NEW BIOMEDICAL TECHNOLOGIES

Effect of Audiovisual Stimulation on Heart Rhythm Variability

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Presentation of visual and acoustic stimuli at a rate of 2-30 Hz modulated variability of the heart rhythm in volunteers. Potentation of vagal influences and a decrease in the contribution of ergotropic systems to the regulation of the heart rate were noted after 10 sessions of audiovisual stimulation. These changes were accompanied by a pronounced decrease of individual and reactive anxiety.

Key Words: *audiovisual stimulation; heart rate; spectral components of heart rate*

Audiovisual stimulation (AVS) is a rhythmical presentation of visual and acoustic impulses at a rate of 2-30 Hz. Clinical application of AVS is based on the concept on electrical activity of the brain [14]. There are at least 4 frequency ranges of brain electrical activity: α-rhythm (9-13 Hz) prevails during relaxation; β-rhythm (14-30 Hz) prevails during wakefulness, θ-rhythm (4-8 Hz) is typical for deep relaxation, and δ-rhythm (1-3 Hz) is a predominant rhythm during deep sleep [6,10]. The effect of some optical and acoustic frequencies is explained by entrainment of cerebral bioelectric oscillations with external rhythmic stimuli [2,7,11].

There is evidence on efficiency of AVS in the treatment of chronic headache, migraine attacks [4], and anxiety [8]. It was also reported that AVS increases minute ventilation [9] and decreases electrical resistance of the skin, heart rate, and α-activity [5]. The mechanisms and effects of AVS remain unclear, although there are hypotheses on the involvement of endogenous opioid peptides [7]. High efficiency of AVS in clinical tests explains importance of the study of its effects on autonomic nervous system. One of the most informative and simple methods to study this system is analysis of cardiac rhythms [1,13]. Our aim was to examine the effect of AVS sessions on heart rhythm variability.

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MATERIALS AND METHODS

Twenty healthy female volunteers (age 18-19 years) were subjected to 10 AVS sessions performed during 20 days in a Voyager XL apparatus (USA). The AVS relaxation programs started from the β-range (14-30 Hz), then the rate of stimulation decreased to α-range (9-13 Hz) and finally to θ-range (4-8 Hz). Before the end of the program, the rate of stimulation increased to slow β-range (12-14 Hz) in order to accelerate adaptation to normal activity after relaxation.

Cardiogram was recorded and individual anxiety was determined before AVS sessions and on the next day after the last session.

Four tests were performed, in which the cardiograms were recorded using a MKA-02 ECG-trigger (METEKC, Tomsk): the first ECG on minute 10 of clinostatism, the second and third ECG on minutes 5 and 10 of orthostatism, and the fourth ECG on minute 4 of adaptation clinostatism.

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Spectral analysis of the heart rhythm was carried out using fast Fourier transform algorithm and Hemming window in a 0-50 Hz frequency band (Statistica for Windows 5.0 software). The total spectral power (TSP) and the power of 3 components were calculated: high-frequency power (HFC, 0.15-0.5 Hz), middle-frequency power (MFC, 0.08-0.12 Hz), and low-frequency power (LFC, less than 0.05 Hz) [13]. Both the absolute and relative values of three power spectrum components were used. The character of parasympathetic and sympathetic interaction was assessed by the relative MFC/HFC ratio. The orthostatic and clinostatic responses were assessed by the percentage of changes in MFC, HFC, and MFC/HFC during ortho- and clinostatism. Numbers in brackets for example, MFC (1-3), denote the corresponding tests.

The level of individual anxiety, which is an individual feature reflecting enhanced anxiety in various situations, and the reactive anxiety, characterizing the present emotional state, were assessed with the Spielberg—Khanin self-evaluation scale [3].

The distributions of the data differed from the normal distribution, so the data are given as the mean values without errors. They were analyzed statistically using nonparametric Wilcoxon test for paired samples, nonparametric Mann—Whitney test for unpaired samples, and Spearman rank correlation coefficient.

RESULTS

There is evidence that HFC reflects vagal activity [1, 13], MFC is an indicator of sympathetic activity or, specifically, as a derivative of sympathetic and vagal baroreflex regulation [1,13], and LFC reflects the degree of activation of cerebral ergotropic systems [1].

