FREQUENCY OF EEG RHYTMS EXAMINED IN PRESCHOOL CHILDREN DURING ACHIEVING GOALS

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Summary. It has been established that high-speed aim approaching activates positive emotional reaction; medium – concentration reaction, and low - active or passive negative emotional reaction. These reactions are accompanied by changes in Cardiac Stress Index - CSI and brain bio potential. It was further shown that 6-7-year old subjects as well as adults presented self-adjustment of central reactions - essential general bioelectric activity, right hemisphere associative areas α-rhythm, increased activity, and its asymmetric distribution in the parietal-temporal areas involved in the emergence of negative-orienting reaction. However, children's α-rhythm asymmetrical distribution across the sub-bands is rather an indicator of child's cerebral cortex maturity and to a lesser degree is determined by emotiogenic stimulus.

Key words: preschoolers, EEG rhythms, achieving the objective

INTRODUCTION

Goal reflex [Pavlov, 1975] and purposeful activity is an integral part of any living being mental activity. Functional organization study of child's goal-directed behavior and aspirations achieving the goals within specified time intervals is a psychophysiological, pedagogical and psychological priority which allows us to analyze object's holistic behavior activity referring to the background of external and internal environment effects.

Studying behavior of primates we have found that high-speed aim approaching activated positive emotional reaction; medium – concentration reaction, and low - active or passive negative emotional reaction. These reactions were accompanied by changes in Cardiac Stress Index (CSI) and brain biopotential.

Growing flow of information, processing necessity and its assimilation by children in early childhood often leads to the development of chronic diseases, social deprivation and delayed intellectual growth. As a result we have a pathological vicious circle of functional immaturity, which leads to deprivation in communication and learning difficulties and eventually to psychosomatic diseases.

One of the brain maturity indicators is an α-rhythm with the usual frequency range within 7-13 Hz which is completely formed by the age of 15-18 years. Thus, it is divided into three subbands according to the child's age [Farber, 2000; Machinskaja, 2007; Bezrukih, 2009].

Our research has presumed finding and understanding of child's formation fundamentals of desire to achieve the objectives during the process of learning in order to maintain motivation, physical and mental health. [Patent № 2313279, Kuznetsova, et al., 2011].

Based on the above formulated task - frequency bands of EEG rhythms and α-rhythm analysis in particular can serve as one of the objective diagnostic signs of child's brain maturity and its readiness for school.

METHODS

The Method of Approaching the Aim has been used (MAA) in the study. [Kuznetsova, 1988]. Its basis is a conveyor belt, at the far end of which the target object was placed. The belt speed was changed within the range of 250 to 5mm/s. After

the command "Attention, work!" an examined subject initiated the whole device by pushing the button in front of them.

Behavioral self-regulation reactions have been videotaped and analyzed. 10 leads Fp1, Fp2, F3, F4, P3, P4, T3, T4, O1, O2, with a combined ear unipolar electrode EEG have been recorded.

Changing the indices of all rhythms, their distribution within the frequency range of 0.5 - 45 Hz for the period of not less than 60 seconds for each of the presented speeds averaging the group of subjects has been considered. The dynamics of the index α-rhythm EEG, asymmetry changes and its distribution to the leads was separately analyzed. The results were analyzed statistically by non-parametric Wilcoxon's test. Significant differences were considered at $p<0.05$.

RESULTS AND REVIEW

Previously, it was found that changing the approaching target speed in all subjects of our research, regardless of age, species and sex discretely activated the modulating systems, i.e. emotional reactions, concentration and orienting reflex [Syrensky, 1990].

In case of object speed range of 250 and 125 mm/s the prevalence of positive emotions was registered. Object movement at the speed range of 25-10mm/s showed self-activated behavioral responses of passive avoidance and caused reduction in the time tracking of the moving object. Object speed reduction to the lover limits of 5 and 10mm/s exacerbated adverse reactions and significantly ($p = 0.002$) reduced tracking time in comparison to speeds of 125, 50 and 25mm/s.

Significant ($r>0.4$-0.8) correlations were noted among EEG distribution in quiet conditions as with the open eyes, so in response to an object velocity changed from 5 to 250mm/s the reactions were similar, despite the occurrence of emotional reactions with the opposite sign. The only exception was the speed of 50mm/s which will be discussed later.

Mostly interrelated were symmetrical fronto-motor (17%-23%), left-parietal-occipital (16%-24%) and right-temporo-parietal-occipital (16%-26%) brain areas with well established interhemispheric temporo-parietal link (19% -28%). Thus it appeared that task solving resumption necessity at low speeds showed passive avoidance such as refocusing from the object as a negative stimulus contributed to the functional state normalization at the behavioral level. These findings are consistent with our previous conclusions concerning the behavioral level [Syrensky, 1990] such as self-regulation at the central level without expressed interhemispheric asymmetry in the distribution of EEG correlations.

