REGULARITY OF BRAIN BIOELECTRIC ACTIVITY REACTION AT HARMONIC SOUND INFLUENCE

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The unknown before common regularity of the human being brain reaction under the influence of harmonic sound signals of various frequencies has been found. The synchronization of bioelectrical brain activity occurs under the sound influence at the frequency equal to extreme maximum of the baseline EEG spectrum, and desynchronization of bioelectrical brain activity occurs under the sound influence at the frequency equal to the extreme minimum of the baseline EEG spectrum. Mentioned brain reactions occur in both multiple rise and multiple fall of sound frequency (if multiple ration is equal to 2^n).

Keywords: brain bioelectric, harmonic sound influence

Human's organism reacts to musical (harmonic) sounds differently. In the works [3] there is a description of method and program, titled as «Music of the Brain» suggested by Ya.I. Levin. The experience has been accumulated concerning insomnia, depression and inquietude treatment as well as increase of adaptation of healthy people to mental workload. However there is no information about the correlation of the particular biosignal spectrum frequencies and the harmonics frequencies activating the sounds.

R.A. Monroe's works are about biosignal resonance at the expense of beat frequency with the appropriate rhythmical delta, theta, alpha, beta ranges. However there is no information about the particular biosignal patient determination for binaural rhythm frequencies selection in order to provide for the appropriate biosignal reaction.

Objectives: to research the reaction of human being bioelectrical brain activity to harmonic sound of different frequencies, which depends on spectral composition of background EEG.

Materials and methods of research

The research included 86 humans (42 men and 53 women) at the age of 18-50 without serious somatic and mental pathology. Baseline EEG was registered (16 channels in accordance with the international standard) and baseline EEG spectral analysis was carried out with the help of the «Brainlog» software. Consequently the EEG spectrograms as a histogram for every deflection with the step 0,5 Hz have been fixed. Studying the baseline EEG spectrums histograms, the extreme harmonic frequencies were defined. Extreme maximum exceeded adjacent harmonics in amplitude and extreme minimum fell behind the adjacent harmonics in amplitude.

Then there was a harmonic sound influence, the frequency of which changed within the scope of the beginning intended frequency according to the linear law. Sound frequency variation was in different randes as with the frequency up and down. Thus the value of given frequency was defined by the period of the sounding, according to the formula

$$f_i = f_{\text{н}} \pm |f_{\text{к}} - f_{\text{н}}| t_i / t \qquad (1)$$

where $f_{\text{н}}$ – beginning frequency; $f_{\text{к}}$ –ending frequency; t – period of the sounding from $f_{\text{н}}$ to $f_{\text{к}}$ – frequency per a moment t_i

Simultaneously with the sound influence, the recording of bioelectric brain activity was made.

Analyzing the EEG the points in time of local synchronization and desynchronization of the biopotentials were recorded. For all the points in time of local synchronization and desynchronization according to (1) corresponding sound frequencies were defined.

Results of research and their discussion

Results of the research have shown that he synchronization of the bioelectric brain activity occurs under the sound influence with the frequency equal to the extreme maximum frequency of the baseline EEG and the desynchronization occurs under the sound influence with frequency equal to the extreme minimum of the baseline EEG.

The unknown before regular occurrence has been determined, it presupposes the regularity if the human being brain reaction at the harmonic sound influence and the matter is that during the harmonic sound signal influence with the frequency multiple of the extreme maximum frequency of that human being bioelectric signal spectral content obtained before the influence, and the synchronization of the bioelectrical brain activity occurs, and the multiplicity factor corresponds to the following formula $k = 2^n$.

Thus the frequency of harmonic sound influence, which stipulates the synchronization of bioelectrical activity, is calculated according to the formula:

$$F_{\text{s.s}} = f_{\text{e max}} k. \qquad (2)$$

When the harmonic sound signal influences the organism at the frequency multiple of extreme minimum of bioelectrical signal spectral composition of the human being, which is obtained before the influence, the desynchronization of bioelectrical brain activity occurs. And thereafter the frequency of harmonic sound influence, which stipulates the desynchronization of bioelectrical activity, is calculated acording to the formula [13, 14, 15]:

$$F_{\text{so.d}} = f_{\text{e min}} k. \qquad (3)$$

In the work, local synchronization and de-synchronization reaction could be both short-term (fractions of second) and long-term (up to several seconds). It corresponds with the Ye.D. Homskaya research [19]. Besides, it is more appropriate to judge about the synchronization and desynchronization (activation and deactivation) not only by its duration as by direction of bioelectrical activity variation in comparison with the initial level [1, 17]. Thus, desynchronization was understood as the replacement of slower, time-ordered wave activity by the faster, less periodic oscillations, significant amplitude drop; synchronization is an opposite phenomenon.

