRV in 8 cognitive samples in the two groups.

### **Conclusion:**

The analysis of the average and personalized dynamics of autonomic functions in natural contexts of activities revealed that:

1. Wireless technology for registration of heart rate-based miniature sensory platforms minimizes the risks of violation of the integrity of the functional system of a person while measuring in the context of the objective function;
2. The Fourier transform with sliding window allows to assess the rapid changes in the mode of autonomic regulation, which is coordinated with time scale of dynamics of information images of the events of the context;
3. The operational management of heart rhythm is consistent with the level of uncertainty of the image information.

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