

РОЗДІЛ III

Фізіологія людини і тварин

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Coherence of EEG Frequency Components While Performing Alternative Finger Movements in Women with Different Modal Frequency of Alpha-rhythm

A test group consisting of 113 right-hand healthy women from the ages of 19 to 21 was divided into two groups according to the average magnitude of their individual modal α - frequency – groups with high and low values of individual modal α - frequency. The ideal time of a simple sensorimotor reaction and choice-point behavior as well as speed capabilities of nervous processes during the tapping test, and measures of the coherence of EEG frequency components individually determined for each testee in quiescent intervals and while performing alternative movements by the right hand fingers were evaluated. Women with high modal α -frequency had better speed capabilities of nervous processes. Women with a high I α F had a less time of simple and complex reactions. The increase of coherence coefficients was seen throughout the EEG frequency spectrum in women performing alternate movements by fingers. Alternate movements of fingers performed by women with low α -frequency are provided by even higher frequency coherence of the EEG components in frontal, anterior temporal and central areas and by much lower frequency in the posterior temporal and parietal-occipital cortex areas compared to testees with high α -frequency.

Key words: coherence, EEG frequency components, mode of the EEG α -rhythm, women, alternate finger movements.

Formulation of scientific problem and its significance. Movements by the upper extremities, particularly but not exclusively, by human fingers, form the basis of the manual movements in any labor activities. This or that person's individual functional capacities of the motor system acquire the critical score for a successful learning of a wide range of trades in the present-day society. For this purpose, an academic community places greater emphasis on issues dealing with the personality traits of the cerebral processes guaranteeing the motorial programming of the manipulation movements (MM).

Analysis of studies of the problem. Various aspects of the abovementioned problem were studied in the area of neurophysiology concerning motor activities [1–8]. MM are obviously associated with the significant alterations of the brain activities ensuring the formation of the appropriate motor programs and orders. However, any specific information concerning these processes in the cerebral cortex is still very limited. It is not improbable that certain performance measures of the cerebration being correlated with MM – their amplitude, speed and accuracy are existed.

Scientists [9–12] found out that individual values of the amplitude-frequency characteristics of any α -rhythm, including the modal frequency of such a rhythm demonstrate a significant informational content in determining the state of the main physiological functions of the man. According to the data of Bazanova [9], Kristeva, Charakov, Losch et al. [12] the ideal coordination of processes organizing movements and capacity for the censorship are positively correlated to the power of the individual EEG α - range and negatively to the tension of the muscles of the facial expression (forehead) being inactive during the MM autocinesia. These statements are study specific of the authors [13–17] considering the modal EEG α -frequency as a rigidly determinate by a genetic trait inasmuch it reflects the essential innate peculiarities of the structural organization of any thalamic and cortical neurons [18–20].

Estimating a crucial importance of results obtained by different scientists, anyway, it is worth mentioning that such information is not clearly inadequate for a thorough understanding of personality traits of the neurophysiological maintenance of the goal directed movements by any individual. Records are critically limited as to the way in which such an innate aspect of the mental functioning as a modal

frequency of EEG α -rhythm deals with the activities regulating distal hand muscles during the execution of MM. The prognostic value of the individual cerebral activities dealing with MM is marginally studied today.

Towards the disclosure of such issues, we conducted a study of changes in the power spectrum (PS) of the EEG frequency components at execution time of alternating movements by fingers in men having some different modal alpha-frequency [10]. According to the results obtained, all the men had the power reduction of θ -, α - and β 1-waves, especially in the posterior cortical areas as well as some power growth of the EEG (θ - and α 1-) low-frequency vibrations in the frontal area. However, men with a low mode of α -frequency had some lower power of the EEG α 1-, β - and γ -activities in the frontal areas whilst the higher power of the EEG frequency components and generalization of such changes were found in the parietal, occipital, central and temporal lobes greater than in men with some high modal α -frequency. Peculiarities of the cortical electrical activity determined in the flow of the regulation of the manipulation movements in men with a high mode of α -frequency were associated with relatively higher rates of the speed and accuracy of the sensorimotor responses. Taking into consideration the obtained results concerning men and the general scientific relevance of the gender flow phenomena of the cerebral activities particularly but not exclusively during the MM, it is timely to carry out the relevant studies with the involvement of women as testees.