The most significant changes in the distribution of correlations emerged when children solved object-approaching task at the speed of 50mm/s. In this case, the subject emerged orientation reaction to sudden object speed change and demonstrated lack of understanding. In response, the subjects showed an increase in the number of links between all investigated areas of the brain, preserved and/or increased the number of right temporo-parietal-occipital (30%-40%) and left-parietal-occipital connections (45%), doubled number of inter-hemispheric fronto-parietal (from 20 to 40%), new hemispheric fronto-frontal, fronto-occipital (up 25%) and fronto-temporal (25%) communication developed. At the same time the uncertainty of the situation, when the object was approaching, was not fast, but not as slow as to activate negative emotions that arose at sudden increase in speed from 50mm/s to 250 and 125mm/s, which led to significant restructuring of the brain bioelectric potentials and enhanced the correlation between the individual zones within all of its frequency bands. Index value analysis of each of the five basic EEG rhythms showed significant differences in the functional state changes as a response to the impact of different emotiogenic speeds of object approaching.

As in the initial state with eyes open, when the object reached the goal, moving at speeds of 10 and 5mm/s there was no significant asymmetry index distribution in basic EEG rhythms in all areas of leads.

Basic indices of distribution similarity of the rhythms can be explained by the fact that, notwithstanding the negative emotion in response to slow speeds, the adverse impact of passive avoidance, such as lead glance, contributed to the functional state normalization and provided a state close to the background. Other results were obtained at high speeds of the approaching object, and after the transition to the low velocity of approaching.

As already mentioned, approaching at high-speed object activated positive emotions, and the transition to low speed produced orienting response. Meanwhile low velocity caused an array of negative emotions.

It was found that reaching the object by children, approaching at the speed of 250 mm/s led to ($p <0.01$) asymmetric distribution of indices α-, β- and γ-rhythms in the right temporal leads. This

fact can be attributed to the emotionally positive reaction activation.

According to some authors, activation of β- and γ-rhythms in the front, center and rear areas of the cortex in adults is associated with affective reaction to a stimulus [Rusalova et al., 1999; Muller et al., 1999]. However, related to emotion inter-hemispheric differences in these ranges were not observed. It was found that the asymmetry in the distribution of indices α-, β- and γ-rhythms in children, on the one hand reflects a more pronounced response to a positive stimulus compared to more restrained response in adults, and on the other hand it indicates active reaction of maturing brain structures at this age.

Desynchronization of α-rhythm especially in the lower range in adults indicated the activation of attention in the idle mode [Klimesch, 1999] and asymmetric amplification caused by its activity in the parietal and parieto-temporal leads cortical areas of the right hemisphere which indicated involvement in the process of emotional responses discernment activity component to presented stimuli [Davidson et al., 2000].

In children α-rhythm desynchronization occurred during modulating system activation with increased concentration of α-activity rhythm in associative areas of the right hemisphere. This mechanism apparently is common in the perception of emotional stimulus significance, regardless of a person's age.

Reducing the object speed down to 125mm/s was accompanied by preservation of right-sided β-rhythm asymmetry index in the temporal area which was apparently associated with the perception of this rate as a positive stimulus.

Based on the behavioral responses that showed as right-handed asymmetry index θ-rhythm in the right occipital area can be considered as the focus necessity on the moving subject and the differences between this movement speed of the object were relative to the first 250 mm/s higher speed.

The appearance of left-sided asymmetry low-frequency index Δ-rhythm in the left frontal and temporal leads was most likely associated with situation assessment and decision making to continue the activity. Currently it is believed that the emergence of emotions and motivations in adults is associated with two basic systems of achieving or avoiding [Rusalova et al., 2000].

In this case, if the front cortex of the left hemisphere is considered in association with the achievement system and the right hemisphere symmetrical area - with avoidance system, the emotional parcels perception and evaluation are mainly realized by the cortex posterior right hemisphere, the right temporo-parietal region. The very same experience of emotions going on with the participation of the front cortex area depends on the sign of emotion and is reflected in their asymmetric activation [Morgan et al., 1993].

Increasing the power base θ-rhythm in adults is associated with the activation of the orienting reflex systems, concentration, emotions [Pavlygina et al., 1994; Sasaki et al., 1996; Basar et al., 2001], encoding new information in the memory, its subsequent reproduction [Klimesch, 1999] and emotional information processing [Rusalova et al., 2000; Krause et al., 2000].

Sudden changes in the speed of object movement with the children as subjects led to the activation of the orienting reaction, uncertainty state, negative emotional response strengthening and the subject's necessity for matching reactions from the requirements of speeds with traces of the previous ones. Speeds causing described reactions differed 5-10 times.

Uncertainty state aroused in response to the speed of 50mm/s was accompanied by the index γ-rhythm increasing in the right hemisphere frontal area.

