Lobasyuk B. A., Bodelan M., Zamkovaya A. V. Relationship of EEG and tremorogram indicators. Journal of Education, Health and Sport. 2021;11(04): 80-91. eISSN 2391-8306. DOI http://dx.doi.org/10.12775/JEHS.2021.11.04.009
https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2021.11.04.009
https://zenodo.org/record/4739447

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

Received: 26.02.2021. Revised: 31.03.2021. Accepted: 30.04.2021.

RELATIONSHIP OF EEG AND TREMOROGRAM INDICATORS

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Abstract

The existing facts and hypotheses regarding the localization of the "pacemaker" of tremor are rather controversial. Fundamentally, the development of tremor (TrG) is explained by the formation of an oscillator (a source of rhythmic activity) at any level of the central nervous system. **The objective** is to study the mutually oriented influences between the frequency and amplitude of the TRH rhythms and the electroencephalogram (EEG), reflecting the work of the generators (oscillators) of both oscillatory processes. It was revealed that more regression coefficients from the EEG indicators of both the right and left hemispheres were determined for the left hand TRG indicators. This may indicate that the generators that form the physiological tremor of the left and right hand are not identical, as well as that the physiological tremor of the left hand is to a greater extent controlled by the generators that form the EEG than the generators that form the tremor of the right hand. The largest number of regression coefficients of multiple regression analysis was determined by the rate of beta-1 rhythm of the left hand TrH from EEG indicators. It was shown that the generators forming the physiological tremor of the left and right hands are not identical. The physiological tremor of the left hand is to a greater extent under the control of the generators that form the EEG than the generators that form the tremor of the right hand. The generator of the alpha rhythm

of the TrG of the left hand is an independent formation and is not similar to the generator of the alpha rhythm of the TrG of the right hand.

Key words: tremor; multiple linear regression; electroencephalography; half-period analysis.

Introduction

According to the concept of selectively distributed oscillatory systems in the brain, there are neuron systems capable of generating waves with a certain frequency [5, 7, 9].

The distributed nature of the ECoG-EEG alpha rhythm source made it possible to put forward a hypothesis about the existence of multiple discrete sources of alpha-range oscillations - "alphas" [12].

It has been suggested that hypothetical generators of beta 2, beta 1, theta and delta rhythms exist in the same way in the cerebral cortex [1].

Fundamentally, the development of tremor (TrG) is explained by the formation of an oscillator (a source of rhythmic activity) at any level of the central nervous system. This applies to both physiological tremor and various types of pathological tremor [6, 8].

The existing facts and hypotheses regarding the localization of the "pacemaker" of tremor are rather contradictory and are reflected in detail in the monographs of E. I. Kandel, L. S. Petelin, A. I. Trokhachev, S. N. Raeva and other authors.

According to microelectrode studies by Alb-Fessar (1966), neurons with a frequency of 5 discharges per second were identified in the nuclei of the optic hillock, which correlated with the frequency of tremor [4].

According to SN Raeva, in patients with trembling forms of parkinsonism, two main types of supraspinal rhythmic impulses are revealed, which are realized by different groups of neurons. A smaller group of neurons located in narrowly localized zones of the VL-thalamus exhibits rhythmic activity only in the presence of a pronounced tremor and is characterized by strict synchrony with it (in terms of the frequency and constancy of phase relations with it. The second group of neurons located in the median regions of the VL-thalamus and in zone, correlates with tremor only in frequency, but not in the constancy of phase relations with it, the activity of the second type of neurons is recorded both at the moment of the appearance of the tremor and when it subsides [3, 11].

Physiological tremor, as you know, depends not only on the mechanical properties of the limb; an important role in its occurrence, in addition to peripheral factors, is played by the 8–12 Hz central component [8].

Based on the foregoing, it is relevant to investigate the mutually oriented influences between the frequency and amplitude of the TRH rhythms and the electroencephalogram (EEG), reflecting the work of the generators (oscillators) of both oscillatory processes.

