

FEATURES OF NEUROENERGOMETABOLISM IN HYPERACTIVE CHILDREN AGED 7-11 YEARS UNDER VARIOUS COGNITIVE STRATEGIES

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The results of the study of neuroenergometabolism in children with hyperactivity under various cognitive strategies were presented. A group of 91 children aged 7-11 years participated in this study. They were divided in two groups by features of stereotypical choice. The computer complex CPPC-99 "Psychomat" and the diagnostical complex Neuroenergokartograf "Neuro-KM" were used. In the first group of children were suggested reduced activity of frontal and stem structures, increased activity of left temporal area with decreasing of interrelations in brain regions and absence of hemispheric dominance. In the second group of children were suggested increased level of brain constant potentials in stem structures and right temporal area with simultaneously reducing of power consumption in occipital area, negative dynamic of structural and functional organization of brain. The level of brain constant potentials represents mechanisms of making decisions in children in different environments.

Keywords: neuroenergometabolism, hyperactivity, attention deficit hyperactivity disorder, children, cognitive strategies

Hyperactivity is one of the most common symptoms of attention deficit hyperactivity disorder. (ADHD) [3]. Insufficient development of mechanisms of concentration and distribution of attention, analytical and synthetic processes, unformed self-esteem as well as the weakness of the visual traces in the children of primary school age determine the inertia of the restructuring strategy selection and difficulties in the assimilation of internal interconnection sequence of stimuli [1, 7, 8].

ADHD - neurobiological disorder, where neurophysiological disorders are one of the major pathogenetic mechanisms. Among these disorders the leading role, in our opinion, can play a factor of the brain energy state. Indirect assessment of the energy metabolism of the brain is carried by recording permanent brain potentials [4]. The level of constant potentials (LCP) of brain is a slowly changing, steady capability millivolt range, which is a type of infraslow physiological processes in the brain [2, 10].

The cognitive strategies, due to the influence of the environment is an important stage in a human mental activity. The decision-making stage forms the physiological apparatus of the foresight results, satisfying the dominant need of the body. In an uncertain situation the decision-making is impossible without significant installation capacity and the element of probability and is

associated with the increased involvement of cognitive processes. One of the most important tasks of the decision-making process in an organizational activity is the availability of adequate information, knowledge and capabilities that helps to minimize mistakes in the choice of purposes and means of their realization. According to the principle of domination, opened by A. A. Ukhtomsky, the interaction of different functional systems builds at the brain level [9]. In the organization of the system functions of the brain the leading role is played by the interaction of the dominant motivations, with the appropriate reinforcements [6]. As repeated reinforcements, the regular activity in the brain neurons, initially included in the dominant motivation, begins to appear in advance on the action of the conventional signals [5].

The aim of this study was to determine the characteristics of neuroenergetabolism in children with hyperactivity under various cognitive strategies.

The materials and methods. The study involved children of both sexes between the ages of 7-11 years (91 people) with the ADHD manifestations. The computer complex CPPC-99 "Psychomat" was used to study the decision-making strategies. Since the mode of "the free choice" allows you to select a form of behavior that is free from the influence on it of any external factors and is only determined by the internal goal formation mechanisms [5], therefore, on the basis of the characteristics of stereotyped choice in this mode, the two groups of students were identified. The first group was consisted of hyperactive children (40 people) with stereotyped choice, the second group was consisted of children with ADHD without stereotyped choice (51 people). The study was conducted in the "Free choice", "Probabilistic choice" and "Controlled Choice" modes. In the "Free choice" mode they were offered to press the left and right buttons in random order, without giving preference to any of them and without showing the stereotypical combinations of clicking, that is carried out the free generated pattern of reactions. In the "Probabilistic choice" mode they were offered to predict the sequence of stimulus alternation, guessing each time which of the two buttons (right or left) would light up the next presentation. We used a stochastic sequence of stimuli in which the subject has an intuitive sense of the fundamental possibility of the successful ("encouraged") decision-making. Each time the subject received the confirmation of his\her choice, if his\her response coincided with the "alleged" in the sequence (a situation of success), or a refutation of his\her choice in the event of an incorrect response (a situation of failure). As determinants of the signals of the right and wrong choices are determinants, that is, "reinforcing and" non-reinforcing "incentives, the external environment signals (light stimulus). These terms and conditions of the study provide an opportunity to examine the motivational component of the probabilistic learning process that is the strategy of behavior of a subject in a situation of success and failure, the analysis of which was conducted in terms of re-election of the left and right buttons (%). In the "Controlled Choice" mode they were offered to respond to the requirements of the light

stimulus quickly and without mistakes, which is switched on in a certain sequence on the left or right button. This task requires the test sequence of stimuli from the subject and the need to quickly switch from one stereotype decision-making to the others. The dynamic indicators of decision-making efficiency were studied: the response time, the time of repeated clicks on the same button if there was a success, the time changing button if there was a success (ms).

For estimating the energy state of the brain in children the diagnostical complex Neuroenergokartograf "Neuro-KM" was used estimating the level of constant potentials of the brain. The LCP of the brain was recorded monopolarly using non-polarizable silver chloride cup electrodes "EE-G2" (active) and "EVL-1-M4" (Referent) and the direct current amplifier with input resistance of 10 megohms. Referent electrode was placed on the right wrist, active - along the sagittal line - in frontal, central, occipital areas, as well as in the right and left temporal areas (points Fz, Cz, Oz, Td, Ts are according to the international system "10-20").

