АКСИОЛОГИЯ КУЛЬТУРЫ / AXIOLOGY OF CULTURE

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| Психологические закономерности восприятия традиционной \ нетрадиционной музыки и их мозговые корреляты. Статья 2. Мозговые корреляты / Psychological Effects of Perception of Traditional \ Non-traditional Music and their Brain Correlates. Article 2: Brain Correlates |

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ПСИХОЛОГИЧЕСКИЕ ЗАКОНОМЕРНОСТИ ВОСПРИЯТИЯ ТРАДИЦИОННОЙ \ НЕТРАДИЦИОННОЙ МУЗЫКИ И ИХ МОЗГОВЫЕ КОРРЕЛЯТЫ*. СТАТЬЯ 2. МОЗГОВЫЕ КОРРЕЛЯТЫ

В статье представлены результаты изучения мозговых коррелятов восприятия музыки разных типов. При восприятии традиционной для испытуемых музыки, были обнаружены признаки генерализованной, общей для группы, электрической активности мозга в диапазоне ЭЭГ. Она состояла в активации лобных зон на фоне общего торможения остальных. При восприятии нетрадиционной музыки, каких-либо четких, объединяющих группу в целом, паттернов изменения электрической активности мозга в диапазоне ЭЭГ не наблюдается, что позволяет формально развести мозговые корреляты восприятия традиционной и нетрадиционной музыки. В диапазоне сверхмедленной активности, обнаружена выраженная тенденция к снижению спектральной мощности колебаний, в первую очередь в лобных и височных зонах коры. Данная закономерность с большой вероятностью является гендерно-специфической.

Ключевые слова: восприятие музыки, мозговые корреляты, диапазон ЭЭГ, сверхмедленный диапазон, традиционное и нетрадиционное искусство, культурное наследование.

PSYCHOLOGICAL EFFECTS OF PERCEPTION OF TRADITIONAL \ NON-TRADITIONAL MUSIC AND THEIR BRAIN CORRELATES*. ARTICLE 2: BRAIN CORRELATES

Brain correlates of perception of music of different types were studied. Generalized, common trends, consisting primarily in activation of frontal zones, accompanied by general slowdown of the other ones, was demonstrated to occur in the EEG bandpass by Ss who passed a course of traditional, light classical music. The opposite trend, comprising absence of generalized, common shifts in the EEG bandpass, was revealed in the case of the subgroup who passed a

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course of non-traditional, designer music. In this way, brain correlates of perception oof traditional and non-traditional music could be roughly discerned. General trend towards the reduction of spectral power of signals in the ultraslow bandpass, especially in frontal and temporal zones, was demonstrated, which tended to be gender-specific.

Key words: perception of music, brain correlates, EEG bandpass, ultraslow bandpass, traditional and non-traditional art, cultural inheritance.

Basic results of the study of the psychological effects of perception of traditional music, and of the non-traditional one, were presented in the first article. The group studied by us consisted of 63 young normal Russian-speaking city dwellers. Having passed a routine medical examination, all of the Ss subscribed standard forms of informed consent. After that, all of them filled in forms of six psychological questionnaires, and passed an electrophysiological examination of brain rhythms. The group was divided into three subgroups thereafter, each of which listened to music / sounds of a definite type for two weeks, 90 minutes a day. Having passed the two-week course, all of the subjects passed the psychological and the electrophyosiological study, following strictly the same procedures. No professional musicians took part in the study. The majority of our subjects had not graduated even from a musical college, which is a popular form of complementary secondary education in Russia. The majority reported however that they felt positive about listening to music, and in fact did it quite often in the course of their everyday life.

Members of subgroup 2 listened to light classical music, which sounded highly traditional to them. Members of subgroup 3 listened to music, which was not traditional for them, both in terms of pitch and rhythm, as well as of timbre[2]. Musical stimuli applied for the subgroups 2 and 3 were in this way contrary to one another, which allowed us to gain access to regularities of perception of traditional and non-traditional music, which forms a focal point of a long-term research program of basic mechanisms of cultural inheritance, conducted by the D.S. Likhachev Russian Institute of Cultural and Natural Heritage. Members of subgroup 1 listened for two weeks to neutral, familiar sounds of nature. In this way, a sound technology was applied, which was indifferent to the dichotomy of traditional vs. non-traditional music. Thus subgroup 1 was regarded as methodologically correct to serve as control group in our research[3].