Research methodology

EEG studies were carried out in 14 students, mean age 20 ± 0.5 years. The EEG was recorded on a computer hard disk using a computer electroencephalograph at a sampling rate of 256 per 1 sec in bipolar leads: 1 - forehead, 2 - temple-crown, 3 - crown-occiput in the left and right hemispheres in a state of operative rest - eyes open (OP) within 2 minutes.

The tremor was recorded using a linear displacement transducer developed by us [2], which consisted of a carbon-resistive transducer (a soft resistor — a rubber tube filled with coal powder) included in a bridge circuit. The linear displacement transducer was supplied with a voltage of 4.5 V, and the tremorogram was recorded during the calibration of the 500 MkV amplifier path. The tremor was recorded under postural loading (arms extended forward). The sensor was alternately placed on the outstretched right and left arms in front of oneself, under conditions of “eyes open” (operative rest).

The analysis of the EEG and TRG files was carried out after the end of the research using the program "Analist2" according to the algorithm of half-period analysis. Five physiological tremor rhythms were identified: beta-2 - 21-32 Hz, beta -1 - 14.22-18.3 Hz, alpha - 8.0-12.8 Hz, theta - 4-7.53 Hz and delta - 0.5-3.87 Hz. For each of the ranges, the following parameters were determined: 1) amplitude in microvolts, 2) frequency in hertz, 3) index - time as a percentage of the severity of waves of gamma, beta-1-, beta-2-, alpha-, theta and delta-ranges ... In statistical analysis, mean values, standard (root-mean-square) deviation, and mean error were calculated.

Each of the set of indicators of the tremorogram of the right and left hand selected in the analysis was considered as a target feature (Y-s), and the indicators of EEG amplitudes and frequencies were considered as influencing variables (sets of X-s) and the equations of multiple linear regression were constructed as follows:

$$Y' = a_0 + b_1 X_1 + b_2 X_2 \ldots + \ldots b_n X_n + e,$$

where a_0 – free term, coefficients b_1, b_2 … b_n – regression indicators reflecting the influence of the elements of the set of EEG indicators (X_1, X_2 … X_n) nt analyzed indicator, e – погрешность, meaning any hesitation Y', not caused by a change in the explanatory variables in the model.

Own research

In multiple regression analysis (Table 1), 25 statistically significant regression coefficients were determined from the indicators of the EEG rhythms of the right hemisphere to the indicators of the TRH rhythms of the right hand, and 45 of the left hemisphere. from the first assignment of the forehead-temple, and the left in the assignment of the temple-crown - 14.

Table 1. The number of statistically significant coefficients of multiple regression and two-dimensional correlation determined from indicators of EEG rhythms to indicators of TRG rhythms

EE branchs	Right hand	Left hand
	Branchs from the right hemisphere	
Forehead temple	14,00	5,00
Temple-crown	10,00	26,00
Vertex-occiput	1,00	14,00
Total	25,00	45,00
Branchs from the left hemisphere		
Forehead temple	9,00	21,00
Temple-crown	1,00	10,00
Vertex-occiput	4,00	9,00
Total	14,00	40,00
Forehead temple	**39**	**85**

From indicators of EEG rhythms of the left hemisphere to indicators of TRH rhythms of the right hand, 14 statistically significant regression coefficients were determined, and 40 coefficients of the left hand.

The greatest number of statistically significant regression relationships-relations from EEG indicators to TrG indicators (Table 2) was determined from the beta-1 rhythm frequency to the left hand TrG indicators - 27. From the amplitude of the alpha rhythm to the TrG indicators of the right and left hands, 11 and 10 were determined, respectively statistically significant regression relationships-relations. Ten statistically significant regression relationships were determined from the frequency of the theta rhythm of the EEG to the TRH indices of the left hand. From the amplitude of the theta rhythm of the EEG by 8 regression connections-relations.