The LCP registration of the subject was carried out in 5-7 minutes after the application at the points of lead of electrodes with contact tampons wetted with hypertensive solution NaCl. The analysis of LCP was produced by mapping the obtained LCP values using the monopolar measurement and calculating the deviations of the level of constant potentials in each lead from the averages, registered in all areas of the head wherein there is a possibility of estimating local values of LCP in each area with the exception of the effects coming from the referent electrode. The obtained characteristics of the LCP of the brain distribution were compared with the average standard values for certain age periods. The statistical processing of the results was performed using the statistical software package SPSS 21.0. The submission of quantitative data to normal distribution law was assessed using the criterion Shapiro-Wilk, which showed that the distribution was normal ($p < 0.05$), therefore, for identifying the differences between the indices corresponding to the criteria of normality, using the Student's t-test.

Results and discussion

While studying the strategies of behavioral response in the «Controlled Choice" mode, the differences between the indicators in the first and second groups were identified.

The total number of errors in children of the second group was higher than in children of the first group. There was also a greater number of errors than in the first group of children when transferring the left and right stimulus, through the repetition and the change of the stimulus. Thus, in children with a tendency to stereotype in an uncertain environment, the parameters indicating the accuracy of fulfillment were higher than in the group without a stereotyped choice. However, the children in both groups showed a low level and difficulty of switching attention, as indicated by a large number of errors when changing the direction of the stimulus.

There was a quick reaction when repeating the previous reaction of the students in both groups and the children of the first group did it much faster than those of the second group.

Analysis of indicators of a behavioral response efficiency in groups showed that the processes of analysis and synthesis proceeded more energetically in the group with a tendency to stereotype in an uncertain environment. Children with stereotyped choice made the followed choice of changing and repetition in situations of success and failure faster.

Thus, students of the first group made fewer errors, which may indicate the better regulation of the motivation in comparison with the children of the second group. The students in both groups reacted faster in a situation of failure than in a situation of success. The children did not think through the answer and did not change the strategy of behavior, because they did not realize that their choice did not lead to a success.

By studying the characteristics of behavioral reaction in the mode of "Probabilistic choice" it was revealed that children of the second group indicator of the probability of choosing the left and right buttons, the probability of a dyad repeat select right and left buttons and re-select the left and right buttons on the background of the success was higher than in the children of the first group. However, in the group of children with stereotype behavior the change of the dyad left and right buttons was more likely.

The success of the assignment in the test mode "Probabilistic choice" is particularly dependent on the multiple reinforcement on the acceptor structures of action result of embodied information about the parameters of the reinforcing effects, about the ways and means of their achievement. It was revealed that the children of the second group were more often committed the repeated selection of a button in a situation of success that is the positive reinforcement determines the behavioral response of the second group children. The first group students repeated less often the previous selection on the background of the success in comparison with the second group that can indicate a smaller diligence, impulsiveness in decision-making, and finally affects the ability to commit more errors in comparison with the second group children.

It was found that the first group children spend less time to do the test than the second group children. Analyzing the time change when a success and the time change when the error it was revealed that the students in the first group spent more time of repetition on a background of a success and on a background of a failure.

Thus, an inadequate behavioral response in the "Probabilistic choice" in children with stereotyped behavior in an uncertain environment indicates their inertness and low interest to good results.

The features of behavioral reaction in children with a tendency to stereotype selection in comparison with their contemporaries without stereotype indicate that they have difficulties with

the concentration and distribution of attention, they are not quickly switch attention from one activity to another, the children operative memory is poor.

The identified distribution of LCP of the students' brain with different strategies of behavioral response indicates a decrease of the total energy consumption of the brain by 6.9 %, in children with the stereotype decision-making in contrast to the children without stereotype, which is reflected in all monopolar values of LCP in the leads.

The high values of LCP in central, right temporal area in students with the stereotype decision-making (group 1) indicate the presence of disorders in the emotional sphere. The identified feature may explain the inadequate strategy of behavior in the "Probabilistic choice" mode in hyperactive children with a stereotype. The indicators of hemispheric asymmetry of energy metabolism had a positive value, which indicates the predominance of right-brain activity in children of this group.

The index of interhemispheric asymmetry in schoolchildren without a stereotyped choice is close to zero that indicates the absence of any hemisphere dominance.

Analyzing the level of constant potentials in children of the first group in comparison with children of the second one, it was identified a state of reduced energy metabolism of the central nervous system.

In children of the first group in comparison with the children of the second one there was found a reduction of energy metabolism in the occipital area of the brain that has a negative impact on the processes of analysis and synthesis in these children.

Revealed in children of the second group a more intense energy exchange in the temporal area of the left hemisphere that along with reduced activity of the frontal parts of the brain may lead to a regulation abnormality of motivation in children revealed by the study of strategy behavioral responses in the "Managed choice" mode. Pupils of the 2nd group, A decrease of interactions between the parts of the brain is observed in the second group schoolchildren in comparison with their contemporaries from the 1st one. These changes, along with the lack of hemispheric dominance in second group children may cause the difficulties of choosing a strategy of behavior that leads to a poor adaptation in a deterministic environment.

Conclusions

In the group of children with the stereotype of choice (the first group) the level of constant potentials of the brain is increased in stem structures and right temporal area with simultaneous reduction of energy consumption of occipital area, the negative dynamics of structural-functional organization of the brain with a predominance of right hemisphere activity is revealed.

In the group of children without the stereotype of choice (the second group) the activity of the frontal and brainstem structures is reduced, the activity of the left temporal area is increased with a reduction of interactions between parts of the brain and a lack of hemispheric dominance.

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