Purpose and objectives of article is to find out the specifics of the EEG power spectrum at the execution of the alternative movements by fingers of women with some high and low modal frequency of the EEG α -rhythm with taking into account the prognostic value of the relevant data in the area of the speed capabilities of nervous processes.

The main material and justification of the results of research. Materials and Methods. *The object of the study.* The participants in our study were 136 female volunteers from the ages of 19 to 21, each of whom has given written consent. Biomedical ethics rules in accordance with the Helsinki Declaration of the World Medical Association on the Ethical Principles of Scientific and Medical Research involving Human Subjects were adhered to during the experiment. All the testees were healthy and had normal hearing with regard to the judgment and advisory conclusions of their medical professionals. A survey of women was conducted during the secretory phase of the menstrual cycle.

Psychophysiological examination. As part of the psychophysiological testing for each subject was determined profile of manual and auditory asymmetry. It determined by the nature of responses in the survey, execution of the motor and psychoacoustic tests and counting the individual ratio of the manual and auditory asymmetries (K skew) (form. 1) [21]:

$$K_{\text{skew}} = \frac{\Sigma_{\text{right}} - \Sigma_{\text{left}}}{\Sigma_{\text{right}} + \Sigma_{\text{left}}} \times 100 \%, \quad (1)$$

where Σ_{right} – the amount of tasks where a right hand (right ear) is dominating during their execution, Σ_{left} – the amount of tasks under which the left hand (left ear) is dominant.

Further studies involved dextral testees whose coefficients of manual and auditory asymmetries were positive and were above 50 %. The total number of women was of 113 people.

The level of speed properties of testees' nervous processes were surveyed with a simple sensorimotor reaction taking into consideration time period and sensorimotor responses in the choice of one of three objects as signals (triangles, circles, squares). See the program «Diagnostician-1», Ukraine. All testees had to respond to the certain stimuli as quickly as possible with pressing the button by the right hand.

All examinations were performed in the morning. The profile of the asymmetry and time of simple and complicated sensory-motor reactions was evaluated 30 minutes before the EEG recording registration. It made impossible to influence on the experiment, particularly, on EEG results.

EEG testing procedures. The testees were in a quiescent state with their eyes closed and in a reclining position with their limbs relaxed and not crossed during the EEG testing. The experiment was carried out in a room which was sound-proof and light-proof. The whole experimental procedure consistently included the following steps for each testee:

Step 1. The EEG recording in the functional balance (background).

Step 2. The EEG recording while performing the alternate movements by fingers of the right hand.

Each step lasted 40 s. To exclude the edge effects, the EEG recording registration was started at 15 s after the beginning and had been stopped at 5 s by its completion.

The testees performed finger movements one by one in the following order: forefinger – fourth finger – third finger – little fingers. The sequence of movements was reported to the testees just before the test to reduce the stereotype of the task.

Movements of each finger were in its bending and unbending. Each finger flexion or extension was performed by the testees in response to the sound. The electronic version of the drum battle (the software of Finale 2006) was used for this purpose. Binaural stimuli were produced by four speakers placed in different corners of the room at the distance of 1,2 m from the testee's right or left ear. The stimulus duration was 130 ms; the playback sound volume did not exceed 55–60 dB at outlet from the speakers under the measurements carried out by the sound level meter of the 'DE-3301' type (certificate of attestation # 025–2009, valid until 21.12.2014). Additionally, the sound loudness was individually regulated for each testee to achieve the necessary level. The rate of the sound stimuli delivery was 2 c^{-1} . The choice of the relatively low acoustic stimulation is caused by the fact that such frequency corresponds to the frequency range of the MM execution. Such a range is essentially determined by biomechanical movements implemented by the distal parts of the hand.

