# Emotional and autonomic responses to IAPS-based stimulation: Effects of 1/f music and white noise on electrodermal and cardiorespiratory variables during the post-stress recovery

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# 국제정서사진체계(IAPS)를 이용한 정서 및 자율신경계 반응연구: 1/f 음악 및 white noise가 스트레스 회복단계에서의 피부전기반응 및 심박호흡계 반응에 미치는 영향

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## Abstract

The special interest should be paid to the analysis of the influences of positive emotions in terms of their possible effects on the dynamics of autonomic recovery after the negative affective stimulation. Taking into account emotion-specific autonomic response patterning and dissociation of parameters of autonomic arousal during experience of both positive and negative emotional states, this problem seems a challenging one. In present study several autonomic parameters were analyzed altogether, namely indices of electrodermal activity, heart rate and respiration rate during consecutive combination of both IAPS-based visual affective and auditory stimulation. The aim of the study was analysis of patterns of electrodermal and cardiorespiratory responses during emotional states evoked by negative affective visual stimulation followed by positive or neutral auditory one with intention to identify if the latter is able to facilitate post-stress recovery and enhance restoration of pre-arousal levels. The main orientation was directed towards the further application of experimentally induced comfort emotions for dampening the negative consequences of exposure to stressful stimuli.

## Introduction

There are available no much data related to the processes of the recovery of autonomic parameters after emotional stressors. The special interest might have the analysis of the influences of positive emotions in term of their possible effects on the dynamic of recovery after the affective stimulation of negative valence. The same time, taking into account emotion-specific autonomic response patterning and dissociation of parameters of autonomic arousal during experience of both positive and negative emotional states, this problem still remains a challenging one.

Another important issue is an identification of the physiological variables definitely associated with certain emotional states and applicable for stress research. One more intriguing topic is the design of the experimental procedure where different specific emotions could be evoked by any sensory stimulation and relevant psychophysiological shifts be detected, reproduced and then used for various applications.

In our previous studies it was demonstrated that auditory stimulation (sounds and 1/f music) is capable to elicit emotional states subjectively evaluated as pleasant or unpleasant [3,6,9,10,11]. Data showed that shifts in emotions were accompanied by significant changes in EEG, namely in alpha and beta bands, as well as by frontal asymmetry parameters and by shifts in electrodermal indices [6,11]. In another set of experiments we applied International Affective Picture System (IAPS) [4] to study physiological changes associated with discrete emotions evoked by IAPS based visual stimulation. There were found significant differences in changes of EEG bands, most prominent in theta, between positive and negative emotions, and also among negative emotions [9].

In present study were analyzed altogether several autonomic parameters, namely electrodermal activity (EDA), heart rate and respiration rate using consecutive combination of both IAPS-based visual affective and auditory stimulation. Selection of physiological parameters was partially determined by the task. Cardiovascular and respiratory variables are essential in any kind of emotional research [2,7], while EDA is one of the most sensitive from available techniques in research oriented to search of emotion specific physiological patterns[1,5,8,12]. EDA was proven to be an indicator of anxiety states, to correlate with subjective measures of emotion strength, to differentiate among experimentally induced emotion conditions [1,2,5,10,12].

The aim of the study was analysis of patterns of EEG, EDA and cardiorespiratory responses during emotional states evoked by negative affective visual stimulation followed by positive auditory one with intention to identify if the latter is able to facilitate post-stress recovery and enhance restoration of pre-arousal levels as it was suggested by [2]. The main orientation was directed towards the further application of experimentally induced comfort emotions for dampening the negative consequences of exposure to stressful stimuli.

## Methods

The current study was carried on 30 female students college. Mean age of the subjects was 20.2 years. Each subject was randomly asigned to one of 3 groups (N=10) in dependence on what kind of auditory stimulation they had to get. One group was in "no sound" control condition and thus was not exposed to any audio stimuli. Grass Neuroacquisition and BIOPAC MP100 hardware with AcqKnowledge III (v. 3.2) software were used for EDA, ECG, pneumogram and EEG (F3, F4, T3, T4, O1, O2) recording. Details of EEG recording and data processing as well as relevant results of EEG analysis are described elsewhere [6,11]. Each subject passed psychometric testing with State-Trait Anxiety Questionnaire and Jenkins Activity Survey.

