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Comparative study of light and music stimulation controlled by one's own or by others' biopotentials of the brain and heart

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A comparative analysis of the effects observed when subjects are presented with light and music influences controlled by their own biopotentials of the brain and heart or by biopotentials of another person, has been carried out.

The study involved 30 students aged 18 to 23 being under stress during the examination session. The volunteers were distributed into pairs for two series of experiments on two parallel experimental setups. In the first experiment, the light and music effects presented to both subjects of the pair were formed on the basis of the biopotentials of the brain (EEG) and the heart (ECG) of one of them, and in the second they were formed on the basis of the biopotentials of the other subject. In both experiments, the subjects were presented with light and music effects formed on the basis of the biopotentials of the brain and heart of one of them for 10 minutes via a device to which the glasses and headphones of both subjects were connected. The current amplitude of the EEG oscillator detected in the subject was converted into music-like signals resembling the sounds of a flute in timbre and smoothly varying in pitch (range 100–2000 Hz) and intensity (range 0–40 dB) in direct proportion to the current amplitude of the EEG oscillator. These EEG-based stimuli were supplemented with weak (10 dB) audio signals corresponding to the subject's current heartbeat rhythm. Simultaneously, LED exposures were carried out in strict accordance with the current values of the subject's native EEG.

With both types of exposure, there was a reduction in the body regulatory systems tension and in the level of stress. Only with light and music stimulation controlled by the subjects' own biopotentials of the brain and heart, a significant increase in the power of the main EEG rhythms was observed.

The data obtained can be used to develop effective methods of personalized light and music influences aimed at the timely elimination of functional disorders and the return of a person to an optimal state.

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Unique cardiac rhythm abnormalities in COVID-19 patients

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Within the study, the functional state of patients diagnosed with COVID-19 was monitored using the technology of event-related heart rate telemetry [1], based on automatic registration and express analysis of RR interval variability (HRV) via the ZephyrSmart sensor platform. In 86% of rhythmogram records (128 measurements) of patients in the red zone of a COVID hospital, the same type of low-amplitude fluctuations of RR intervals of an unusual shape was detected. The specific spike pattern (further named cardiospike) is distinguished by two jumps from the average value successive by RR number: a longer RR is followed by a shorter one with further slight relaxation. This form of COVID -cardiospike is a mirror image of the S-shaped rhythmogram pattern typical for extrasystoles. In our database of rhythmograms for 2015-2018 containing more than 15,000 measurements, cardio spikes are present in only 3% of records. This suggests that cardiospikes can be considered as markers of COVID-specific modes of regulatory systems operation.

However, a comparative analysis of cardiac rhythmograms obtained using various algorithms showed that only some methods of heart signal processing make it possible to identify the cardiospikes unique to COVID-19. To verify the algorithms, a native electrocardiogram (ECG) was recorded simultaneously to the processing of HRV records, using a standard medical complex POLY-SPECTRUM (Neurosoft, Russia). The following algorithms for detecting R peaks in the original ECG signal were tested: Pan-Tompkins, Hamilton, and Two-Moving-Average. It was found that when the Two-Average algorithm ensuring signal normalization and reduction of deviations from the mean is used to calculate rhythmograms from ECG, the cardiospikes unique to COVID-19 are not detected. But if the Pan-Tomkins and Hamilton algorithms are used to calculate rhythmograms from the same ECG, then patterns of RR intervals similar to the cardiospikes of rhythmograms from the ZephyrSmart platform used traditionally appear in the rhythmogram.

The data obtained indicate that cardiospikes are not the result of hardware-software signal distortions, but are of endogenous nature and can be considered unique markers of COVID-specific modes of heart rhythm regulation.

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Effects of artifact-reduction methods on the required EEG data length for evaluating mental workload with an auditory probe ERP technique

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Introduction: Event-related potentials (ERPs) elicited by auditory stimuli unrelated to a current visual-cognitive task (i.e., task-irrelevant auditory probes) can be used to evaluate the level of mental workload; the size of auditory N1 and P2 elicited by auditory probes can decrease when participants engage in a task with higher mental workload. In the present study, towards the evaluation of mental workload in the shorter time, we examined the effects of artifact reduction methods on the minimum data length required for observing significant N1 and P2 differences.

Methods: We re-analyzed our previous data (Sugimoto, Kimura, & Takeda, 2022, Int. J. Psychophysiol.). While participants ($N = 26$) were performing a driving game at slow and fast speeds (i.e., imposing low and high workload, respectively), task-irrelevant auditory probes were presented. EEG during the driving game was bandpass-filtered offline at 0.1–30 Hz. To remove eye-related and muscle-related artifacts, we performed a widely used artifact decomposition/identification method [(1) independent component analysis (ICA, Delorme & Makeig, 2004) with visual inspection] and recently developed five methods [(2) wavelet ICA with statistical algorithm using modified multiscale sample entropy and kurtosis (Mahajan & Morshed, 2015, IEEE J. Biomed. Health Inform.), (3) wavelet ICA and ICLabel (Pion-Tonachini, Kreutz-Delgado, & Makeig,