The electrophysiological block of our study consisted in registration of patterns of the activity of the brain of each of our subjects, which was conducted in each case two times, first 1-2 days before the onset of the music course, and second, 1-2 days after its end. Recordings were done in a calm study, with eyes open, and then with eyes shut. The only instruction our Ss got was to stay for at least half an hour in a relaxed state. In each case two types of brain activity was reg-

[2] Musical racks designed by iAwake Technologies in the USA, which is a world leader in this particular realm; were applied in our research; for details, see references 9, 10 in the text of the first article of ours. The authors are grateful to E. Thompson for the permission to use the aforementioned tracks in this study.

[3] For details of sound technologies applied at subgroups 1, 2, and 3, see article 1 of the present series, references 8, 11, 12; for brief review of the scientific literature, cf. references 13, 14, 15.

istered, one of which comprised the bandpass of EEG, and another one, of the ultraslow processes[4].

In formal terms, the EEG bandpass comprises frequencies of electrical activity from 1.5 to 30 Hz, the ultraslow bandpass from 0 (in practical terms, 0.05) to 0.5 Hz. In functional terms, the main task of the EEG activity consists in providing a broad range of short-term cognitive and communicative activities[5]. As to the ultraslow activity, its main task consists in providing the so-called non-specific activation of the brain, which is indispensable in conducting its long-term regulatory and integrative functions[6]. As a result, both types of the electrical brain activity may be regarded as complementary, both in structural and in functional terms.

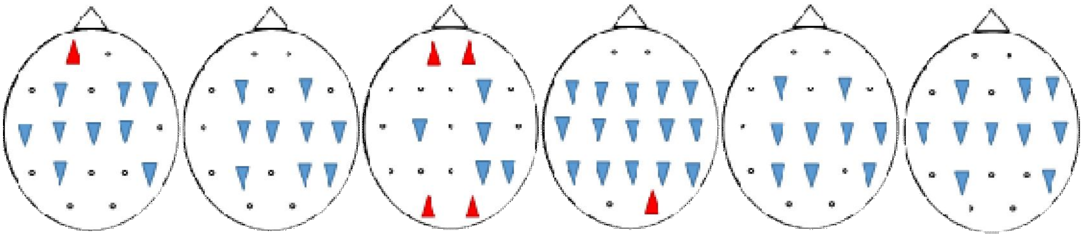
Biopotentials of the aforementioned two types, along with the impulse activity of neurons, represent the three “different aspects of brain functioning, its different “languages” , to follow a constructive formulation coined by N. P. Bechtereva and her co-authors[7]. As a result, application of our methodology, combining the registration of brain activity in both the swift (EEG), and the ultraslow bandpasses, allowed in each case to draw a methodologically correct assessment of a number of basic processes in the brain, starting from those providing short-term cognitive and communicative tasks, and ending with the long-term ones, including those supporting its general energetic balance and stability. This block of our research was conducted in the framework of the scientific school founded by N. P. Bechtereva, which currently functions at the basis of N. P. Bechtereva Human Brain Institute, Russian Academy of Sciences.

Basic differences in the organization of the electrical activity of the brain in the EEG bandpass, occurring as a result of passing the music course, are presented at Figure 1. The Figure presents the head of a subject, seen from above, looking forward (the nose is schematically depicted at the upper part of the picture). The head is depicted at our Figure six times in a row, according to the six basic types of the EEG activity, studied by us, i.e. delta, theta, alpha-1, alpha-2, beta-1, and beta-2 waves, looking from left to right.

In each case, the electrical activity was registered with the help of 19 silver chloride electrodes, at 19 standard points at the surface of the skull, marked as dots at the Figure 1. If there was a statistically relevant difference in spectral power of the signal in the given point after the end of the musical course, compared to the state before its beginning, a triangle was drawn by us at the given point. The triangle was red and directed upwards by its top, if the power of the signal rose. The triangle was blue and directed downwards by its top, if the power fell. If no statistically relevant shift occurred, the dot remained intact.