Registration and primary analysis of EEG data. Active electrodes were placed in accordance with the international system 10/20 in nineteen points on the scalp of the head during the electroencephalogram (EEG «Neurocom», and the Certificate of State registration # 6038/2007, valid until 18.04.2014) recording. The performance of the EEG recording was monopolar, with the use of ear electrodes as a reference. The Fourier analysis era was 4 s with a 50 % overlap. Duration of sample was 40 s. ICA-procedure analysis was used for the rejection of EEG anomalies.

The coherence of the brain electrical activity in the θ -, α -, β - and γ -frequency intervals were also evaluated. Taking into consideration the functional heterogeneity of different sub-bands of the EEG α - and β -rhythms, the changes in the power and coherence of each of them were considered, and coefficients of coherence above 0,5 were analyzed as well.

The mode of the EEG α -rhythm spectral power was determined for each testee at each EEG lead and when they (testees) were motionless and had their eyes closed. Its value was averaged for all the leads; value obtained was considered as an individual α -frequency for each testee ($I\alpha F$, Hz) [15,16]. Any average value of the index was calculated for all the men and women.

Conditional distribution of the sample was taken into account. The testees, having the value of $I\alpha F$ less than average, belonged to the group of testees with a low $I\alpha F$. The testees, having value of $I\alpha F$ higher than average, joined to the group of testees with a high $I\alpha F$, and additionally, the level of the value sustainability of the EEG individual α -frequency was identified for ten testees in quiescent intervals and according to the indicators of human memory registered in different days.

The EEG frequency interval limits were determined individually, relying on the value of the testee's IAF. The following algorithm [15,16] was used and the truth of which was that the upper limit of $\alpha 3$ -subband was set to the right side of the IAF in increments of 2 Hz. It corresponded to the lower limit of the $\beta 1$ -band. The upper limit of the $\beta 1$ -sub-band was defined according to the standard concepts as 25 Hz. The lower limit of the $\alpha 2$ -band was determined in steps of 2 Hz to the left of the peak, and the $\alpha 1$ -band in 4-Hz steps, as well as θ -frequencies – in 6 Hz. Limits of $\beta 2$ - and γ -bands were recognized as standard, properly, 26–35 Hz and 36–45 Hz.

Statistical analyses. A statistical data analysis was performed by using the package 'STATISTICA 6.0' (Stat-Soft, 2001). Any normalcy of the data distribution in testees' subgroups was evaluated by means of the Shapiro-Wilks test (indicator SW). Based on test results, it was found that all of our studied samples had a normal data distribution. To estimate the significance of differences existing in testees' subgroups, the Student's t-test (indicator t) was used between steps of testing both for independent equal samples and for dependent samples. Significant differences between testees' subgroups and among steps of testing were statistically considered at $p \leq 0,05$ and $p \leq 0,01$. Statistical calculations and plotting or diagramming were made by means of the computer whose type – IBM PC Pentium and software package M. Excel Windows Vista.

Results and discussion. *The individual modal frequency evaluation of the α -EEG activity and individual limits of the frequency content of the EEG sub-rang in female testees findings.* The average value of the modal frequency of any α -activity in samples of female testees was $10,25 \pm 0,03$ Hz. Considering the leveled nature of the individual α -frequency value histogram (Fig.1) in the female testees, it was made the conditional distribution of samples under the average mean of the modal frequency of α -activity. Two groups were formed, in particular, groups having the high value of $I\alpha F$ ($n=59$, $I\alpha F \geq 10,25$ Hz) and groups with the low value of $I\alpha F$ ($n=54$, $I\alpha F < 10,25$ Hz).

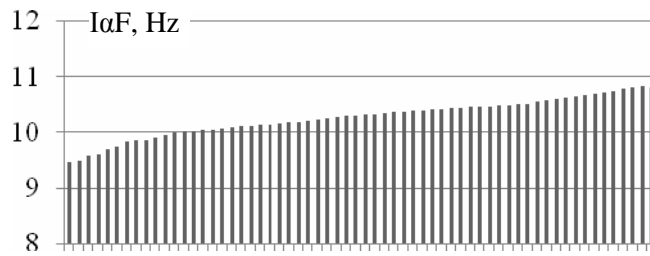


Fig. 1. Histogram of Values of α -Frequency Mode in Female Testees

Note: vertical columns – individual values of the EEG α -frequency mode in samples involving female testees.

