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# Electrical Brain Activity in Students with Different Lateralization of the Dominant Arm, Yakutsk

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**ABSTRACT**
Analysis of spectral power and EEG rhythm index in Yakut students (n=38) was carried out. Higher spectral power values of base alpha rhythm were noted, relatively slow wave teta- and delta-activity. Regardless of the lateralization of the dominant hand, the decreasing occipital-frontal gradient of the alpha-rhythm index was clearly expressed. For the delta rhythm index, the decreasing gradient was directed in the opposite, frontally occipital direction. A similar organization of the bioelectric activity of the brain is characteristic of the tendency to become a "mature" EEG pattern in youth. The formation of brain functional maturity in right-handed and left-handed women is reflected in certain differences in the wave structure of the EEG pattern. A large degree of dominance and great heterogeneity of the alpha rhythm was revealed in the right-handed, while in the left-handed – a greater decrease in the power of slow-wave teta- and delta-rhythms. The obtained results of the study of background EEG in young Yakut men indicated the ongoing process of bioelectric activity of the brain. Some lag in the formation of mature EEG in Yakut students may be based on a slowdown in the connections between regulatory subcortical structures (diencephalic synchronizing and stem desynchronizing) and the cerebral cortex, which in turn is specific to the age development of the body in the complex climatic and social conditions of the North.

***Keywords:*** *electrical brain activity, spectral power, EEG rhythm index, lateralization, dominant arm, Yakutsk*

## 1. INTRODUCTION

The extreme climate of Yakutia, the huge territory, the distance from the center of Russia, the lack of developed transport infrastructure create difficult socio-economic conditions in the region. The success of adapting a northern student to a complex of adverse factors of the natural and social environment (severe climate, geomagnetic and weather disturbances, high mental and emotional loads) is determined by the morphofunctional state of the brain. In these conditions, children of indigenous nationalities have more prolonged processes of physical development and puberty in time compared to peers of other regions of Russia [1, 2]. A number of works have studied the influence of exogenous environmental factors (climatic, socio-economic, methods of education and training) on morphofunctional maturation of the brain [3–6]. To study the formation of various parts of the brain and connections between them in ontogenesis, the electroencephalography method is widely used [5, 7]. Maturation of the cortex of the large hemispheres, the functional organization of its nerve centers, manifests itself in a decrease in the representation of teta- and delta-rhythms with age and intensity increase of alpha-rhythm, the formation of its spatial organization [5]. The predictor of the level of functional maturity of the brain is the formation of zonal power distribution of the basic alpha rhythm. By the age of 7, the decreasing occipital-frontal gradient of the power of this rhythm should be clearly expressed. The EEG feature of morphofunctional brain maturity is the establishment of alpha rhythm synchronization between frontal and temporal cortical zones. Synchronization reaches a high degree by the age of 16 [5]. Coherence between frontal and occipital zones is increased due to maturation of long associative links [8]. The high significance of forming the connection of the prefrontal cortex with the associated mediodorsal nucleus of the

 

thalamus is also noted [9]. Immaturity of the fronto-thalamic system is manifested by impaired cognitive processes, difficulties in teaching schoolchildren [5]. According to [10], the final formation of the spatial and temporal organization of alpha rhythm takes place in the central and frontal departments only by 22–25 years. In the process of age development of morphofunctional maturity of the brain there is a decrease in index and power in the teta- and delta-ranges of the EEG and an increase in alpha-rhythm activity [5].

The number of right-wingers in the human population, according to various sources, ranges from 80–95 %. The rest are left-handed and ambidexters (people with equal capabilities of both hands). One of the individual typological characteristics of the peoples of the North is the relatively greater prevalence of ambidexters and leftists than among people living in the temperate zone. Higher level of adaptive capabilities is indicated in northerners with high functional activity of the right brain hemisphere [3, 11]. However, the specifics of inter-hemisphere relations among the ethnic groups of Yakutia remains still unexplored. Electrophysiological studies of the rhythmic components of the EEG are one of the informative approaches to the study of neurophysiological mechanisms of interhemispheric asymmetry of the brain in right and left-handers.

