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Functional System of Creative Thinking.

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ABSTRACT

In the article on the basis of electroencephalographic and psychological indicators the concept the mechanism of creative thinking was formulated. Creative thinking as a process involves operating images and searching similar tasks in memory (mental representations). High result in creative thinking is possible under the condition of high decision-making and low level of critical-controlling program.

Keywords: creative thinking, electrical activity of the cerebral cortex, delta-rhythm, alpha-2-rhythm, beta-rhythm

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INTRODUCTION

Despite the great interest in the problem of creativity until now there is no detailed and complete information about the neurophysiological mechanisms of these processes. In modern neurophysiology the most popular is the hypotheses of K. Martindale [1], according to which highly creative people in comparison with people with lower level of creativity are more capable of switching between the primary and secondary information processing, tend to "regress" to the primary cognitive process that is required to generate creative ideas. In addition, creative people are prone to creating "flexible" associative connection with the proposed incentive as well as they can pay attention to many things at the same time, i.e. they are able to a "defocused" information processing.

And, therefore, people with high creative abilities are characterized by more "flexible" brain activation processes according to the nature and conditions of creative problem-solving. Compared to existing alternative hypotheses based on the fact that more creative people are characterized by a localized activation of the cortex [2], or that the cognitive program of creative activities does not require high-level tension of brain processes [3], Ivanitskiy A. M. [4] puts forward the assumption that the growth of stochastic processes of the brain is the basis for the emergence of predictable solutions that are often effective.

Creative activity as a complex cognitive process is realized through the activity of many areas of the cortex, each of which plays a specific role by demonstrating the specific nature of the activation or interaction with other areas. In modern studies of human cognitive fairly common and effective is the search for individual rhythmic components of EEG, which could serve as indicators of the status of various brain functions. As pointed out in the works of G. Buzsáki [5] and W. Klimesch [6], within such researches fragmentation methods of basic EEG frequency ranges with further analysis of the capacity characteristics under different conditions are most commonly applied.

The analysis of literature sources on the EEG correlates of creative thinking indicates that specific functional changes in the electrical activity of the cerebral cortex associated with high and low creativity are manifested in almost all ranges and are differently expressed when speaking about men and women. Neuroscientists nowadays almost abandoned the search of "centers of creativity" as changes in various parameters of the EEG during creative thinking are manifested in different areas and are caused by different factors: previous experience [7], level of creativity [8], level of intelligence [9], gender of the examinees [10], emotional coloring of stimuli [11], success of the creative activity itself [12]; left or right-handedness [13]. In particular, it was found out that the success of convergent thinking is mainly linked with rapid and accurate identification of information on a global level of selection and the success of the divergent thinking is linked with increasing time of selective processes on the local level. It should also be noted that different EEG effects of men and women in the process of creative activities are often associated with different strategies of thinking. Today we are talking about different strategies for the execution of any current tasks, which are reflected in the EEG indicators.

In general, one must admit that, despite the fairly large interest of scientists in the problem of finding EEG correlates of creative thinking, they still cannot be identified today. This is due to a number of factors. The age of the examinees varies greatly. The procedure of the experiment (type of tasks, their subjective complexity, method of presentation, motivation to work) is differently represented by different authors, which is obviously reflected in the received results and brings in a certain imbalance into their generalization and interpretation. Equally important obstacle to understanding of the neurophysiological mechanisms of creative thinking is an insufficient number of studies that take into consideration the gender of the examinees.

We have previously highlighted electroencephalographic and psychological criteria of predicting high level of creativity and the mathematical model of the neural network of such forecasting was built. It was established that the likelihood of a high level of creativity is related to the speed of decision-making; value of the coherence coefficient Fp1-O1 between in the α2-range; focus interactions in lead of T6 in Δ-range focus and interaction in the lead of P4in the β-range. Based on these factor variables the linear neural model of forecasting that can effectively assess the likelihood of a high level of creativity was constructed: + LR = 1,5 (95% BI 1,2-1,9), -LR = 0,6 (95% ² 0.4-0.8) [14].

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Therefore, the aim of this work was to formulate the concept of creative thinking by analyzing the logistic model coefficients and psychological examination of men and women.

EXPERIMENTAL

Subjects

The study involved 95 men and 98 women aged 18-21 years. The research was conducted in accordance with generally accepted bioethical norms in compliance with relevant international provisions on experimental work and clinical research. Study participants (volunteers) gave a written voluntary consent to participate in the study.

Data psychophysiology

The following physiological parameters were identified: intelligence level and cognitive styles "Reflexivity/impulsivity".

The level of creativity was evaluated based on performance indicators (number of proposed options) when solving tasks of divergent type.