Features of the Output Speed Characteristics of the Nervous Processes in Women with Some High and Low IaF. Women with a high IaF had a less time of simple and complex reactions (tab.1). Features of the output speed characteristics of the nervous processes in women indicate the higher speed capabilities of nervous processes in women with some high IaF compared with those with low IaF.

Table 1

Results of Psycho-Physiological Tests Characterizing Time of Simple and Complex Sensor and Motor Reactions in Women

Value \ Group	Women	
	With high IaF	With low IaF
Simple Reaction Time, ms	253,40 ± 6,54	322,52 ± 6,6**
Selection Reaction Time, ms	378,33 ± 8,77	435,74 ± 9,4**

Note: *, ** – indicators of significant differences between the groups of the testees with a high and low IaF, $p \leq 0,05$ – $\leq 0,01$.

Changes in coherence Of EEG Frequency Components while performing alternate finger movements in the testees' groups. Some increase of coefficients of coherence being registered high throughout the frequency content ($p \leq 0,05$, $p \leq 0,01$), particularly in the EEG $\alpha 2$ -sub-band was disclosed in women (fig. 2).

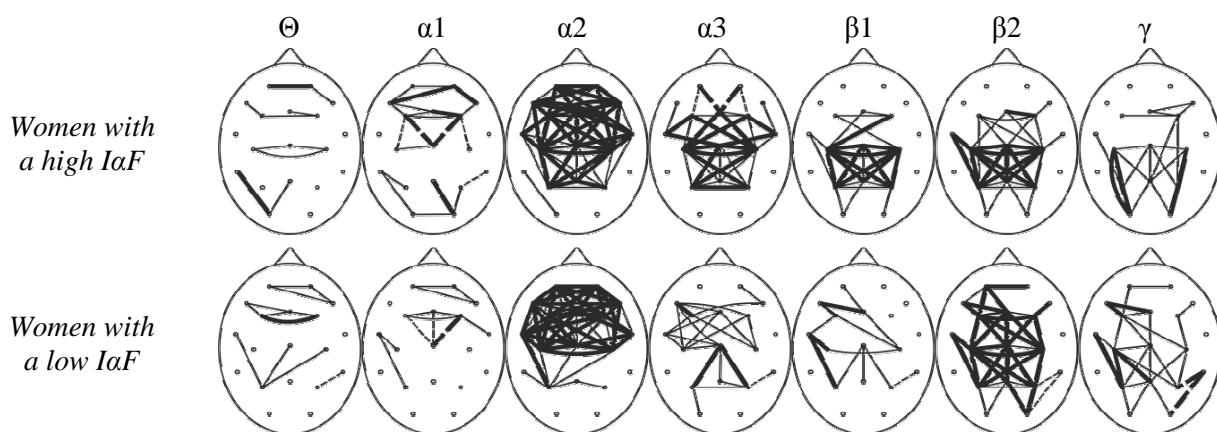


Fig. 2. Topo Maps of Changes in EEG Coherence Fluctuations While Performing Alternate Finger Movements by Female Subgroups

Note:

1) — (---) increase (decrease) of coherence compared to coherence in a quiescent state, $p \leq 0,05$ (thin line), $p \leq 0,01$ (thick line).

It can be obviously related to redundancy peculiarities of brain processes [22]. Both frontal and central interactions were intensified. According to Rhodes [6], it may be associated with a voluntary control being increased while movements of distal muscles were being carried out and checked. A decrease in the right posterior temporo-occipital area in a wide frequency range of the EEG was registered in women with low I α F. According to research made by Pfurtscheller et al [23], some asymmetric desynchronization found in women with low I α F in their posterior temporal and occipital areas can hypothetically reflect the reciprocal refocusing from the processing of the sensory stimuli to the processes related to programming movements in frontal and central areas.