The effect of synchronous light and acoustic impulses presented at rates corresponding to α-, θ-, and δ-rhythms of cerebral electrical activity induced structural changes in the heart rhythm (Table 1). It should be stressed that both paired and non-paired tests revealed significant differences in many parameters before and after AVS. The most pronounced changes were observed in HFC and LFC. The data obtained on minute 10 of the first clinostatism and on minute 4 of adaptation clinostatism revealed an increase and decrease in absolute HFC and LFC, respectively. At the same time, the relative values of HFC differed in the first, second, and third tests, while that of LFC differed in the first, third, and fourth tests.

AVS induced significant changes in MFC only in the second test. Assuming that the middle-frequency components of ECG depend on activity of both sympathetic and parasympathetic systems, the observed stability of MFC can be explained by opposite shifts in activity of these systems.

During clinostatism the character of sympathetic-parasympathetic relationships assessed by MFC/HFC ratio did not differ from the control, while the orthostatic tests revealed moderation of the prevailing sympathetic regulation characteristic of orthostatism.

It should be noted that AVS changed ECG parameters both in ortho- and clinostatism. Indeed, the degree of attenuation of relative HFC value decreased and the degree of increment of HFC increased after orthostatic load performed during adaptive clinostatism, which is explained by AVS-induced increase of HFC in orthostatism.

According to current views, the heart rate is closely related to psychic status of the organism [12]. AVS affects psychic parameters, which in turn can modulate the autonomic nervous control of physiological functions or induce changes in autonomic regulation [1,12]. Therefore, in order to study comprehensively the effect of AVS on the autonomic nervous system, we compared vegetative and psychic effects of AVS by measuring changes in spectral parameters

TABLE 1. Spectral Indices of Heart Rhythm, Individual and Reactive Anxiety before and after 10 AVS Sessions

Index		Before AVS	After AVS
HFC1	abs	3435.6	4986.8**
	% TSP	49.1	57.2^{***++}
HFC2	abs	515.3	732.8
	% TSP	21.5	24.2^{+++}
HFC3	abs	351.5	917.3*
	% TSP	14.4	26.3^{*+}
HFC		44161.5	5659.2***
HFC(1-3)		-69.5	-45.4^{**++}
HFC(3-4)		349.2	179.1^{*++}
MFC2,	% TSP	47.3	42.8^{**+++}
LFC1	abs	1467.1	904.9^{**++}
	% TSP	23.76	16.514^{*+}
LFC3	abs	1048.9	698.3**
	% TSP	42.756	35.632***
LFC4	abs	2466.6	737.5^{**+}
	% TSP	25.648	14.431^{*++}
TSP3,	abs	2219.9	2539.2***
TSP5,	abs	9440.3	8561.0
MFC/HFC2		4.3	2.5^{***+++}
MFC/HFC3		4.1	2.2^{**+}
MFC/HFC(3-4)		-76.0	-6.9***
Individual anxiety		46.2	41.6^{**++}
Reactive anxiety		43.6	35.8^{*+}

Note. Significant differences from baseline indices: $^{*}p<0.001$, $^{**}p<0.01$, $^{***}p<0.05$ (paired test), $^{+}p<0.001$, $^{++}p<0.01$, $^{+++}p<0.05$ (impaired test).

of the heart rhythm simultaneously with assessing individual and reactive anxiety. It was found that AVS decreased both the individual and reactive anxiety (Table 1). The correlation coefficients between the percent changes in the level of reactive anxiety and the percent changes in the absolute values of MFC3, LFC3, and relative value of HFC were 0.43, 0.41, and -0.27 (p=0.01, p=0.01, and p=0.04, respectively).

The correlation coefficient between changes in individual anxiety and the same parameters of the heart rhythm were 0.31, 0.38, and -0.39 (p=0.02, p=0.03, and p=0.03, respectively). The revealed correlation indicates that changes in some parameters of the heart rhythm occur in parallel with modulation of individual and reactive anxiety. Moderation of anxiety directly correlated with the decrease in MFC and HFC, and increase in HFC. These data agree with general views on interrelation between great psychoemotional stress on the one hand, and high activity of sympathetic and ergotropic systems, on the other [1,12]. Therefore, AVS induces parallel changes at the psychic and vegetative levels.

Thus, AVS increases vagal activity, which probably attests to enhancement of trophotropic influences and to decreased contribution of ergotropic mechanisms to the heart rhythm control. Probably, the observed changes in autonomic regulation of the heart rhythm reflect the general pattern of the changes induced by low-frequency AVS.

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