[4] EEG is a common abbreviation for electroencephalogram.
[5] For detailed account, see: Guselnikov V.I. Electrophysiology of the Brain. Moscow, Vysshaya Shkola, 1976 (in Russian).
[6] Aladzhalova N.A. Psychophysiological Aspects of Ultraslow Rhythmic Avtivity of the Brain. Moscow, Nauka, 1979 (in Russian). A prominent representative of the scientific school of N.P.Bechtereva remarked recently that the main function of the ultraslow activity consisted in its providing “…the state of rest, and of long-term psychological states”(Ilyukhina V.A. Continuity and development of research in systemic psychophysiology of normal and pathological functional states, bordering on issues of clinical neurology // Rossiyskiy Neirokhirurgicheskiy Zhurnal im. professora A. L. Polenova, 2009, Vol.1, No.3, p.12) (in Russian).
[7] Bechtereva N.P., Gogolitsyn Yu.L., Kropotov Yu.D., Medvedev S.V. Neurophysiological Mechanisms of Thought. Reflection of Cognitive Activity in Impulse Activity of Neurons. Leningrad, Nauka, 1985. P. 45-46 (in Russian).

Figure 1. Differences in spectral power of signals in the EEG bandpass after passing a course of traditional European (light classical) music (subgroup 2), compared to the state before its start, eyes closed.

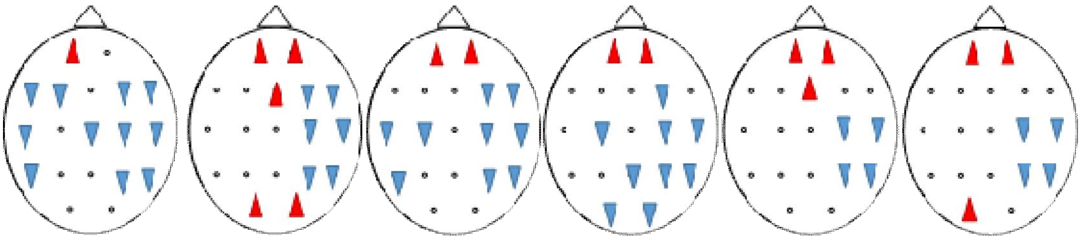


Note: For details, see the main text of the present paper.

Regarding the data of Figure 1, we are feeling authorized to conclude that the musical course of the given type has affected the brain activity in the EEG bandpass in a rather strong way. General slowdown of the electrical activity was dominating. At the same time, activation of several zones, especially frontal ones in the alpha-1 bandpass, has to be marked.

Regarding the data of the control subgroup (Figure 2), we have to state that the main patterns of the dynamics of the brain activity have remained similar to the regularities registered by us in the previous case. We see here again general slowdown of brain activity in all six sub-bandpasses, serving as background for more or less pronounced activation of frontal zones.

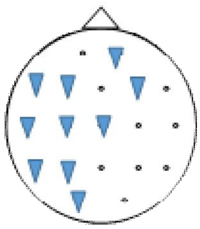
Figure 2. Differences in spectral power of signals in the EEG bandpass after passing an audiocourse of sounds of nature (subgroup 1), compared to the state before its start, eyes closed..



Note: For details, see the main text of the present paper.

Next comes the turn of subgroup 3, members of which listened for two weeks to designer music[8], which sounded definitely non-traditional to them. The first thing that we have to state is that it revealed principal difference from the regularities registered in the case of the two previous two subgroups. The difference consists not in specific patterns of activation or, inhibition, but in the lack of regularities that would be common for all the members of subgroup 3. To be more precise, some kind of affinity may be seen in the case of the beta-2 sub-bandpass (Figure 3). However no statistically relevant patterns were revealed in the cases of other brain waves. This meant that no systematic comparison of subgroup 3 with subgroups 1, 2 was possible.

Figure 3. Differences in spectral power of signals in the EEG bandpass after passing a course of non-traditional music (subgroup 3), compared to the state before its start, eyes closed.



Note: data on brain activity in the beta-2 sub-bandpass are represented, the only type of activity where statistically representative shifts were revealed. For other details, see the main text of the present article.

Similar regularities were registered in the case when the registration was conducted with eyes open[9]. This means that the regularities briefly reviewed above, seem to be characteristic of the electrical activity of normal brain in the EEG bandpass, in general terms. As to their essence, we are feeling authorized to cite here several brief remarks.