Negative emotional reactions emerged in response to the speed of 25mm/s, accompanied by increased β-rhythm in the parietal area. These findings are consistent with earlier data concerning significant increase in general index values Δ- and θ-rhythm emotion activation system [Kuznetsova et al., 2012]. Indices β- and γ -rhythms in the parietal-temporal areas right asymmetry reflect negative-orienting reaction emergence in response to the transition of speeds which is consistent with other authors' opinions [Aftanas et al., 2003; Lapshina, 2007; Pape et al., 2005] Parallel to this, retrieval of previous positive images extraction from the memory process from high speeds made these data consistent with the data obtained in adults [Zhirmunskaja et al., 1982; Kostjunina, 1996].

Therefore identifying EEG rhythm, rebuilt index and its hemispheric asymmetry distribution accompanied by progressively reducing speed of aim achievement along with activation of 6-7-year old children modulating brain systems demonstrates their readiness to accept emotionally significant information in a similar way to adults. Further fact analysis revealed an interesting nuance, i.e. α-rhythm index subband changes in

response to emotionally significant stimuli. It is known that α-rhythm is finally formed by the age of 15-17 years. Low frequency up to 8 Hz α-rhythm appears by the age of 7 years. This rhythm still has no «fusiform» modulation or occipital to the frontal zones gradient falling.

It is subdivided into a low frequency - from 7.0 to 8.5 Hz, medium - from 8.75 to 9.75 Hz and a high - from 10.0 to 13.5 Hz subbands [Farber et al., 2000; Machinskaja et al., 2007; Bezrukih et al., 2009]. It was found that in the full range (8-13 Hz) α-rhythm index, when the overall children's emotional state was changing, it did not vary significantly which is consistent with the foreign authors' data obtained in adults when «passive» viewing IAPS stimuli were analyzed (International Affective Picture System, University of Florida, 1999) [Muller et al., 1999].

The analysis revealed emotiogenic stimuli perception rhythm asymmetry across the subbands of rhythms in children.

It was found that low-frequency range of α-, rhythm produced significant, similar to the background, right asymmetry in almost all leads regardless of the activation of the modulating systems associated with the speed of achieving the object in 77% of children. Left-sided mid- α-, -rhythm asymmetry was observed in 11.5% of children in the initial state along with positive and negative emotion activation, or was completely absent. Significant high frequency α-rhythm left-sided asymmetry was demonstrated by the 11.5% of the children examined, mostly in the frontal, temporal and parietal brain areas in the initial state independently of the applied speed emotional coloring.

Thus it was proved that in 6-7-year old children as well as in adults the α-, β- and γ-rhythm indices distribution and parietal-temporal areas asymmetry reflect negative-orienting reaction occurrence and processes associated with working memory. Meanwhile, α-rhythm right hemisphere associative areas increased activity appeared to be a common mechanism in the perception of emotionally significant stimuli, regardless of person's age. In contrast to adults, children revealed some sub-band asymmetry. Significant low frequency sub-band α-rhythm right-sided asymmetry was observed in almost all leads. Left-sided asymmetry in the mid- and high-frequency sub-bands was not related to the stimulus emotional significance. This fact characterizes 6-7-year old children's cerebral cortex level of maturity and shows that group α-rhythm has not been formed and has a low-frequency range in the majority of children at this age. Only smaller part of this group is nearing completion or already finished its formation.

CONCLUSIONS

Concluding, it must be said that 6-7-year old subjects, as well as adults self-adjustment central reaction - essential general bioelectric activity, right hemisphere associative areas α-rhythm increased activity and its asymmetric distribution in the parietal-temporal areas are involved in the emergence of negative-orienting reaction. Meanwhile children's α-rhythm asymmetrical distribution across the sub-bands is more of a child cerebral cortex maturity indicator and to a lesser degree is determined by emotiogenic stimuli.

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РОЛЬ РЕАКЦИЙ САМОРЕГУЛЯЦИИ В ОРГАНИЗАЦИИ ЦЕЛЕНАПРАВЛЕННОГО ПОВЕДЕНИЯ РЕБЕНКА

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Аннотация: В работе установлено, что стремление к достижению цели, приближающейся с различными скоростями, активирует поведенческие, вегетативные и центральные реакции саморегуляции. При этом скорость, равная 50 мм/с, в отличие от высоких и низких, вызывая реакцию неопределенности, обладает наибольшей физиологической силой, что проявляется в увеличении показателя “стресс-индекса” и наиболее значимой перестройке биопотенциалов головного мозга.
Обнаружено, что усиление активности α-ритма в ассоциативных зонах правого полушария является общим механизмом при восприятии эмоционально значимого стимула независимо от возраста человека. При этом у детей обнаружилась значимая правосторонняя асимметрия α-ритма в низкочастотном поддиапазоне (7-8 Гц) по всем отведениям, а в средне- и высокочастотных поддиапазонах (8,75-9,75 и 10,0 до 13,5 Гц соответственно) – преобладала левосторонняя асимметрия.
Ключевые слова – дети дошкольного возраста, ЭЭГ, достижение цели

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