Experimental procedure consisted of baseline recording (both with closed and opened eyes ) and presentation of 6 slides with negative affective valence (Nos. 3130, 3170, 3051, 3071, 1300) from the International Affective Picture System (IAPS) [4]. Visual stimulation (60 sec) was used to evoke negative emotional state (surprise, disgust or fear). After the cessation of the session with IAPS-based stress subjects were exposed to auditory stimulation (60 sec) in the form of 1/f music (Mind Relaxation Music, namely "Spring Song" by Victor Musical Industries) or white noise (20 Hz - 20 kHz, 35 dB). Post-stress recovery was recorded for each person during 4 consecutive minutes both with closed and opened eyes.

In each 60 sec long session magnitude, latency, rise and half-recovery time of skin conductance response (SCR), as well as basal skin conductance level (SCL) and trend of SCL drift were calculated, since some of the subjects happened to be electrodermal non-responders (N=8). In each condition there were calculated also heart rate (HR) and respiration rate (RSR) on per minute basis. EEG and psychometric data of this experiment were already reported [11].

## Results

Experimental data on autonomic changes in above described design might be described as follows:

IAPS-based visual stimulation evokes significant increase in respiration rate (RSR), moderate increase of heart rate(HR) and tonic increase of basal skin conductance level (SCL) and its drift. Skin conductance response (SCR) is profound and reproducible both in amplitude and duration.

During the exposure to auditory stimulation ("1/f music" or "white noise") in the process of recovery in post-stress period RSR continue to rise in "1/f music" and then slightly decrease in post-stimulation period, while during "white noise" condition it decreases during the auditory stimulation and is followed by significant decrement in post-stress period expressing typical rebound effect exceeding initial in baseline values changes resulted from IAPS stress. Effects of "no sound" control conditions on RSR are the same as those induced by "white noise" but of less values (Fig.1 ).

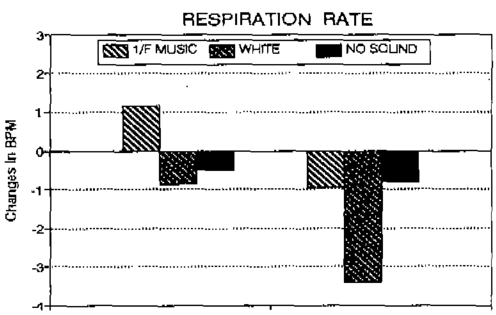


Fig. 1. Changes of the respiration rate in groups of subjects (N=10 in each group) exposed to 1/f music, white noise and "no sound"(control) conditions during the recovery from IAPS-based stress. Changes are expressed in breath rate per minute as compared to IAPS session level. Left part of the figure shows the super-imposition of relevant auditory stimulation on post-stress recovery process, while right part shows recovery from both visual (IAPS) and auditory stimulation conditions. Mean increase during IAPS stress to initial pre-stress baseline was 2.58 bpm.

Heart rate changes during super-imposure to auditory stimulation in post IAPS stress recovery period is similar in all 3 groups but have different magnitudes, namely "1/f music" group is featured by more deceleration during exposure to music as compared to post-stimulation period, while "white noise" group exhibited more significant HR decrease in post-stimulation period as well as control "no sound" group (Fig 2.)

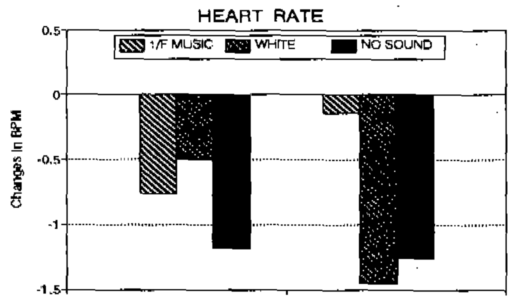


Fig. 2. Changes of heart rate in the same groups as compared to IAPS level during the process of post-stress recovery. Heart rate was increased by 1.1 bpm during IAPS session as compared to initial baseline. Composition is the same as in Fig.1., namely, left part is the auditory stimulation super-imposed on post IAPS stress recovery, while right side shows condition after cessation of stimulation.