Right hand. The first assignment is the forehead-temple of the right hemisphere. In this lead, the EEG beta-2 rhythm amplitude had a statistically significant negative effect on the tremorogram beta-2, alpha and theta rhythms. The rate of beta-2 rhythm frequency is statistically significantly positive for the same indicators. The amplitude of the beta-1 rhythm of the EEG had a statistically significant positive effect on the amplitude of the alpha rhythm and had a statistically significant negative effect on the amplitude of the theta rhythm of the tremorogram. The rate of the beta-1 rhythm of the EEG had a statistically significant positive effect on the amplitude of the alpha and theta rhythms of the tremorogram. The indicator of the amplitude of the EEG alpha rhythm had a statistically significant positive effect on the indicators of the amplitude of the beta-2 rhythm, and the indicator of the frequency of the EEG theta rhythm had a statistically significant positive effect on the indicator of the frequency of the TrH alpha rhythm.

Table 2. The number of statistically significant multiple regression coefficients determined from specific indicators of EEG rhythms to indicators of TrG rhythms.

		Hand	
		right	left
Beta-2	A	3	0
	C	2	10
Beta-1	A	5	5
	C	0	27
Alpha	A	11	10
	C	1	7
Theta	A	8	8
	C	7	10
Delta	A	3	5
	C	0	2
Total		40	84

The amplitude of the delta rhythm had a statistically significant positive effect on the amplitude of the alpha and theta rhythms of the tremorogram. The amplitude of the EEG theta rhythm had a statistically significant positive effect on the frequency of the TrH theta rhythm.

In total, 15 statistically significant regression coefficients were determined from the indices of the first EEG derivation to the TRG indices of the right hand, of which 5 were negative and 10 were positive.

The second assignment is the temple-crown of the right hemisphere. In this EEG derivation, the amplitude of the alpha rhythm had a statistically significant negative effect on the amplitude indices of the alpha, theta and delta TRH rhythms, and the frequency index of the EEG alpha rhythm had a statistically significant positive effect on the amplitude indices of the alpha, theta and delta TRG rhythms. The amplitude of the theta rhythm of the EEG had a statistically significant positive effect on the amplitude of alpha and the frequency of theta rhythms of TrG. The frequency of the EEG delta rhythm had a statistically significant negative effect on the amplitude of the TrH alpha rhythm. The amplitude of the alpha rhythm and the frequency of the EEG delta rhythm had a statistically significant negative effect on the amplitude of the delta rhythm, and the frequency of the alpha rhythm had a statistically significant positive effect.

In total, 10 statistically significant regression coefficients were determined from the indicators of the second EEG derivation to the TRG indicators of the right hand, of which 5 were negative and 5 positive.

The third assignment is the crown-occiput of the right hemisphere. In this lead, only one statistically significant negative effect was determined - the amplitude of the EEG theta rhythm on the frequency of the TrH beta-2 rhythm.

The first assignment is the forehead-temple of the left hemisphere. In this lead, a negative statistically significant effect of the amplitude of the theta rhythm and frequency of the delta rhythm on the amplitude of the alpha rhythm and EEGTrG was determined. It should be noted that the reverse influences from the amplitude of the TrH alpha rhythm were greater in magnitude, i.e. the influence of the amplitude of the TrG alpha rhythm on the EEG parameters was statistically probable. The frequency of the theta rhythm of TrG was determined by a statistically significant negative effect of the amplitude of beta-2, the frequency of beta-1, the amplitudes of the alpha and delta EEG rhythms, and a statistically significant positive effect of the beta-2 frequency, the beta-1 amplitude and the frequency of the EEG alpha rhythms. It should be noted that the influence of the frequency of the theta rhythm of TrH on the amplitude of the delta rhythm of the EEG in modulus was greater than the inverse influence, i.e. the influence of the TrG indicator on the EEG indicators was statistically probable.