The number of dextral humans in the human population, according to various sources, ranges from 80–95 %. The rest are left-handed and ambidexters (people with equal capabilities of both hands). One of the individual typological characteristics of the people of the North is the relatively greater prevalence of ambidexters and left-handed than among people living in the temperate zone. Higher level of adaptive capabilities is indicated in northerners with high functional activity of the right brain hemisphere [3, 11]. However, the specifics of inter-hemisphere relations among the ethnic groups of Yakutia remains still unexplored. Electrophysiological studies of the rhythmic components of EEG are one of the informative approaches to the study of the neurophysiological mechanisms of interhemispheric asymmetry of the brain of right-handed and left-handed women.

To assess the degree of functional maturation of the cerebral cortex in Yakut students with different manual dominance, the amplitude-frequency parameters of EEG and the features of spatial localization of rhythms in various zones of the cortex of the large hemispheres were studied.

## 2. METHODS AND MATERIALS

The features of the background ranges (α-, θ- и δ-rhythms) of the EEG among the right-handed and left-handed students of the North-Eastern federal university (Yakutsk) were studied. Studies were carried out in February and the 1st decade of March 2017 in 38 practically healthy Yakut students aged 17–19 years old. 20 students wrote with their right hand (13 boys and 7 girls) and 18 with their left (9 boys and 9 girls). All subjects gave written consent to participate in the study, EEG was registered on the Neuron-Spectrum 3 hardware and software complex in 16 leads according to the international system 10–20. Monopolar leads with combined ear reference electrode were used. The filtration band was 0.5–35 Hz, the digitization frequency was 200 Hz. EEG registration was carried out in a darkened room, in the absence of extraneous stimuli with closed eyes. For analysis, the era was chosen – 30 s without artifacts. The analysis included data for 5 couples of assignments located in symmetric points of the right and left hemispheres: O2, O1, P4, P3, C4, C3, T4, T3, F4, F3. The values of absolute power ($\mu V^2$) of the average amplitude of the frequency ranges: α, θ, δ were analyzed. The rhythm index of the studied EEG ranges was also evaluated. Statistical processing of the results of the studies was carried out by MS Excel program. Since the distribution of spectral power parameter values is not described by the normal distribution law, the data is represented as quartile values. The significance of the differences in values was determined by the criterion of rank sums. Logarithmetic was used to normalize the distribution of spectral power values of the studied EEG rhythms. All students were recognized as almost healthy according to the results of comprehensive medical examinations conducted by the doctors of the university clinic, and at the time of the examination there were no signs of any disease.

## 3. RESULTS AND DISCUSSION

The alpha rhythm patterns of the background EEG of the examined students are characterized by interhemispheric smoothness, more pronounced in the left-handed relative to the right-handed (Table 1). These data confirm the high prevalence of ambidextrism in Yakut students by tests to determine the motor and sensory asymmetry of the hemispheres. The more pronounced interhemispheric smoothness of the power of the α-range in the left-handers relative to the right-handed is consistent with the literary data (12) and indicates a diffuse interaction of electrical activity in both hemispheres of the brain. Only the right-handed people have a distinct excess of spectral power in the occipital region of the right hemisphere relative to the left. Large values of spectral power of alpha-rhythm of right-handed people in occipital-parietal and central leads than of left-handed people pay attention to themselves. Only in the temporal and frontal zones of the cortex of the hemispheres does the alpha-rhythm power become the same among the right and left-handed (fig. 1).

In both examined groups, the decreasing occipital-frontal gradient of the spectral power of the θ`-rhythm is

weakly expressed, and its interhemispheric differences are practically absent. The power of the sound-rhythm in the parietal zones of the right-handed is significantly higher: in the retraction P3 ($p = 0.028$) and in P4 ($p = 0.021$) in comparison with the left-handed ones (Table 1).

