

# Reflection of the Mental Reproduction of Emotional Experiences in the EEG Pattern of 10- to 11-Year-Old Children

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We studied the effects of mental reproduction of emotions on the EEG characteristics in 10- to 11-year-old children. Independently of the sign of emotions, their reproduction was related to a rise in the modal alpha frequency and to a decrease in the spectral power of the EEG alpha1 subcomponent. Increases in the power of the beta-rhythm and in the ratio between the beta rhythm power and that of the theta rhythm were more manifested upon mental reproduction of positive emotions.

**Keywords:** electroencephalogram, emotions, children.

## INTRODUCTION

The instability and “redundancy” of emotional processes may be a reason for abnormal development of the cognitive sphere of a child, as well as adversely affecting social functioning of his/her personality; this can, later on, result in corresponding negative changes in the adult personality [1, 2]. The reported data on EEG correlates of emotional experience are contradictory to a considerable extent; only a few studies were devoted to examination of EEG markers of different emotional processes in children. This is why we studied the peculiarities of modifications of the EEG patterns related to voluntary mental reproduction of different emotiogenic situations in 10- to 11-year-old children.

## METHODS

Thirty-five reasonably healthy 10- to 11-year-old children (16 boys and 19 girls) took part in this study.

Multichannel EEG recording was performed using generally accepted techniques. Electrodes were

positioned on frontal (F3, F4), central (C3, C4), temporal (T3, T4), parietal (P3, P4), and occipital (O1, O2) sites according to the international 10-20 system. As a reference electrode, we used interconnected contacts positioned above the *proc. mastoidei*.

First, we recorded the background EEG in the resting state with the eyes closed. Then, the tested children were asked to imagine sequentially three emotionally brightly colored situations experienced earlier. Among them, two such situations related to a social event (communication) and episodes of school life should be of a negative pattern, while the third situation should be a positive one. Prior to each EEG recording, the tested child was instructed in detail (taking into account his/her age-related abilities); after finishing the EEG recording, the tested persons were asked to describe, in the course of interviewing, what situations they imagined.

Spectral EEG analysis included calculation of the square root of the power spectral density (PSD,  $\mu\text{V}/\text{Hz}$ ) of oscillations of the following ranges and subranges, theta (4-8 Hz), alpha *en masse* (8-13 Hz), alpha1, alpha2, and alpha3 subcomponents (8.0-9.5, 9.5-11.0, and 11-13 Hz, respectively), beta1 (16-20 Hz), and beta2 (21-30 Hz) rhythms. The modal frequencies of the alpha subranges were calculated as arithmetic means of the frequency of the given subrange with the maximum amplitude within 20-25 segments of 2.56-sec-long recordings. We calculated ratios of the PSDs of the alpha rhythm and its three

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subranges vs PSD of the theta rhythm, as well as ratios of the PSD of beta1/beta2 rhythms vs PSD of the theta rhythms.

Numerical data obtained in the electrophysiological study were quantitatively processed using standard techniques of variation statistics. The Wilcoxon test was used for estimation of significant intergroup differences.

## RESULTS AND DISCUSSION

Analysis of the data obtained showed that mental imagination (reproduction) of positively and negatively colored emotional events by the examined children was characterized by significant ( $0.001 < P < 0.05$ ) changes in the PSDs and modal frequencies of some EEG rhythms, as well in the ratios of their PSDs.

In the case where the tested children imagined all the three types of emotionally colored events, the modal frequency of the alpha rhythm significantly increased in nearly all leads (except for the right temporal and frontal ones). Under conditions of mental reproduction of a negative emotional situation related to school life, the mean intragroup value of the PSD of the alpha1 subcomponent significantly decreased, as compared with the background values, in the left parietal and central leads and also in both frontal leads. If the children imagined a negative situation related to interpersonal communication, this index significantly dropped in leads T3, T4, C3, P3, P4, O1, and O2. In the case where the children imagined a positive situation, analogous modifications were observed in leads F3, T3, C3, C4, P3, P4, O1, and O2. It should be noted that the ratio of PSDs of the alpha1 and theta rhythms also decreased if the children imagined positive and negative social situations; the corresponding changes within the examined group were significant in practically all leads.

As is believed, the clearly manifested alpha rhythm and especially its low-frequency subrange, which are most typical of 10- to 11-year-old children [3], are related to a quiet relaxed state of the individual. The transition from such a state to the state of emotional experience is reflected, as a rule, in decreases in the PSDs of the above-mentioned EEG rhythms. Based on these data, we conclude that the emotional experience of negative events related to social communication was the most significant factor for the tested children. The formation of a mental image of such a situation was reflected in significant drops of the PSD values of the alpha rhythm and alpha1 subrhythm in most recording sites.

It was reported that under conditions of concentration of attention on emotionally colored reminiscences, the modal alpha frequency increases [4-6]. Correspondingly, a rise in this index during mental reproduction of all three types of the above-mentioned situations can be explained by the fact that, probably, the imagined story was associated in most children with episodes of their earlier experience.

The PSD values of the beta1 and beta2 rhythms, similarly to their ratios to the PSD of the theta rhythms, exceeded those within the background EEG recording during mental reproduction of emotionally colored situations. This fact agrees with the reports of other researchers [7, 8]. Most cases of significant differences of the above-mentioned values were found under conditions of reproduction of positively colored emotional situations; the ratio between PSDs of the beta1 and theta rhythms increased significantly in nearly all leads, while the ratio between the PSDs of the beta2 and theta rhythms also increased significantly in nearly all sites (except for leads F3 and F4). Based on the fact that an increase in the beta activity usually correlates with the level of attention [9], we can hypothesize that mental reproduction of positive emotions in children is accompanied by the maximum concentration of attention on the imagined situation.

It should be noted that, unlike the characteristics of other EEG rhythms, the characteristics of the theta rhythm demonstrated no significant changes in the course of comparison of the samples of segments recorded during reproduction of experimental situations with the background ones. Therefore, we conclude that the characteristics of EEG oscillations of the alpha and beta ranges can be considered most adequate electrophysiological correlates of the emotional experience in 10- to 11-year-old children.

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