In total, 9 statistically significant regression coefficients were determined from the EEG indices of the first derivation of the left hemisphere to the TRG indices of the right hand, of which 6 were negative and 4 were positive.

The second assignment is the temple-crown of the left hemisphere. Only one statistically significant negative effect was determined from the frequency of the beta-1 rhythm of the EEG to the amplitude of the beta-1 rhythm of TrG.

The third assignment is the crown-occiput of the left hemisphere. In this EEG derivation, the effects from EEG indices only to the beta-1 rhythm of TrH were determined - from the amplitude of the beta-2 rhythm and the frequency of the alpha rhythm - negative statistically significant influences, from the frequency of the beta-2 rhythm and amplitude of the beta-1 rhythm - positive statistically significant influences ...

In total, 4 statistically significant regression coefficients were determined from the EEG indices of the third derivation of the left hemisphere to the TRG indices of the right hand, of which 2 were negative and 2 were positive.

Left hand. The first assignment is the forehead-temple of the right hemisphere. In this lead, statistically significant regression coefficients were determined to the rate of the beta-1 rhythm of TrH from the amplitude of the beta-1 EEG rhythm positive, from the rate of the beta-1 rhythm of the EEG - negative and from the frequency of the alpha rhythm of the EEG - positive. A statistically significant positive effect was determined from the frequency index of the beta-2 rhythm of the EEG to the amplitude of the delta rhythm of TrH.

The second assignment is the temple-crown of the right hemisphere. Statistically significant negative influences were determined to the rate of the beta 1 rhythm from the indicators of the amplitude of beta-2 and the frequency of the EEG alpha rhythms, and from the rates of the beta-2 amplitude of the alpha and theta EEG rhythms - a positive effect.

Statistically significant negative influences from the amplitudes of beta-2 and alpha rhythm and frequencies of beta-1 and theta rhythms and positive influences from the frequencies of beta-2 and delta rhythms and amplitudes of beta-1 and theta rhythms were determined to the amplitude of the TrH alpha rhythm of the left hemisphere from EEG indicators. EEG.

The frequency of the TrH alpha rhythm was statistically significantly negatively influenced by the indicators of the amplitude of the beta-1 rhythm and the frequency of the EEG theta rhythm, and the frequency of the EEG alpha rhythm was statistically significantly positive.

The amplitude of the theta rhythm of TrH was statistically significantly negatively influenced by the amplitude and frequency of the alpha rhythm of the EEG and the positive effects of the frequency of the beta-1 rhythm.

The frequency of the theta rhythm of TrH was statistically significantly influenced by the amplitude of the beta-2 rhythm and statistically significantly negatively influenced by the frequency of the beta-2 rhythm of the EEG.

The amplitude of the TRH delta rhythm was statistically significantly influenced by the amplitude of beta-1, alpha and theta rhythms, and statistically significantly negatively influenced by the frequency of the beta-1 EEG rhythm.

The third assignment is the crown-occiput of the right hemisphere. The beta-1 rate of the TrH rhythm was statistically significantly negatively influenced by the values of the amplitude of beta-2 and the frequency of the beta-1 EEG rhythms, and the rate of the beta 2 rate of the EEG rhythm was statistically significant.

The rate of beta-1 rhythm of TrH was statistically significantly negatively influenced by indicators of the amplitude of beta-2 and the frequency of beta-1 EEG rhythms and statistically significantly positively by indicators of the frequency of beta 2 and the amplitude of beta-1 EEG rhythm. The indicator of the frequency of the EEG theta rhythm had a statistically significant positive effect on the indicator of the frequency of the beta-1 rhythm of TrH.

The index of the amplitude of the alpha rhythm was statistically significantly negatively influenced by the indicators of the frequency of beta-1 and the amplitude of the EEG alpha rhythms.

The amplitude of the theta and delta TRH rhythms was statistically significantly negatively influenced by the frequency of beta-1, EEG rhythm, and the amplitude of the delta TRH rhythm, by the frequency of beta-2 EEG rhythm.