Primarily, we have demonstrated that listening to music which was traditional for our Ss (subgroup 2), tended to induce generalized (i.e. not limited by a particular brain zone) shifts in the brain activity, shared by all subjects. The opposite trend was actual for the non-traditional subgroup, which revealed neither common nor generalized patterns of brain activity. Thus common strategies tended to be applied by the brain for the purposes of processing traditional art, while individual strategies were likely to be applied in the case of the non-traditional art: cultural collectivism was in this case opposed to cultural individualism.

Control subgroup tended to reveal considerable structural affinity to the subgroup which listened to the traditional music. Sounds applied in this case were definitely not traditional, because they belonged not to culture, but to nature; however they were quite familiar to our Ss. If this assumption is right, there exist common patterns in the perception of familiar sounds, compared to the traditional ones.

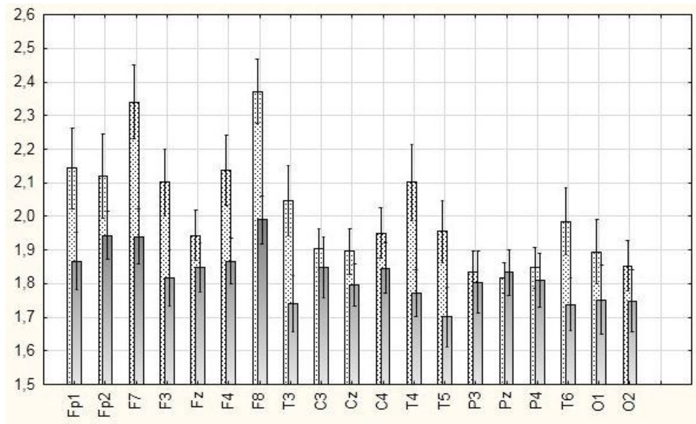
The first cluster of our conclusions, just cited above, doesn't have obvious parallels in the scientific literature, it seems to be quite novel. As to the second cluster, its main parts tend to correspond quite well to the state of the art. Briefly reiterating our conclusions, general slowdown of brain activity in all six EEG sub-bandpasses was registered by us, serving as back-

[8] Designer music is a general term applied in present-day science for any kind of musical tracks "…designed to have specific effects on the listener" (McCraty R., Barrios-Choplin B., Atkinson M., Tomasino D. The effects of different types of music on mood, tension, and mental clarity. // Alternative therapies in health and in medicine. 1998. Vol.4. No.1. P. 75-84). Music applied by us in the case of the subgroup 3, could be roughly defined in these terms.

[9] Analysis of coherence of brain rhythms was also conducted in the framework of our study, apart from analysis of the spectral power. Its results will not be cited here explicitly, due to the fact that it did not yield definite, statistically relevant regularities.

ground for more or less vivid activation of frontal zones. As to the generalized slowdown, which is firmly associated with temporary stress reduction, and often with general relaxation, it tends to arise regularly by subjects listening to music regarded by them as pleasant[10]. As to the activation of frontal, and often parietal zones, which may take place against its background, it is often linked to the activation of mechanisms of perceiving and processing both the inner structure of the musical text, and the emotional patterns encoded in it[11]. In general terms, enhanced cognitive performance, which takes place against the background of reduced emotional instability, forms a desired target in quite a few systems of present-day psychotherapy, sometimes defined as ‘skilled response’.

Figure 4. Mean spectral power of signals in the ultraslow bandpass, before and after passing an audiocourse of sounds of nature (subgroup1).



Notes: Fp1, Fp2, - anterior-frontal (left, right) derivations, F7, F8 – fronto-temporal (left, right), F3, Fz, F4, - frontal, T3, T4 – mid-temporal (left, right), C3, Cz, C4 - central, T5, T6 - posterior-temporal (left, right), P3, Pz, P4 - parietal, O1, O2 - occipital derivations. Mean spectral power logarithms of signals are presented at the ordinate axis. Registration was conducted with eyes closed. For other details, see the main text of the present paper.

Basic differences in the organization of the electrical activity of the brain in the ultraslow bandpass, occurring as a result of passing the music course, are presented at Figure 4. The signal was registered at 19 standard points at the surface of the head of each of our subjects. All of these 19 points are marked in turn at the absciss axis. For each of them, two histograms are presented, one of which (on the left, marked by light color) measures the volume of spectral power of signal at this point, prior to passing the two-week audiocourse; another one (on the left, marked by dark colour) measures the same, after the course. Figure 4 presents mean values of the spectral power for the whole of the control group, which listened, as we remember, to sounds of nature.