**Table 1.** Values of spectral powers ($\mu B^2$) of EEG-rhythms at right and left Me (Q1-Q3)

| Lead | α-rhythm | | θ- rhythm | | δ- rhythm | |
|---|---|---|---|---|---|---|
| | right-handed | left-handed | right-handed | left-handed | right-handed | left-handed |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| F3 | 0.22 (0.13-0.34) | 0.2 (0.1-0.3) | 0.25 (0.16-0,43) | 0.21 (0.16-0.44) | 0.47 (0.3-0.9) | 0.53 (0.2-0.71) |
| F4 | 0.24 (0.2-0.31) | 0.25 (0.13-0.33) | 0.25 (0.19-0.37) | 0.2 (0.16-0.44) | 0.5 (0.38-0.72) | 0.46 (0.26-0.67) |
| T3 | 0.15 (0.1-0.21) | 0.15 (0.1-0.25) | 0.16 (0.12-0.28) | 0.21 (0.11-0.28) | 0.55 (0.34-0.92) | 0.55 (0.36-0.7) |
| T4 | 0.17 (0.08-0.21) | 0.12 (0.09-0.22) | 0.17 (0.09-0.26) | 0.15 (0.11-0.2) | 0.51 (0.38-1.05) | 0.53 (0.34-0.79) |
| C3 | 0.23 (0.14-0.33) | 0.19 (0.11-0.45) | 0.16 (0.13-0.25) | 0.14 (0.1-0.19 | 0.36 (0.26-0.6) | 0.34 (0.25-0.48) |
| C4 | 0.33 (0.16-0.36) | 0.21 (0.1-0.54) | 0.2 (0.13-0.3) | 0.17 (0.13-0.29) | 0.37 (0.31-0.79) | 0.47 (0.36-0.68) |
| P3 | 1.1 (0.45-1.34) | 0.74 (0.32-1.07) | 0.3 (0.2-0.43) | 0.15* (0.11-0.28) | 0.48 (0.44-0.92) | 0.43 (0.34-0.66) |
| P4 | 1.04 (0.71-1.4) | 0.65 (0.33-1.11) | 0.28 (0.22-0.43) | 0.16* (0.11-0.24) | 0.58 (0.44-1.12) | 0.53 (0.4-.69) |
| O1 | 1.54 (1.1-2.13) | 1.16 (0.83-1.77) | 0.39 (0.21-0.53) | 0.23 (0.19-0.48) | 0.68** (0.59-0.9) | 0.52 (0.48-0.68) |
| O2 | 2.22 (1.04-2.5) | 1.22 (0.97-1.68) | 0.35 (0.19-0.57) | 0.26 (0.21-0.43) | 0.82** (0.41-1.08) | 0.6 (0.44-0.9) |

Note: * – significance of differences at p≤ and higher between 3 and 4, * * – between 5 and 6.

**Table 2.** Index values (%) alpha-, teta-, delta-rhythms for right and left-handed

| Lead | α-rhythm | | θ- rhythm | | δ- rhythm | |
|---|---|---|---|---|---|---|
| | right-handed | left-handed | right-handed | | right-handed | left-handed |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| F3 | 24.3 | 22.2 | 17.7 | 13.1 | 30.1 | 26.1 |
| F4 | 29.7 | 20.8 | 16.2 | 14.1 | 26.4 | 29.1 |
| T3 | 19.9 | 18.9 | 15.2 | 17.4 | 39.4 | 38.7 |
| T4 | 22.1 | 19.3 | 13.6 | 15.6 | 45.2 | 45.3 |
| C3 | 43.4 | 30.6 | 17.1 | 16.0 | 28.2 | 27.3 |
| C4 | 43.9 | 40.3 | 16.5 | 12.9 | 34.6 | 32.9 |
| P3 | 58.9 | 56.8 | 11.0 | 12.9 | 19.2 | 24.8 |
| P4 | 63.9 | 45.4 | 10.8 | 11.1 | 17.2 | 20.1 |
| O1 | 64.5 | 61.9 | 9.6 | 7.7 | 17.8 | 15.2 |
| O2 | 65.8 | 61.0 | 8.7 | 8.0 | 15.8 | 13.6 |

In right-handed and left-handed women, a tendency has been revealed to increase in index of sound-rhythm from occipital to frontal: in right-handed women, on average, in hemispheres from 8 to 17 %, in left-handed women from 8 to 14 % (Table 2). O1 ($p = 0.046$) relative to the left-handed. The δ-range index, as well as the sound-rhythm index, increases in the occipital-frontal direction: for right-handed, on average, in hemispheres from 17 to 27 %, for left-handed from 16 to 30 % (Table 2). It is believed that in young men when waking with their eyes closed, the slow rhythms of EEG with a predominance of index in the frontal departments are no more than 35 % the norm. It should be noted that we detected high values of power and index of slow wave rhythms in winter (February), when the intensity of solar radiation in Yakutsk is low: total radiation is 4 kcal/cm$^2$, while in June-July – 20 kcal/cm$^2$. In the teenagers of the Arctic, a decrease in the total level of brain activation on polar night was established, which may be somewhat due to a reduction in afferentiation from visual receptors and proprioreceptors of motor analyzers in winter [13].