The first assignment is the forehead-temple of the left hemisphere. The frequency of the beta-2 rhythm of TrH was statistically significantly negatively influenced by the amplitude of beta-2 and positively by the frequency of the beta-2 rhythm of the EEG.

The frequency of beta-1 rhythm of TrH was statistically significantly negatively influenced by the amplitude of beta-2, the frequency of beta-1 and theta EEG rhythms, and statistically significantly positively, the amplitude of beta-1 and theta rhythms and the frequency of delta EEG rhythms.

The frequency of the alpha rhythm was statistically significantly negatively influenced by the amplitude of beta-1 and the frequency of theta and delta rhythms of the EEG, and the amplitude of the beta-1 rhythm of the EEG had a positive effect.

The frequency of the theta rhythm of TrG was statistically significantly negatively influenced by the frequencies of beta-2, alpha and theta EEG rhythms and the amplitude of beta-1 EEG rhythms and positively by the frequency of beta-1 and delta and the amplitude of alpha EEG rhythms.

The second assignment is the temple-crown of the left hemisphere. The frequency of the beta-2 rhythm of TrG was statistically significantly negatively influenced by the frequencies of beta-2, beta-1 and alpha EEG rhythms and the amplitude of the alpha EEG rhythm and statistically significantly positively by the amplitudes of beta-2, beta-1 and theta EEG rhythms.

The frequency of beta-1 rhythm of TrH was statistically significantly negatively influenced by the frequency of beta-2 and statistically significantly positively influenced by the amplitude of beta-2 and delta EEG rhythms.

The third assignment is the crown-occiput of the left hemisphere. The frequency of beta-1 rhythm of TrH was statistically significantly positively influenced by the rate of beta-2 and the amplitude of beta-1 EEG rhythms, and statistically significantly negatively influenced by the indicators of the amplitude of beta-2 and the frequency of alpha EEG rhythms.

The frequency of beta-2, alpha and delta EEG rhythms is statistically significantly positive for the amplitude of the theta TRH rhythm, and the frequency of the EEG theta rhythm is statistically significantly positive for the amplitude of the TRH delta rhythm.

Most of the regression coefficients from the EEG indices to the TRG indices of the right and left hand were greater in magnitude than the inverse influences, i.e. the effect of EEG on tremor was greater than the opposite effect. However, situations were determined when the influence of tremor indicators on EEG indicators was significantly greater, the influence of EEG on tremor. These situations are listed below.

Left hand. The indicator of the amplitude of the theta rhythm of TrH influenced the indicator of the amplitude of the EEG delta rhythm in the right forehead-temple abduction. The indicator of the amplitude of the TrH alpha rhythm statistically significantly influenced the frequency of theta and delta EEG rhythms in the right temple-crown derivation, and the frequency of the beta-1 EEG rhythm in the vertex-occiput derivation on the right. The amplitude of the beta-1 rhythm of TrG influenced the frequency of the EEG delta rhythm in the right occiput lead, and the frequency of the ToG beta-1 rhythm influenced the frequency of the EEG theta rhythm in the right occiput vertex lead. The indicator of the frequency of the theta rhythm of TrG influenced the indicator of the amplitude of the EEG alpha rhythm in the forehead-temple leads to the left, and the indicator of the frequency of the theta rhythm of TrH influenced the indicator of the amplitude of the delta rhythm of the EEG in the derivation of the forehead-temple to the left.

Right hand. The indicator of the amplitude of the theta rhythm of TrH influenced the amplitude of the delta rhythm of the EEG in the abduction of the forehead-temple of the right hemisphere, the amplitude of the alpha rhythm of the TrH on the amplitude of the theta rhythm in the lead of the forehead-temple of the left hemisphere, and the frequency of the theta rhythm influenced the amplitude of the delta rhythm in the lead of the forehead-temple of the left hemisphere.

Discussion.

