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The frequency-spatial distribution of the cortex bioelectric activity among musicians at musical creative activity

In the work there are presented the results of the research of functional, spatial and structural correlates of musical creative activity with the view to reveal the cerebral mechanisms underlying creativity. There are revealed differences in the specificity of power spectral characteristics and the character of coherent correlations among the examinees at a creative problem decision process for different frequency ranges.

***Key words**: nonverbal creativity, EEG, spectral power, coherence, frequency range.*

For a long time scientists of all epochs have been interested in creativity and it caused desire to frame "the creativity theory". The history numbers a large quantity of attempts to find the universal formula which application would allow to create invaluable artworks, to create masterpieces made to order. How many times they have tried "to measure harmony by algebra"! However there's no telling that scientists could finish the explanation of this phenomenon nature. We can ascertain the increasing interest to the creativity problem, to its social aspects (G. Fisher), analysis of cognitive and emotional components of creativity (T. Lubarta and K. Mushiru), diagnostics of intellectual and creative abilities (A. Froinda and K. Hollinga), the problem of intelligence and creativity correlation (J. Maker), researches of the evolutionary genius in music (P.A. Kulichkin), to psychophysiological aspects of the correlation of creativity and anxiety, psychological protection, the brain zones put into operation (I. Carlsson). For today even more often there is the scientific data describing the results of researches of features of cerebral activity during the creative process, unlike the not creative, at the decision of creative problems depending on the examinees' sex, the problem decision strategy selected by them, the type, character and degree of complexity of problems, motivation level to a decision finding (N.P. Bekhtereva, S.V. Medvedev, S.G. Danko, I. Carlsson, O.M. Razumnikova, N. Weinberg, N.Jausovec, K.Jausovec, Martindale, Molle, H.Petsche). Thus it should be noted that a special value there gets studying of cerebral mechanisms of true, internally motivated creative process. Such a spontaneous creative act is music composing. Revealing of functional, spatial and structural correlates of musical creative activity allows to understand the cerebral mechanisms underlying the creative process, to find, how to control and influence a creative condition. The neurophysiology researches of musical creativity still are fragmentary (R.A. Pavligina, V.I. Davidov, A.V. Sulimov, Y.V. Lyubimova, D.S. Sakharov, T.D. Panyusheva; K.J.Pallsen, E.Brattico, C. Bailey, A. Korvenoja, J. Koivisto, A.Gjedee, N. Ann, L.Gabora, Th.Bever, R.Chiarello) while the scientific interest to this sphere of the cognitive science continues to grow. The research urgency is caused by the contradiction between the constantly growing interest to revealing of patterns of the brain functioning during creative process (in particular during nonverbal forms of creative activity) and the in-

sufficient level of the theoretical and applied base of psychophysiological and neurophysiological researches of the persons who are engaged in nonverbal creativity, first of all, during the very creative process. Special complexity is represented by the experiment organization as much as possible approached to the natural, and absence of unequivocal interpreting and classification of the experiment product of as a truly creative.

The work purpose is to investigate the frequency-spatial distributions of the cortex bioelectric activity at musical creative activity among musicians. Practicing musicians, the professionals having profile music education, became the research object.

We have assumed that at examination of the EEG characteristics among the musicians-composers there may be revealed the regions of cerebral activity involved in the process of music composing, different from those involved in realization of other kinds of musical activity (perception, reproduction). During the research it was supposed to solve the following problems: 1. Studying of the value of powers, and also coherent correlations in various frequency ranges in a background and the used functional tests: perception of a musical fragment, reproduction of the heard musical fragment, composition of own melody relevant to a certain emotional condition caused by the heard fragment. 2. Carrying out of the comparative analysis of the indicators of powers in various ranges at comparison of functional tests. 3. Revealing of the cerebral activation specific zones exclusively inherent in the process of music composing on the basis of comparative analysis of the indicators of powers in various ranges at functional tests. 4. Studying of intra- and interhemispheric correlations (at the results analysis there have been used only authentic coherent correlations of a high order with an indicator above 0,7) at music composing and revealing of the composition specificity on these indicators unlike a background. 5. To spend the data mathematical processing by means of the mathematical statistics methods: T-criterion of Student and MANOVA analysis of variance.