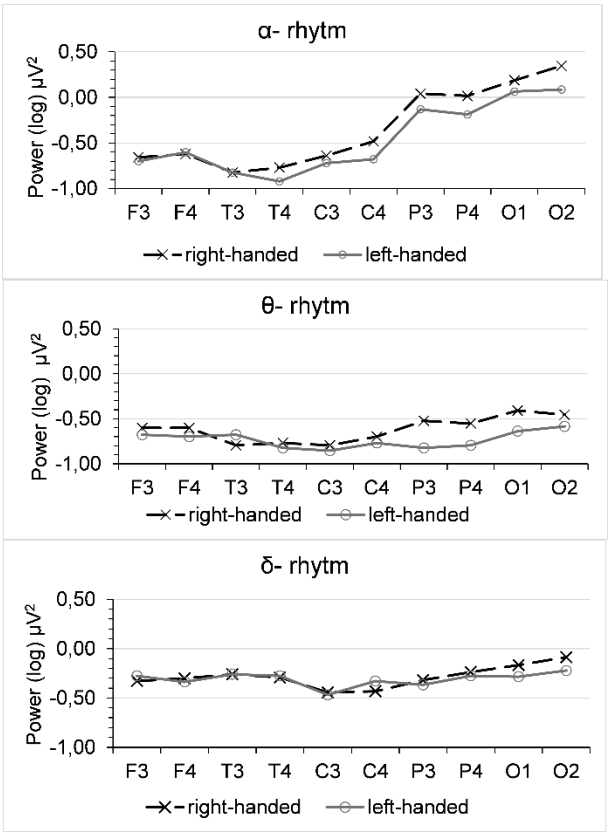


**Figure 1.** Power of EEG rhythms in various leads

The high representation of slow wave delta rhythms of EEG in a state of calm wakefulness in Yakut students is possibly due to excessive synchronizing effects on the cortex of stem structures (anterior hypothalamus, transparent septum). In turn, these hypnogenic centers are under the inhibitory control of the frontal cortex. It is known that hypnogenic centers have extensive morphofunctional connections with stem nonspecific structures having activating effects on the cortex [3]. Obviously, in the process of morphofunctional maturation of the brain, a balance must be established between the inhibitory stimulation of the frontal cortex and the ascending activating influences of the brainstem. At the same time, it is known that the prefrontal zones of the cortex are formed last [11]. In general, the examined students showed a lag in functional maturation of the brain and the formation of cortical-subcortical connections compared to peers living in the central part.

## 4. CONCLUSION

The dominance of alpha-rhythm spectral power values identified in Yakut students, as well as the characteristic zonal distribution of the index of this rhythm (decreasing occipital-frontal gradient) in right-handed and left-handed people, indicates a tendency to become a mature type of structural-functional brain activity.

In Yakut students, there is a tendency to lower power values of slow wave activity relative to the basic alpha rhythm and a clearly manifesting decreasing fronto-occipital gradient of delta rhythm.

The formation of functional maturity of the brain in Yakut students is reflected in the wave structure of the EEG pattern, which has certain differences in people with different lateralization of the dominant hand: a large degree of dominance and greater heterogeneity of the alpha rhythm in the right-handed, while in the left-handed – a greater decrease in the power of slow wave teta- and delta-rhythms.

The obtained results of the study of background EEG in young Yakut men indicate the ongoing process of development of bioelectric activity of the brain. Some lag in the formation of mature EEG in Yakut students may be based on a slowdown in connections between regulatory subcortical structures (diencephalic synchronizing and stem desynchronizing) and the cerebral cortex, which in turn is specific to the age development of the body in difficult climatic and social conditions.

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