Intergroup Differences. Any performance of alternate movements by women with low α -frequency is provided by some higher coherence of the EEG components in frontal, anterior temporal and central areas ($r \leq 0,05$, $r \leq 0,01$) compared to testees with high I α F. However, relatively lower rates in the posterior temporal and parietal-occipital areas of cortex ($r \leq 0,05$) are registered in women with low I α F.

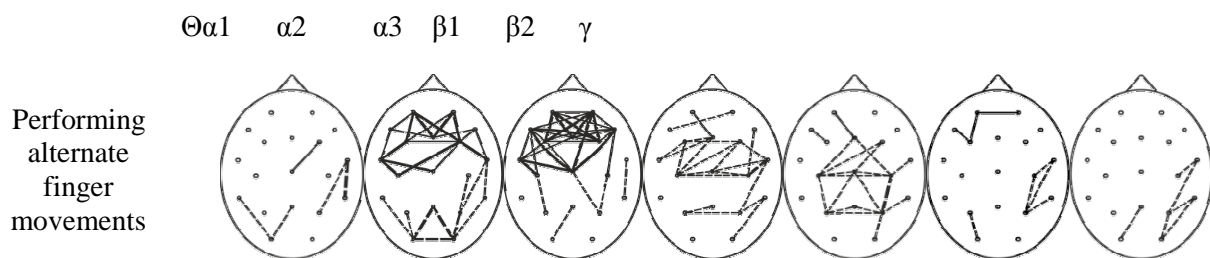


Fig. 3. *Intergroup Differences in Coherence of EEG Fluctuations While Performing Alternate Finger Movements by Female Subgroups*

Note:

- 1) $\triangle \blacktriangle \nabla$ higher (lower) coherence in women with a low I α F in comparison with women with a high I α F, $p \leq 0,05$ (thin line), $p \leq 0,01$ (thick line).

Lower coefficients of the coherence prevailing in the EEG high frequency range in patients with low I α F can give evidence of comparatively weaker cortical integrative capabilities associated with the interaction among neocortical projections of different sensory receptor systems whereas even higher coherence of the EEG frequency components was detected in the posterior temporo-occipital and parietal areas of the cortex in women with higher I α F. This goes to prove even relatively higher level of some spatial attention, motivation and energy requests, and the tension of nervous processes in them.

Conclusions and perspectives for future research

1. Women with a high I α F had a less time of simple and complex reactions.
2. The increase of coherence coefficients was seen throughout the EEG frequency spectrum in women performing alternate movements by fingers.
3. Alternate movements of fingers performed by women with low α -frequency are provided by even higher frequency coherence of the EEG components in frontal, anterior temporal and central areas and by much lower frequency in the posterior temporal and parietal-occipital cortex areas compared to testees with high I α F.

Based on the obtained results, the prospect of any further research is to establish the characteristics of the electromyographic activity of hand distal muscles involved in the performance of alternate movements by fingers.

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Коржик Ольга, Моренко Алевтина. Когерентность частотных компонентов ЭЭГ при выполнении поочередных движений пальцев у женщин с разной модальной частотой альфа-ритма. Движения верхних конечностей человека, в том числе движения пальцев, составляют основу манипуляторной моторики трудовой деятельности. Индивидуальные функциональные возможности моторной системы того или иного человека приобретают критическое значение для успешного овладения целым рядом профессий в современном социуме. Поэтому научное сообщество уделяет все большее внимание проблеме индивидуальных особенностей мозговых процессов, обеспечивающих моторное программирование манипуляторных движений. Цель нашего исследования заключается в выяснении особенностей когерентности частотных компонентов ЭЭГ во время выполнения последовательных движений пальцев у женщин с высокой и низкой модальной частотой α -ритма