Data electroencephalography

The electrical activity of the cerebral cortex of 193 men and women aged 18-21 was recorded during assignments of divergent types. The electrical activity of the cerebral cortex was recorded in monopolar way from 19 leads according to the international system 10/20 with the help of the hardware-software complex "Neyrokom" developed by the scientific and technical center of electronic medical devices and technologies "HAI-Medika" National Aerospace University "KhAI" (certificate of registration № 6038/2007 from 26 January 2007).

The indicators of performance capacity and coherence of EEG in frequency ranges were analyzed: delta, alpha-2, beta rhythms taking into account the individual frequency of alpha rhythm of each patient [6].

Mathematical Methods

In order to detect pair ponding between individual indicators the methods of correlation analysis were used and Spearman's Rank Correlation Index was calculated [15]. When analyzing multifactorial dependencies, such methods as constructing and analyzing methods of multifactorial statistical models were applied. Construction of neural network models was conducted in a statistical package Statistica Neural Networks v.4.0 B (StatSoft Inc., 1996-1999). Construction of logistic regression models, models analysis was performed in a statistical package MedCalc v.14.12.0 (MedCalc SoftWare bvba, 1993-2014).

RESULTS AND DISCUSSION

One of the factors of logistic model was the focus of cooperation in the parietal area of the right hemisphere formed in beta-range of EEG. The importance of activity of parietal areas for creative thinking has been expressed in several papers. After all, these areas belong to the neocortical system of attention and they are focused on the selection of multimodal stimuli [16] related to visual-spatial representations and attention [17]. As the results of our research have shown, the important role plays back system of attention (central-parietal area) when speaking about creative individuals (Fig. 1).

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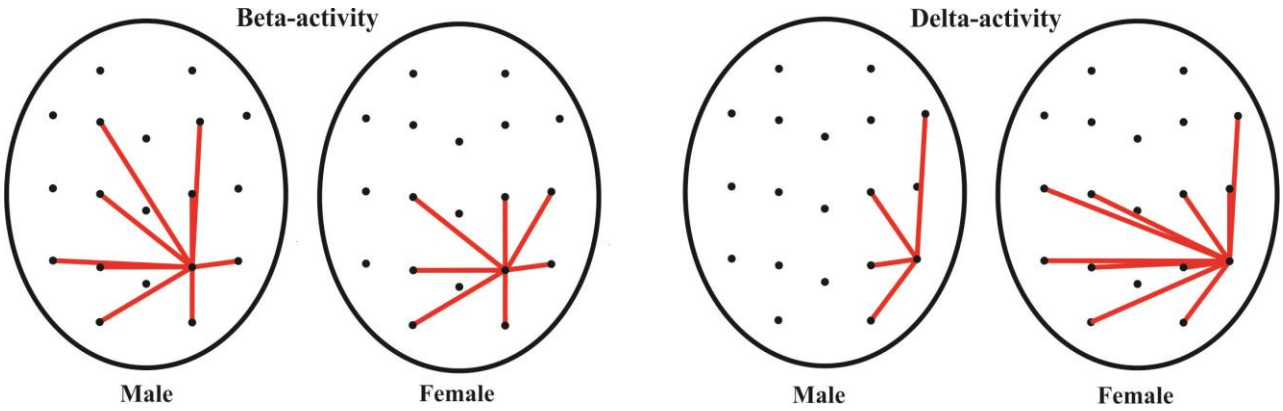

Figure 1: Focuses of interaction in beta and delta range. Marked coherent connections that are closer (p <0,05) of examinees with the high level of creativity.

Despite the fact that the functional significance of beta rhythm is not still fully understood, it is known as the indicator of many cognitive processes. In particular, it is associated with the processes of "differential" attention which is a characteristic feature of creative thinking [18].

The fact that one of the factors of the constructed neural network model was the focus of interaction in the right parietal area, a greater importance of which is the correlation with an increase in the likelihood of a high level of creativity, in our opinion, this shows that the selection of information is crucial in finding multiple solutions for the assigned creative tasks.

At the same time the increase in the likelihood of a high level of creativity is correlated with a decrease in the relationship between the frontal and occipital area of the left hemisphere at frequencies of alpha-2-rhythm, which is associated with the processes of voluntary attention [19]. This obviously shows that for effective creative thinking it is necessary to reduce interaction between the front and back system of attention. It is especially important to create such conditions in the left hemisphere and thus reduce its controlling and critical-initiating function.

Machynskaya R. I. [20] believes that a functional specialization of prefrontal areas is determined by its connections with postcentral associative areas as well as by peculiarities of interaction with deep brain structures, such as mediodorsal nucleus of the thalamus, hippocampus and basal ganglia. Some areas of the prefrontal cortex and subcortical structures form functional connections that provide different aspects of main executive functions of the brain. Obviously, such a reduction in control "releases" creative flow.