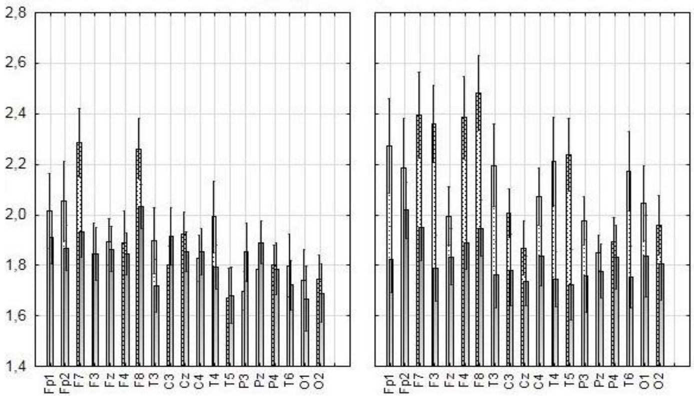
Interpretation of data presented in Figure 4, seems to be quite obvious: practically at all points, especially at the frontal and the temporal zones of the cortex, there existed a strong tendency towards reduc-

[10] For an overview of present-day trends, cf.: Levitin D. Neural correlates of music behaviours: a brief overview // Music Therapy Perspectives, 2013. Vol.31. P. 15-24.
[11] For more details, see: Altenmüller E., Schürmann K., Lim V., Parlitz D. Hits to the left, flops to the right: different emotions during listening to music are reflected in cortical lateralisation patterns. // Neuropsychologia, 2002. Vol.40. P. 2242-2256; Andrade P., Bhattacharya J. Brain tuned to music. // Journal of the Royal Society of Medicine. 2003. Vol. 96. P. 284-287; Schmidt L., Trainor L. Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions // Cognition Emotion. 2001. Vol. 15. P. 487–500; Schmidt L., Trainor L. Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions // Cognition and Emotion, 2001. Vol. 15. No. 4. P. 487-500. For a more general theoretical perspective, cf.: The neurosciences and music II: from perception to performance. NY, New York Academy of Sciences, 2005.

tion of the mean spectral power of signal at the ultraslow bandpass. Before passing to the interpretation of this convincing and highly impressive result, a routine check of gender differences was conducted[12]. Results of this check are presented in Figure 5.

Figure 5. Mean spectral power of signals in the ultraslow bandpass, divided by gender, before and after passing an audiocourse of sounds of nature (subgroup 1).

Note: Mean data for all the members of the female part of



the subgroup 1 are presented on the left; data for all the members of the male part of the subgroup 1, on the right. For other abbreviations and notes, see note to Figure 4.

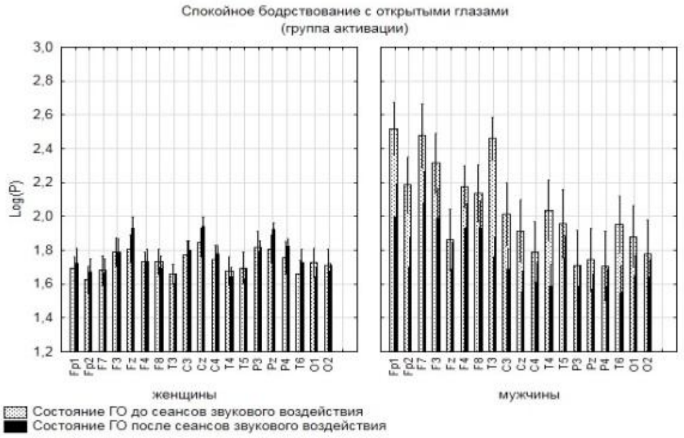
As clearly shown by Figure 5, the effect of reduction of mean power of signal, occurring as a result of passing an audiocourse, is proper for only the male part of the subgroup 1, and is not proper for its female part. This means that the effect discovered by us seems to be gender-specific. One has to admit that it was not to be predicted, basing upon theoretical assumptions. Routine checks of data acquired in the case of the EEG bandpass for all of our subgroups, were by no means gender-specific, either. To check how basic this regularity could be, we have reviewed data on the electrical activity of the brain in the ultraslow bandpass of other two subgroups, studied by us.