For studying of the functional organization of the brain of examinees during the performance of musical activity the EEG method was used. The EEG registration was carried out by means of the "Entsefalan" electroencephalograph, the "Elite-M" version of the MTB "Medicom" manufacture (Taganrog) under the international standard of the electrodes placing under the 10–20 % scheme. For registration of the brain electric activity there were placed 21 electrodes, the monopolar scheme with lateral aural referents was applied. There also have been placed the polygraphic channels (EOG, EMG, ECG, GSR) with a view to suppress artifacts. There were investigated the following frequency ranges: delta 1 (0,5–2,0 Hz) and delta 2 (2,0–4,0 Hz), theta 1 (4,0–6,0 Hz), theta 2 (6,0–8,0 Hz), alpha 1 (8,0–10,5 Hz), alpha 2 (10,5–13,0 Hz), beta 1 (13,0–24,0 Hz) and beta 2 (24,0–35,0 Hz). For the analysis there were selected the non-artefact EEG intervals of 10 seconds duration. During the experiment the EEG indicators were registered in a quiet condition (a background EEG blindly) and at performance of functional tests (perception, reproduction and composing). In the beginning of each experience during 1 minute there was registered

the EEG when the examinee stayed in a condition of quiet wakefulness blindly in the absence of sound and visual stimulus (test 1). This data was considered as a background. In the following part of the experiment the examinee heard classical music of the fixed power through ear-phones (60 Db) and within 1 minute they registered the EEG (test 2). In the experiment as classical music there was used the fragment from the Strauss's operetta "Bat" characterized by major emotional coloring. Before this the following instruction was offered the examinee: "Listen to the music and try to define the emotions it causes". In the next test (test 3) the examinee should reproduce to himself the heard musical fragment. Then the examinee's task was: "Try to compose own melody so that it would have the same emotional colour, as well as the fragment earlier heard by you; and after the research it will be necessary to reproduce the thought up melody in writing or orally" (test 4). Further another musical fragment from the E. Grig's ballet "Per Gunt" characterized by minor emotional coloring was offered the examinee, it was necessary to do the same procedure with it. For an estimation of qualitative characteristics of the received melodies they were given to experts, pedagogues of Rakhmaninov Rostov conservatory. Further there were analyzed the EEG-data of those examinees whose results of the third test have been estimated as high creative.

As a result of the comparative analysis of the EEG spectral power between the indicators of each functional test (test 2, test 3, test 4) taking into account use of the melody with certain emotional coloring there are revealed cortex regions specific to the process of music composing unlike other kinds of musical activity. Analyzing the research results of we started with modern ideas about delta-range. From the point of view of a number of researchers: L.I. Aftanas, N.V. Reva, A.A. Varlamov, S.V. Pavlov, V.P. Makhiev the delta- oscillations are not only a correlate of the lowered functional condition (dream, pathology), but also a correlate of accompanying components of an active condition [6]. So in emotions generation process the intensification of power in delta-range is observed. In our research the greatest changes of power are in delta-range in frontal divisions and occipital zones.

Various aspects of the musical information processing are connected with activity of numerous cerebral structures some of which provide music perception (for example, temporal lobes are functionally connected with melody understanding), and others mediate development of emotional reactions (subcortical structures and frontal cortex lobes) [12].

In our research we consider the increase of activity and significant coherence of the theta-rythm in parietooccipital region as a reflexion of the process of activization of access and extraction of emotional information from memory, process of search of new, original decisions.

The alpha-rhythm activity is associated with the current functional condition of the person which is influenced by the character of music (its power, style). At composing the music with minor emotional colouring there has been increased power in frontal and post-temporal zones of the right hemisphere in the alpha–range.

