The Journal of International Civilization Studies
Uluslararası Medeniyet Çalışmaları Dergisi
Volume IV/ Issue I
ISSN: 2548-0146, Nevşehir/ TURKEY
DOI: <doi>10.26899/inciss.241</doi>
Geliş Tarihi/ *Received:* 16/04/2019
Kabul Tarihi/ *Accepted:* 22/04/2019

THE INFLUENCE OF THE METHOD OF BIOACOUSTIC CORRECTION (EEG NEUROFEEDBACK-BASED SYSTEM) ON THE RESTORATION OF PSYCHOPHYSIOLOGICAL PARAMETERS AFTER STRESS

Dr. Elena N. ASHANINA

The Nikiforov Russian Center of Emergency and Radiation Medicine EMERCOM of Russia

elen.ashanina2015@yandex.ru

Mikhail N. SENIK

Saint Petersburg State Institute of Technology (Technical University)

senikm@ya.ru

Abstract

The objective of our study was to determine the possibility of using the bioacoustic correction (BAC) to restore the psycho-emotional state after stress to prevent the development of post-traumatic disorder. 20 students were examined. Before the procedure of BAC, each student spent 20 minutes at a computer simulating first-person fighting. It was found that during the course of the procedures of listening to the test subjects of the acoustic image of their own Electroencephalography (EEG) in real time in the main group there is a more rapid and significant recovery of the psycho-emotional sphere (normalization of stress level, blood pressure and heart rate) than in the control group. These changes are accompanied by restructuring of EEG parameters. To a greater extent, changes in the frequency structure of EEG affect the right hemisphere. There is a decrease in the activity of the alpha range and an increase in the activity of the theta range in the frontal leads, an increase in the beta activity of the occipital lead.

Key words: *audiovisual impact, biological feedback, EEG - biofeedback, sensory stimulation, psychological rehabilitation*

Introduction

Analyzing the data on the mechanisms of musical influences, the researchers pay attention to the similarity of the organization of neural and musical rhythms, there is a coincidence of frequencies of musical rhythms and lower frequencies of neuronal oscillations of thalamocortical circuits, as well as the similarity of the hierarchical organization of neural activity and rhythmic components of music [12, 1]. Moreover, the researchers emphasize the anatomical conditionality of musical perception. Firstly, due to the differentiated processing of tonal (melodic) and rhythmic information by different thalamic structures and cortical layers and, secondly, the integration of these musical components in the thalamocortical loops. In this case, melodics or frequency information is given the role of the main content with the corresponding delivery of this information to the auditory cortex through direct inputs to the fourth layer of neurons, and rhythm – context, mainly modulating character, with the corresponding passage into the auditory cortex through the modulating inputs of the second and third neural layers. [7, 8, 9]. The features of the frequency-time structure of musical signals, which is similar to the frequency-time structure of the impulsive flows of neurons and anatomical conditionality of the effective processing of music-organized sounds indicate that the mechanisms of the therapeutic influence of music are the processes of synchronization between afferent influences and endogenous neurodynamic processes.

Much attention is paid to the issues of synchronization of neurodynamic processes and physiological significance of this phenomenon in the literature. It is shown that synchronization phenomena play a key role in the mechanisms of higher integrative brain functions [2]. This applies to both endogenous neurodynamic processes and neural activity caused by external stimuli. For example, the development of conditioned reflex is possible at a certain level of synchronization (combination) of external stimuli: conditional and unconditional. The time factor or temporal coincidence of different activations is considered as the most important condition for long-term changes in synaptic efficiency. An example of the importance of endogenous synchronization is the message that the activation of attention and consciously predicted arbitrary movements are accompanied by synchronized discharges of neurons of the nonspecific and motor thalamus. Processes of synchronization of neural activity are considered as one of the important mechanisms of thalamo-cortical integration [4, 15]. Synchronization of endogenous neural activity with external stimuli is no less important for the brain [13]. Shows the different effects of presentation of sensory stimuli synchronously with EEG oscillations in the mode of stimulation to trigger. The dependence of the trigger photostimulation effects on synchronization with different phases of the alpha wave was studied. It is concluded that the effects of photostimulation are determined by the phase of renal neuronal activity of thalamo-cortical loops combined with neural activity caused by sensory stimulus. In this regard, there is no doubt that afferent impulses, combined with certain phases of spontaneous neural activity expressed in certain graph elements of the bioelectric activity of the brain leads to the restructuring of the latter. The dependence of this restructuring on the level of synchronization of the initial bioelectric activity of the brain with the afferent flow is also obvious.