In the dynamic systems of brain structures that provide mental function, every phase is marked with a key section, by impacting on which the integral function can be changed, what is considered to be «rigid link» of bio-electrical brain activity [1, 2]. Found regularity of the human reaction at harmonic sound influ-ence provides the creation of the mechanism, which can rearrange bioelectrical brain activity for overcoming pathologically stable state.

Found regularity is characteristic for all 86 healthy humans, for all 16 deflections, but its higher expression is in the occipitle and upper temporal areas.

The table of results of one patient is given as an example. The values of sound frequencies, calculated according to the formula (2) for maximum and according to the formula (3) – or minimum extreme frequencies of EEG spectrum and corresponding to them sound frequencies, causing synchronization and desynchronization of bioelectrical brain activity. The table shows an evidence of the fact that the deflections of sound frequencies causing the synchronization and desynchronization of bioelectrical brain activity from the frequencies, calculated according to the extreme frequencies of the EEG spectrum, do not exceed 1%.

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Number seria-tim	$O_{1\,max}$			$O_{1\,min}$			$O_{2\,max}$			$O_{2\,min}$		
	1	2	3	4	5	6	7	8	9	10	11	12
	$f_{e\,max}\cdot2^n$	$f_{so.s}$	mis-take	$f_{e\,min}\cdot2^n$	$f_{so.d}$	mis-take	$f_{e\,max}\cdot2^n$	$f_{so.s}$	mistake	$f_{e\,min}\cdot2^n$	$f_{so.d}$	mistake
	Hz	Hz	%	Hz	Hz	%	Hz	Hz	%	Hz	Hz	%
1	896	896	0,0	912	915	0,4	896	902	0,7	880	880	0,0
2	960	960	0,0	928	937	1,0	944	944	0,0	912	915	0,4
3	1024	1034	1,0	960	968	0,8	1024	1034	1,0	960	968	0,8
4	1184	1184	0,0	976	986	1,0	1056	1056	0,0	992	992	0,0
5	1280	1280	0,0	1024	1024	0,0	1280	1280	0,0	1024	1024	0,0
6	1472	1465	0,5	1152	1162	0,8	1472	1461	0,8	1152	1152	0,0
7	1536	1544	0,5	1216	1216	0,0	1536	1536	0,0	1216	1216	0,0
8	1568	1562	0,4	1408	1408	0,0	1632	1632	0,0	1248	1248	0,0
9	1600	1600	0,0	1536	1536	0,0	1696	1696	0,0	1408	1408	0,0
10	1792	1792	0,0	1664	1664	0,0	1792	1792	0,0	1600	1593	0,5
11	1888	1888	0,0	1824	1824	0,0	1888	1888	0,0	1664	1664	0,0
12	1920	1923	0,1	1856	1856	0,0	2048	2042	0,3	1760	1764	0,3
13	2048	2048	0,0	1920	1910	0,5	2112	2116	0,2	1824	1835	0,6
14	2368	2368	0,0	1952	1958	0,3	2560	2560	0,0	1920	1910	0,5
15	2560	2560	0,0	2048	2048	0,0	2944	2944	0,0	1984	1980	0,2
16	2944	2944	0,0	2304	2310	0,3	3072	3072	0,0	2048	2048	0,0
17	3072	3072	0,0	2432	2438	0,2	3264	3264	0,0	2304	2301	0,1
18	3136	3159	0,7	2816	2816	0,0	3392	3397	0,1	2432	2442	0,4
19	3200	3200	0,0	3072	3076	0,1				2496	2504	0,3
20				3328	3322	0,2				2816	2816	0,0
21										3200	3194	0,2
22										3328	3328	0,0

Conclusions

1. Unknown before common reaction regularity of human brain under the influence of harmonic sound signals of different frequencies has been found. The frequencies values of harmonic sound influence, under which the synchronization and desynchronization of brain biopotentials occurs, have been determined by the initial EEG (before the sound influence) of every person as consistent with the extreme frequencies of spectral EEG content.

2. Synchronization of the bioelectrical brain activity occurs under the sound influence at the frequency equal to the extreme maximum of the baseline EEG spectrum, and desynchronization of bioelectrical brain activity occurs under the sound influence at the frequency equal to the extreme minimum of the baseline EEG spectrum.

3. Under the sound influence at the frequency exceeding maximal frequency of the EEG spectrum, synchronization of the bioelectrical brain activity occurs at multiple exceeding by the sound frequency of the extreme maximum frequency of the baseline EEG spectrum, and desynchronization occurs at multiple exceeding by the sound frequency of the extreme minimum frequency.

4. It has been determined that the exceeding multiplication factor by the sound frequency of the relevant extreme baseline EEG spectrum is equal to 2^n.

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