In our research the increase of activity in beta 1 – and beta 2-frequency ranges in the prefrontal region of the right hemisphere and the occipital region of the left hemisphere may be considered as a reflexion of the creative process activation at creation of a musical image of a melody. It is proved by researches where it is revealed that the correct construction of language and musical syntax (the set of rules defining appropriate bond of elements – notes and words, accordingly) is provided by the frontal cortex region, and other regions are responsible for processing of the language and music components connected with it. N.P. Bekhtereva also specifies that at the of creative divergent tasks decision in the right frontal lobe (10, 11, 44, 45, 46, 47), and also in parietooccipital regions at the left (67, 7, 19) local rising of a blood flow was observed [3]. In the research of O.M. Razumnikova a substantial growth of the beta 2 rhythm as a correlate of successful divergent thinking was observed in frontal and parietal zones. Thus it is observed a mosaic character of the neural ensembles organization with the diffusive-presented synchronisation in the beta 2-range which represents a correlate of "the differentiated attention", providing widely distributed at various cortex regions processes of information selection necessary for the open type problems decision – in our case composition creation [7].

In the research of emotional influence of musical chords on the brain it becomes perceptible that the response at perception of minor chords in comparison with major ones was shown in hyperactivity of the tonsil, retrospinal cortex, brainstem and cerebellum. N.P. Bekhtereva also emphasized the importance of the retrospinal region in the emotions providing process [2].

In result of the analysis of coherent correlations between the background indicators and the indicators of "music composing" functional tests it is revealed that during music composing it is observed the increase of intrahemispheric hemisphere coherence values in frontal divisions of the cortex right hemisphere and in frontal divisions of the left hemisphere. And such activation is characteristic for the delta, theta and alpha frequency ranges. Similar synchronization of the theta rythm in cortex frontal regions is often observed in situations with a cognitive effort and memory load [3]. In the beta 2 range it is revealed the increase of intrahemispheric long- distant correlations between frontal and posterior divisions of the right hemisphere. As to the interhemispheric interactions it is most brightly presented in frontal divisions between homologous leads in the delta2 range. Thus, the researches have shown that intrahemispheric coherent correlations during music composing are almost evenly distributed in both hemispheres without significant domination of any hemisphere.

Intensifying of the coherent correlations of the alpha rhythm in temporal and frontal regions among the musicians can matter activation of mental processes of search. There occurs an original scanning ("reading") of information and close connection with perception and memory mechanisms takes place.

In the beta 1 and beta 2 frequency ranges the dynamics of distribution of coherent correlations is following: it is expressed the integration of frontal and posterior regions in the right hemisphere that means active involving of parietal, occipital and temporal regions into collaboration.

Weakening of functional correlations between hemispheres among the musicians can also specify in more independent work of hemispheres, separate information processing at the stage of a nonverbal creative problem decision. In research of Bekhtereva N.P., Nagornova Z.V. as well as in our research it is revealed an independent and parallel work of hemispheres during the nonverbal creativity process. Authors believe that the reduction of coherent communications in EEG high-frequency ranges between hemispheres at performance of creative tasks specifies in reduction of influence of the left (supervising) hemisphere in the nonverbal creativity process [2]. This assumption confirms the revealed in our research coherence depression of cerebral cortex biological potentials in the left hemisphere.

It should be noticed that the number of significant coherent correlations in the left hemisphere at major melody composing is greater than in the right that reflects a pattern of the EEG-activation, characteristic for experience of positive emotions which are presented at the process of creation of melodies with major emotional coloring.

Thus, as the specificity of musical creative process it is possible to ascertain the independent, but parallel active functioning of hemispheres at musical creative activity. Thus the greatest value there get frontal, temporal and occipital cortex regions, carrying out the integrating functions of organization of the processes of attention, emotional regulation and strategies of the problem decision in whole.

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