In this paper, we present the results obtained using the bioacoustic correction (BAC) method, which allows to use it in the rehabilitation of persons in professions exposed to professional stress.

Objective

To determine the possibility of using the BAC to restore the psycho-emotional state by activating the endogenous processes of self-regulation to activate the processes of recovery of mental activity, to accelerate the recovery processes after stress and, possibly, to prevent the development of post-traumatic disorder. In the BAC method, sensory stimulation of brain structures associated with the processes of motivation and reinforcement is carried out, which is achieved by the presentation of acoustic stimuli of the musical range, the parameters of which are consistent with the parameters of the current bioelectric activity of the patient's brain.

Methods

20 male students aged 19-22 years were examined. The main group of students (MG), 10 people, took a course of bioacoustic correction procedures, which consisted in listening to the test subjects of the acoustic image of their own EEG in real time. In the control group (CG), 10 students listened to the recording of the acoustic image of the EEG of a healthy adult made in advance.

Before the procedure of bioacoustic correction, each student spent 20 minutes at a computer simulating first-person fighting.

Testing the level of the stress was made using the scale "Assessment of mental stress PSM25 Lemur-Tessier-Fillion". The measurement of stress was performed three times: before a combat simulator, before the procedure of bioacoustics correction and after the BAC procedure.

In parallel, each time when determining the level of stress using the PSM25 scale, we measured the physiological parameters of the subjects (pulse and blood pressure) using an automatic tonometer A&D UA-911BT.

Registration and conversion of EEG into a sound image were carried out using a computer complex "Synchro-C" (fig. 1). Bioelectric activity of the brain was recorded at Fp1, Fp2, O1, O2 points (according to the 10-20 system) relative to the combined ear electrode with a sampling rate of 250 Hz with closed eyes. All EEG recording channels were transformed into an acoustic image simultaneously and independently. The received sounds were presented in accordance with the EEG registration party. The duration of the session was 20 minutes. The EEG transformation into an acoustic image was carried out on the basis of the operation of matching the values of the EEG oscillation periods with a set of sound samples, where each EEG oscillation period in the range from 1 to 30 Hz corresponded to a sound sample with a certain pitch frequency [6]. The frequency ratios of the main tones of the sound samples corresponded to the tempered musical structure, which gave the EEG acoustic image a pronounced musical character. The presentation of sound samples was synchronous with the current EEG, while the frequency of the main tone of the presented sound corresponded to the value of the period of the current oscillation of the EEG [11].