As clearly demonstrated by data of Figure 6, the mean power of signal tends to fall as a result of passing a music course by male members of subgroup 2, which is definitely not the case of the female part of this subgroup. This means that dynamics of the electric activity of the brain in the ultraslow bandpass tended to be gender-specific not only in the case of listening to sounds of nature, but also in the case of light classical music, which was traditional for them.

Members of subgroup 3, listening to non-traditional, designer music did not reveal any regularities which would be statistically relevant. Thus no histograms comparable to those presented at Figures 4-6, could be constructed for them. This is in line with the regularity demonstrated by us basing upon the data of the EEG bandpass: traditional or familiar sound technologies tend to bring about generalized, common shifts in the electrical activity of the brain; the opposite tends to be true for the non-traditional, designer music.

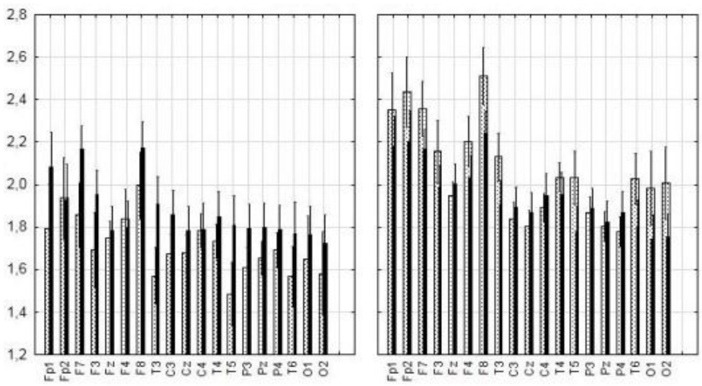
[12] This kind of check was applied on a routine basis to all of the data acquired in this research. However statistically relevant difference was registered only in the case of ultraslow potentials (Fig.5, 6).

Figure 6. Mean spectral power of signals in the ultraslow bandpass, divided by gender, before and after passing a course of light classical music (subgroup 2).



Note: Mean data for all the members of the female part of the subgroup 2 are presented on the left; data for all the members of the male part of the subgroup 1, on the right. For other abbreviations and notes, see note to Figure 4.

Figure 7. Mean spectral power of signals in the ultraslow bandpass, divided by gender, before and after passing a course of designer music (subgroup 3).



Note: Mean data for all the members of the female part of the subgroup 3 are presented on the left; data for all the members of the male part of the subgroup 1, on the right. The registration was conducted with eyes open. For other abbreviations and notes, see note to Figure 4.

However characteristics of the electrical activity of the brain acquired by us are in fact quite extant. For instance, our registration was conducted not only with eyes closed, as in Figures 4-6, but also with eyes open[13]. Results of this kind have not been explicitly cited in this paper up till now, because they did not yield results which would have qualitatively differed from the results of registrations conducted with eyes closed. However in this particular case, the situation was different.

As shown by figure 7, spectral power of signal in the ultraslow bandpass by male members of subgroup 5, definitely tended to fall after the music course, especially in the case of the fontal zones. The opposite was true for the female part of the subgroup 3, although the data were strongly blurred there, preventing us from the application of more sophisticated methods of statistical processing. This means that subgroup 3 followed two main tendencies, that is, the lack of common, generalized patterns, when the registration was conducted with eyes closed; and the reduction of signal power, with eyes open. Thus traces of gender specificity may be traced back even in the case of the subgroup 3.

Gender specificity seems thus to form quite a strong trend in the ultraslow bandpass. In present-day psychophysiological literature, organization of brain rhythms is regarded as being definitely affected by

[13] Both methodologies are standard and frequently used in brain studies. In the case when the registration was conducted with eyes being opened, the Ss were instructed to focus their sight for 12-17 minutes upon a point displayed at the screen of a computer, which was put at approximately 1.5 meter away.

gender dimorphism[14]. However this trend is regarded as most actual in the case of the EEG bandpass[15], especially cerebral asymmetry[16]. In the case of the ultraslow bandpass, presence of gender specificity seems to be still quite unclear[17]. This is the case of perception of sounds, especially such complex ones as music[18].