As a result of multiple regression analysis of the ratios of the TRG and EEG rhythm indicators, it was revealed that more regression coefficients from the EEG indicators of both the right and left hemispheres were determined to the left hand tremor indicators. This may indicate that the generators forming the physiological tremor of the left and right arms are not identical.

It may also indicate that the physiological tremor of the left hand is more controlled by the generators that form the EEG than the generators that form the tremor of the right hand.

The greatest number of regression coefficients of multiple regression analysis was determined to the rate of beta-1 rhythm of the left hand TrH from EEG indicators - 27. From the amplitude of the beta-2 rhythm of different EEG derivations, 5 statistically significant regression coefficients were determined, and the frequency of beta-2 rhythm - 4 statistically significant regression coefficients. It can be assumed that the generator forming the beta-1 rhythm of the left hand TrG is a rigidly controlled structure on the EEG side.

10-11 regression coefficients were determined from EEG indices to the parameters of the beta-2 rhythm frequency, left hand, alpha rhythm amplitude of the right and left hands, theta frequency of the left hand TrG. It can be assumed that the above indicators of TrG are controllable structures on the part of the EEG.

It should be emphasized that the regression coefficients from the indicator of the amplitude of the alpha rhythm of the TRH of the left hand to the indicators of the frequency of the theta rhythm of the EEG in the temporal-crown derivation on the right, the indicator of the frequency of the delta rhythm of the EEG in the derivation of the temple-crown on the right, the indicator of the frequency of the beta-1 EEG rhythm in the derivation of the nape on the right, there were more regression coefficients from these EEG indicators to the amplitude of the TrH alpha rhythm.

This allowed us to assume that the generator of the alpha rhythm of the TrG of the left hand is an independent formation and is not similar to the generator of the alpha rhythm of the TrH of the right hand.

In order to test this assumption, relationships-relationships in the multiple amplitudes of the alpha rhythm of all six EEG and TrG derivations of the left and right hands were studied using multiple regression analysis.

As a result of the performed multiple regression analysis, it was determined that the relationship-relationship was not determined to the indicator of the amplitude of the TrH alpha rhythm of the left hand (Fig. 1), and the right one was determined. This may indicate that the generators of tremors in the alpha range for the right and left hands are not identical.

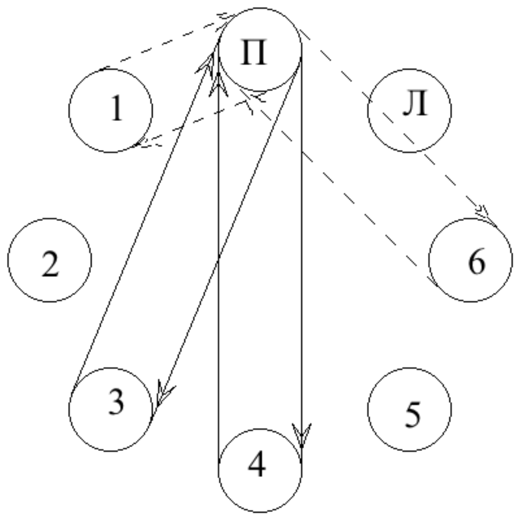

Figure 1. Polycyclic multigraph describing the rhythm of the amplitude of alpha TrG and EEG.

Designations: П - right hand, Л - left hand, 1 - forehead-temple right hemisphere, 2 - temple-crown right hemisphere, 3 - crown-crown right hemisphere, 4 - forehead-temple left hemisphere, 5 - temple-crown left hemisphere, 6 - crown-occiput, left hemisphere.

Conclusions:

1. The generators that form the physiological tremor of the left and right hands are not identical

2. Physiological tremor of the left hand is to a greater extent under the control of generators forming EEG than generators forming tremor of the right hand.

3. The generator of the alpha rhythm of the TrG of the left hand is an independent formation and is not similar to the generator of the alpha rhythm of the TrG of the right hand.

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