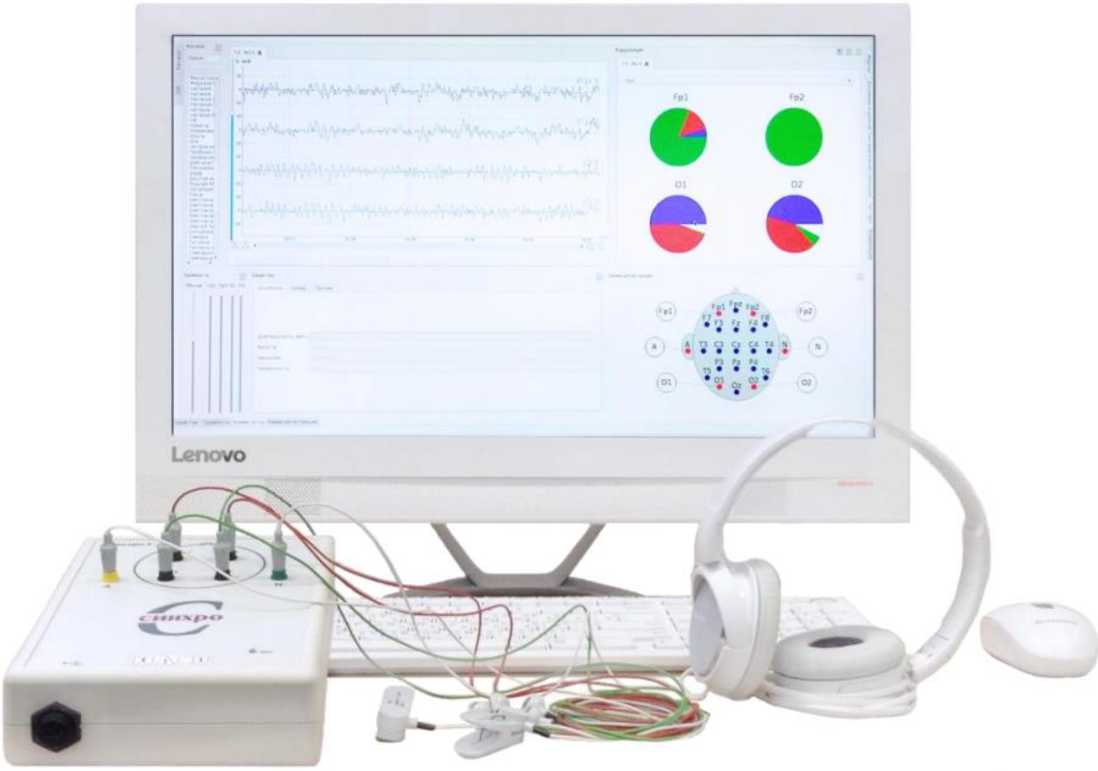

Fig.1 Hardware complex "Synchro-C»: a device for converting the total electrical activity of the brain into the sound of the musical range for the bioacoustic normalization of the psychophysiological state of a person.

The level of spatial synchronization of EEG was estimated on the basis of the analysis of cross-correlation functions. For couples derivations: Fp1-Fp2, Fp1-O1, Fp1-O2, Fp2-O1, Fp2-O2, O1-O2 was carried out search for the maximum cross-correlation function. If the maximum of the cross-correlation function was observed at the zero point on the abscissa axis and exceeded 0.3 on the ordinate axis, then for this time interval of the EEG, the analyzed pair of processes was considered synchronous. The duration of the analysis era was two seconds. Calculated the proportion of plots simultaneous EEG consistent bitartarate eras. For each pair of leads, 60 epochs from the beginning of the EEG acoustic image listening procedure were analyzed. The task of this work was to assess the dynamics of spatial synchronization of EEG during the course of bioacoustic correction.

Statistical analysis was carried out using the software package "STATISTICA". Checking the normality of the distributions of the obtained arrays was carried out according to the criterion of Kolmogorov-Smirnov. The estimation of reliability was calculated by student's t-test and nonparametric Wilcoxon test for paired samples.

Results

Before the study, both groups of students had a low level of stress, the level on the PSM25 scale in both groups is less than 100 points (MG – 75±2, KG – 77±3), which indicates the state of psychological adaptation to the workloads.

The average values of blood pressure and pulse in the studied groups were:

MG – 114 ± 1 mmHg for systolic pressure and 73 ± 1 mmHg for diastolic. Average heart rate – 61 ± 2.

CG – 115 ± 1 mmHg for systolic pressure and 76 ± 1 mmHg for diastolic. Average heart rate - 60 ± 3.

After a 20-minute session at a computer simulator simulating the fighting, testing and measurement of physiological parameters showed a marked increase in the level of stress: the PSM25 index in both groups increased:

- MG up to 112 ± 4 (mean stress level)

- CG up to 114 ± 5 (mean stress level).