Having thus detected presence of gender specificity in our data, we could not find a simple solution, basing on the present-day scientific literature. In any case, it would be correct to conduct further inquiry in the ultraslow bandpass, only having divided the subgroup into men and women. Having done this, we found that our subgroups became too small to apply serious methodologies of statistical data processing. The reason is that our subgroups were initially minimal in size, comprising in each case about 20 subjects, as usual in a pilot study. Next, data on some of the subjects were removed, as their recorded contained too many artefacts, due to casual reasons. As a result, only 18 subjects formed subgroup 1, 18 subjects formed subgroup 2, and 17 formed subgroup 3, out of the initial total number of 64 Ss. Further dividing each of these subgroups into men and women would make their size definitely too small to form a basis for demonstrative conclusions. Thus registration of brain activity of additional 12-15 subjects in case of each subgroup would be necessary to elaborate this aspect of our study.

Thus having reviewed the main results acquired in our study, we are feeling authorized to formulate several basic conclusions:

1. Perception of light classical music, which was traditional for our Ss, induced common generalized shifts of electrical brain activity in the EEG bandpass. These shifts comprised primarily general activation of frontal zones, accompanied by general slowdown of the other ones. Such trend may be linked to enhanced cognitive performance, taking place at the background of general relaxation, possibly linked to stress reduction;

2. No statistically relevant shifts of electrical brain activity in the EEG bandpass were demonstrated to have occurred in the case of perception of designer music. In this way, the dichotomy of traditional vs, non-traditional music was translated on the level of brain waves into the dichotomy between generalized, common brain electrical activity vs. non-generalized, individual brain activity, respectedly. This regularity,

[14] Ilyin E.P. Differential Psychophysiology of Men and Women. St.Petersburg.: Piter, 2002. Especially cf. chapter 1, part 1.7 (in Russian).

[15] Belskikh I.A., Golubev S.A., Kozarenko L.A., Plotnikov D.V. Gender differences of structure of general brain indices of background EEG by humans // Chelovek i Ego Zdorovye. 2011. No. 2. P. 5-8 (in Russian).

[16] Morenkov E.D. Gender dimorphism of brain functional asymmetry // Functional hemispheric asymmetry. Moscow: Nauchnyj mir. 2004. P. 369-385 (in Russian); Bianki V.L., Filippova E.B. Brain asymmetry and Gender. St.Petersburg, St.Petersburg State University, 1997 (in Russian), cf. in this context basic regularities of the effect of perception of music of various types upon the level of functional asymmetry of the brain: Evtushenko A.V., Tikhonova I.O., Fokin V.F. Alterations of hemispheric relations under the influence of classical and modern dance music // Actual Issues in Functional hemispheric Asymmetry. Moscow, Russian Academy of Medical Sciences, 2003. P. 121 (in Russian), Gasanov Ya.K., Bragina N.N., Dobrokhotova T.A., Kornienko V.N., Repin T.Ya. Brain hemispheric relations and the perception of music (in Russian) (in Russian) // A.R.Luria and Contemporary Psychology. Moscow, Moscow State University. 1982. P. 207-214 (in Russian).

[17] Ilyukhina V.A., Zabolotskikh I.B. Energy Deficient States in Normal and Pathological Cases. St.Petersburg, Human Brain Institute, Russian Academy of Sciences, 1993 (in Russian), especially cf. data concerning electrical activity of the brain in the ultraslow bandpass by pregnant women: as shown by Table 9, they are by no means gender-specific (op.cit. P.102).

[18] Ilyukhina V.A Psychophysiology of Functional States and Cognitive Activity in Normal and Pathological Cases. St.Petersburg, N.-L, Publishers, 2010 (in Russian), cf. especially data from Table 4 (op.cit., p. 55-56).

opposing cultural collectivism and cultural individualism in art perception, forms a constructive context for a similar regularity, demonstrated by us in the previous paper of the present series on the level of psychological processes and states;

3. General trend towards reduction of spectral power of signal, as a result of passing a music course, was traced back in the ultraslow bandpass. This regularity, which is quite novel for studies of art perception, forms a constructive trend of further research;

To corroborate the aforementioned tendencies and to trace back the new ones, it would be most appropriate to raise the intensity of sounds, primarily by using headphones, and to apply the methodology of evoked potentials[19].

[19] Analysis of molecular genetic correlates of the perception of traditional vs. non-traditional art forms a wider interdisciplinary perspective of this research, which will be regarded in a separate paper (cf. Spivak I., Mikhelson V., Spivak D. Telomere length, telomerase activity, stress, and aging // Advances in Gerontology. 2016. Vol. 6, No.1. P. 29-35).