Quite unexpected to us was the focus of interaction in the right back temporal area of delta-range of EEG. This rhythm is basically not mentioned in the context of electrical activity of the cortex, which provides creative thinking. If to take into consideration that slow delta waves are associated with the motivational component of mental activity, we can assume that the high results of creative thinking are received under the condition of high motivation to achieve success. Obviously in this case, high level of motivation in finding in memory the required tasks gives an opportunity to find variants of solution to the current task. (see Fig. 1).

Even Martindale [1] placed a greater focus on the fact that activation of many mental representations is important for effective course of creative process. It's highly possible that such activation may be connected with delta-activity.

Psychological studies showed that previous experience may either play a positive role by providing a person with already known rules for problem-solving, or it can play a negative role in thinking, when it slows down problem-solving of new tasks and when it creates conservative irrational basis for decisions [21].

Based on the mathematical model of neural network, the results of psychological testing of the examinees and the analysis of suggested answers after the task-solving on divergent thinking the concept of creative thinking was formulated by us (Fig. 2).

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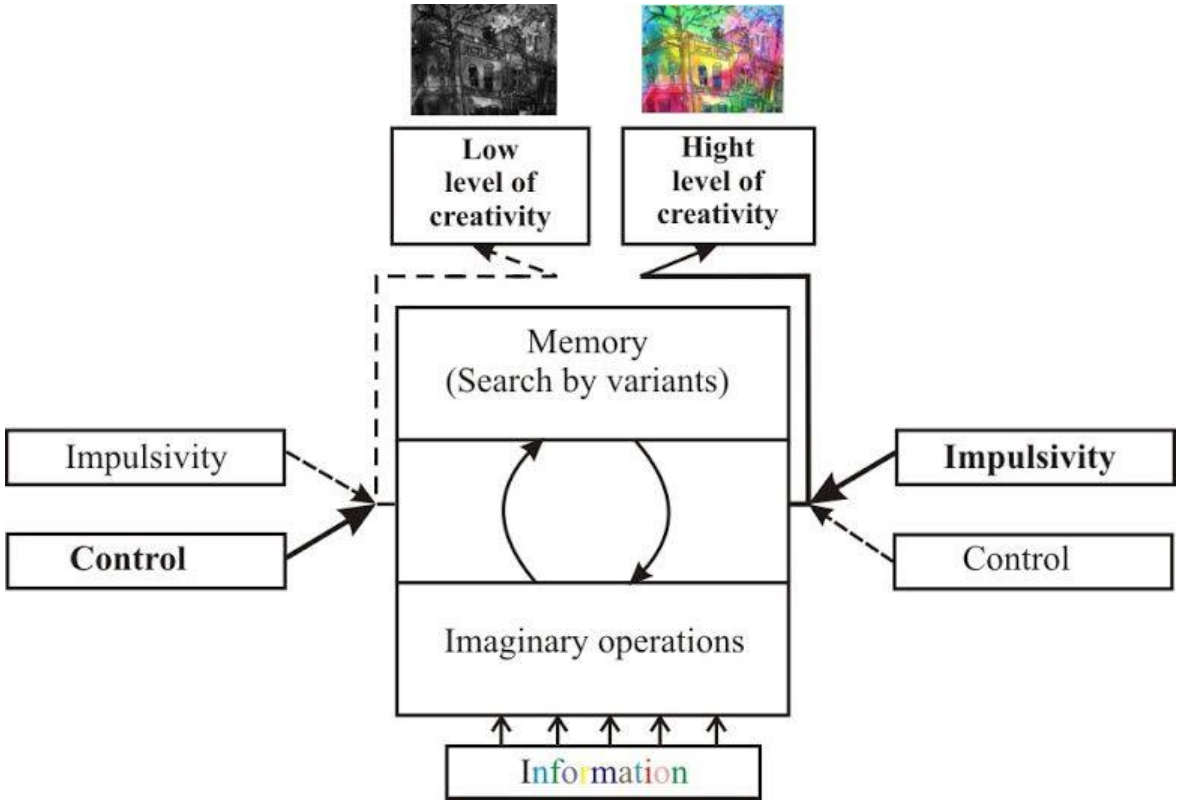

Figure 2: General functional system of creative thinking.

Creative thinking is a complex cognitive process that activates in its realization systems of visual thinking, memory and consciousness. Regardless of gender in the process of creative thinking visualization of tasks and elements and reconciliation with existing mental representations occur. New variants are generated on the basis of mental representations due to through careful analysis of the elements of the problem. And a good result in creative thinking is achieved in case when the most adequate to the current problem of mental representations decision is taken quickly, and the critical-controlling activity program is reduced (up to the complete elimination).

CONCLUSION

Creative thinking as a process involves operating images and searching of similar tasks in memory (mental representations). High result in creative thinking is possible under the condition of high decision-making and low level of critical-controlling program.

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