There was also a marked increase in blood pressure and pulse (table No. 1).

Table 1. Psycho-physiological indicators of stress level of subjects before and after the BAC procedure.

	The stress level on a scale PSM25		Blood pressure (BP)				Pulse	
			MG		CG			
Indicator	MG	CG	systolic BP, mmHg	diastolic BP, mmHg	systolic BP, mmHg	diastolic BP, mmHg	MG	CG
Before using combat simulator	75±2	77±3	114 ± 1	73 ± 1	115 ± 1	76 ± 1	61 ± 2	60 ± 3
After using combat simulator	112±4	114±5	128 ± 1	85 ± 1	129 ± 1	83 ± 1	80 ± 3	79 ± 4

After BAC procedure	88±3	105±2	116 ± 1	75 ± 1	125 ± 1	81 ± 1	59 ± 3	69 ± 2

After the BAC procedure can be noted that both physiological and stress indicators on the PSM25 scale in the main group significantly ($p<0.05$) normalized to a greater extent than in the control group, namely:

The level on the PSM25 scale in MG decreased to 88±3 (low stress level), while in CG the average value remained in the range of the average stress level - 105±2.

Also, the physiological parameters of the main group almost returned to normal, while the corresponding indicators of the control group remained elevated (table No. 1).

The above difference in the recovery processes after stress was accompanied by certain changes in the brain of the subjects, fixed on EEG, namely:

In the course of the procedure of listening to the acoustic image of own EEG in the main group in the frontal leads there was a decrease in the proportion of alpha rhythm from 27.5 ± 4.5% to 25.0 ± 5.5% ($p<0.05$) on the left and from 27.6 ± 4.5% to 25.0 ± 4.1% ($p<0.05$) on the right. In the theta range there was an increase in the proportion of EEG oscillation periods on the right from 22.5 ± 4.2% to 26.0 ± 7.1% ($p<0.05$). In the occipital leads, an increase in the proportion of the beta-range oscillation periods on the right was recorded from 29.9 ± 10.2% to 34.5 ± 12.1% ($p<0.05$).

In the control group of students who listened to the recording of the acoustic image of a someone else's EEG, there was a decrease in the alpha rhythm in the right frontal lead from 28.5 ± 2.2% to 24.5 ± 3.1% ($p<0.05$), as well as a decrease in the activity of the theta range in the right frontal lead from 25.1 ± 4.2% to 23.2 ± 4.1% ($p<0.05$). No significant changes were observed in other leads and frequency ranges of EEG.

Initially, in the main and control groups there is an approximate equality of values of spatial synchronization. The highest values of correlation are observed in the interhemispheric pairs of parallel derivations (Fp1-Fp2 and O1-O2), the lowest values of the synchronization points obtained for EEG registration are on the diagonal (Fp1-Fp2 and O2-O1). Levels of synchronization of intrahemispheric pairs occupy intermediate values.

During the procedures of listening to the acoustic image of the EEG in the main group, there is an increase in the level of spatial synchronization of the frontal leads, and a decrease in the spatial synchronization of the occipital leads. There were no significant changes in the level of commonality in the diagonal pairs.

No significant changes in spatial synchronization were found in the control group by the end of the course of procedures.

Discussion

During the course of the procedures of listening to the test subjects of the acoustic image of their own EEG in real time in the main group there is a more rapid and significant recovery of the psycho-emotional sphere after stress than in the control group. These changes are accompanied by restructuring of EEG parameters. To a greater extent, changes in the frequency structure of EEG affect the right hemisphere. There is a decrease in the activity of the alpha range and an increase in the activity of the theta range in the frontal leads, an increase in the beta activity of the occipital lead.