ЭЭГ, учитывая прогностическое значение соответствующей информации в сфере скоростных возможностей нервных процессов. 113 праворуких здоровых женщин в возрасте от 19 до 21, взявшие участие в тестировании, были разделены на две группы в зависимости от среднего значения их индивидуальной модальной частоты альфа-ритма, определённого в состоянии покоя, – групп с высокой и низкой индивидуальной модальной альфа-частоты. Оценивали время простой сенсомоторной реакции и реакции выбора как критерий скоростных возможностей нервных процессов, коэффициенты когерентности частотных компонентов ЭЭГ во время состояния покоя и выполнения поочерёдных движений пальцев правой (ведущей) руки. Частотные субдиапазоны ЭЭГ были индивидуально определены для каждой испытуемой за алгоритмом W. Klimesh (2007). Полученные нами результаты свидетельствовали, что женщины с высокой модальной частотой альфа-ритма имели меньшее время простых сенсомоторных реакций и реакций выбора. Во время движения пальцев у женщин обеих групп фиксировали увеличение коэффициентов когерентности всех частотных субдиапазонов ЭЭГ в коре. В этих условиях у женщин с низкой α -частотой установили высшую когерентность частотных компонентов ЭЭГ в лобных, передних височных и центральных участках и низшую – в задних височных и теменно-затылочных областях коры по сравнению с обследуемыми с высокой индивидуальной α -частотой.

Коржик Ольга, Моренко Алевтина. Когерентність частотних компонентів ЕЕГ під час виконання почергових рухів пальців у жінок із різною модальною частотою альфа-ритму. Рухи верхніх кінцівок людини, зокрема рухи пальців, складають основу мануальної моторики в трудовій діяльності. Індивідуальні функціональні можливості моторної системи тієї чи іншої людини набувають критичного значення для успішного оволодіння низкою професій у сучасному соціумі. Тому наукова спільнота приділяє все більшу увагу проблемі індивідуальних особливостей мозкових процесів, які забезпечують моторне програмування маніпуляторних рухів. Мета нашого дослідження полягає в з'ясуванні особливостей когерентності частотних компонентів ЕЕГ під час виконання почергових рухів пальців у жінок із високою і низькою модальною частотою α -ритму ЕЕГ, урахувуючи прогностичне значення відповідної інформації у сфері швидкісних можливостей нервових процесів. 113 праворуких здорових жінок у віці від 19 до 21, які взяли участь у тестуванні, були розділені на дві групи залежно від середнього значення їхньої індивідуальної модальної частоти альфа-ритму, визначеного в стані спокою, – груп із високою й низькою індивідуальною модальною альфа-частотою. Оцінювали час простої сенсомоторної реакції та реакції вибору як критерій швидкісних можливостей нервових процесів, коефіцієнти когерентності частотних компонентів ЕЕГ у стані спокою та під час виконання почергових рухів пальців правої (провідної) руки. Частотні субдіапазони ЕЕГ були індивідуально визначені для кожної випробуваної за алгоритмом W. Klimesh (2007). Отримані результати свідчили, що жінки з високою модальною частотою альфа-ритму мали менший час простих сенсомоторних реакцій і реакцій вибору. У жінок обох груп виявляли збільшення коефіцієнтів когерентності в усьому частотному спектрі ЕЕГ у корі під час виконання почергових рухів пальців. У цих умовах у жінок із низькою α -частотою встановили вищу когерентність частотних компонентів ЕЕГ у лобових, передніх скроневих і центральних ділянках та нижчу – у задніх скроневих і тім'яно-потиличних ділянках кори, порівняно з обстежуваними із високою індивідуальною α -частотою.

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Вплив надлишку та нестачі мелатоніну на продукцію супероксиду в тонкій кишці щурів

Нестача мелатоніну сприяє збільшенню продукції супероксиданіонрадикалу в тонкій кишці щурів від фагоцитарних електронно-транспортних ланцюгів, а надлишок – від мітохондріального окиснення, що відповідає антиоксидантним властивостям мелатоніну. Витік супероксиду з мікосомального електронно-транспортного ланцюга окиснення в обох випадках не змінювався.

Ключові слова: тонкий кишечник, супероксиданіонрадикал, гіпомелатонінемія, гіпермелатонінемія.