The dynamics of spatial synchronization deserves the greatest attention. According to neurophysiological data, the normal functional state is characterized by increased synphase of the frontal leads and a noticeable phase shift of the EEG of the occipital parts, that is, the predominance of the level of synchronization of the frontal parts over the occipital. During the procedures of listening to the acoustic image of own EEG, there was an increase in the synphase of the frontal parts and a decrease in the synphase of the occipital leads. Therefore, the observed dynamics of spatial synchronization can be interpreted as normalization. Changing the level of synchronization of frontal and occipital leads towards normalization may indicate the processes of restoration of thalamocortical interactions. It can be assumed that to a greater extent these changes affect the fronto-thalamic system, the important role of which is shown for the implementation of complex forms of mental activity and regulation of the level of wakefulness [5].

Thus, the presentation of sounds synchronized with the current bioelectric activity of the brain can activate the processes of recovery of mental activity, accelerate the recovery processes after stress and, possibly, prevent the development of post-traumatic disorder. The initial complementarity of musical sounds to neurodynamic processes determines the high efficiency of such influence.

Conclusion

The presentation of musical sounds synchronized and consistent with their own EEG promotes mental activity, accelerate recovery processes after suffering stress and possibly prevent the development of post-traumatic stress disorder. Normalization of the mental state is accompanied by an increase in the spatial synchronization of the bioelectric activity of the brain of the frontal divisions and a decrease in the spatial synchronization of the occipital divisions.

References

Ashanina E. N., Kulakov D.V. (2012). Teoriya i praktika korrekcii dezadaptivnyh nervno psihicheskih sostoyanij s pomoshhyu audiovizualnogo vozdejstviya i biologicheski obratnoj svyazi (Theory and practice of correction of non-adaptive neuro–psychiatric conditions using audiovisual effects and bio feedback) // Vol.2. SPb. : Polytechnic-service, 101 PP. (In Russ.)

Baars B.J., Gage N.M. (2010). Cognition brain and consciousness, introduction to cognitive neuroscience. Oxford.

Bressler SL1, Menon V. (2010). Large-scale brain networks in cognition: emerging methods and principles. Trends Cogn Sci. Jun;14(6):277-290.

Contreras D., Steriade M. (1997). Synchronization of low-frequency rhythms in corticothalamic networks. Neuroscience. 76 (3): 11-24.

Ghajar J, Ivry RB. (2009). The predictive brain state: asynchrony in disorders of attention Neuroscientist. Jun;15(3):232-42.

Jausovec N, Habe K. (2003). The “Mozart effect”: an electroencephalographic analysis employing the methods of induced event-related desynchronization/synchronization and event-related coherence. Brain Topogr,16:73-84.

Jones EG. (1998). A new view of specific and nonspecific thalamocortical connections. Adv Neurol. 77:49–71.

Jones EG. The thalamic matrix and thalamocortical synchrony. Trends Neurosci. 2001;24:595–601.

Jones EG. (2003). Chemically defined parallel pathways in the monkey auditory system. Ann NY Acad Sci. 999:218–233.

Koelsch S. (2010). Towards a neural basis of music-evoked emotions. Trends in Cognitive Sciences. 14 (3 1): 131-137.

Konstantinov K.V. (2002). Samoregulyaciya psihofiziologicheskogo sostoyaniya cheloveka v usloviyah EEG-akusticheskoj obratnoj svyazi (Self-Regulation of the human psychophysiological state in terms of EEG-acoustic feedback): Dis. ... kand. Biol. sciences'. SPb, 121 p. (In Russ.)

Musacchia G, Large EW, Schroeder C.E. (2014). Thalamocortical mechanisms for integrating musical tone and rhythm. Hear Res. Feb;308:50-59.

Ngo H.V., Martinetz T.,2 Jan Born J., Molle M. (2013). Auditory Closed-Loop Stimulation of the Sleep Slow Oscillation Enhances Memory. Neuron. 78: 1-9.

Rauscher F.H., Shaw G.L., Ky K.N. (1993). Music and spatial task performance. Nature. V. 365 N 6447. P. 611.

Steriade M. (2000). Corticothalamic resonance, state of vigilance and mentation. Neuroscience. 101 (2): 243-276.