Skin conductance level during the exposure to "1/f music" condition lowered unsignificantly but was followed by statistically valid decrease in post-stress period as compared to control. As for "white noise" condition, it have to be emphasized that it was significantly increased during the auditory stimulation and showed no decrement even in post-stimulation period, staying at higher level until the end of experiment (Fig 3.).

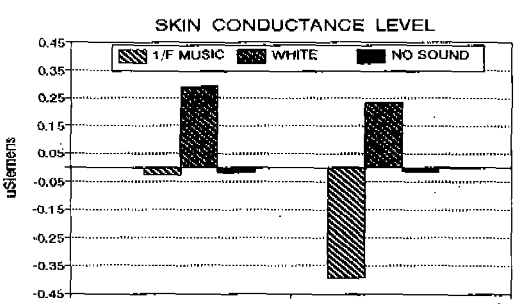


Fig. 3. Changes in basal Skin Conductance level (in $\mu$Siemens) during the post-stress recovery in the same groups. Mean shift of basal SCL during IASP stimulation was −0.167 $\mu$Siemens vs. baseline. See Fig. 1 and 2 for comments regarding composition.

Comparison of the electrodermal responses in different stimulation conditions (IAPS, "1/f music, "white noise") revealed that "white noise" was able to elicit largest magnitude of response (mostly in a form of single short-term high amplitude SCR), while IAPS-based SCR was appearing in a form of 6 superimposed peaks with mean magnitude higher than SCR during "1/f music" stimulation (Fig. 4). It must be mentioned that there were scored only the SCRs with amplitude exceeding 0.02 $\mu$Siemens and since reactions of 8 subjects did not qualified to this criteria their data were not included in comparative analysis presented in Fig. 4.

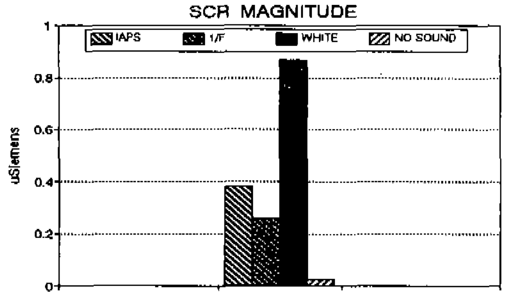


Figure 4. Skin Conductance Response (SCR) magnitude during IAPS stress, 1/f music, white noise and "no sound" conditions. Presented are mean values of SCR magnitude (in $\mu$Siemens) during 1 min long exposures to stimuli.

## Discussion

Obtained results demonstrated that monitored autonomic and cortical [11] indices are sensitive to identify physiological changes during negative emotional states elicited by unpleasant visual stimulation based on the International Affective Picture System [4,9] and arousing but effects of positive (1/f music) and emotionally neutral (white noise) auditory stimulation superimposed during post-stress recovery period. The results are in agreement with previous EEG data [9,11] and suggest that IAPS could be a useful tool for study of emotions and their physiological manifestations. Taken altogether with cortical and other autonomic indices, EDA parameters might be rather effective for both differentiation of specific experimentally induced emotions and following up the dynamics of the recovery process during post-stress period. In IAPS-based stress conditions SCR shows significant differences in amplitude, magnitude and amplitude rise time in negative vs. positive emotions, being significantly higher during aversive, unpleasant stimulation [1,10]. Meanwhile, response onset latency and half-recovery time of SCR do not show statistically valid differences in above experimental conditions [10], however, application of parameters of tonic SCL (basal SCL and drift of SCL) is quite reasonable but less sensitive in this term. There have to be specially noted that SCL in "white noise" condition was high and did not expressed decrease to baseline levels even in post-stimulation period showing significant differences both with "1/f music" groups. It was important that "1/f music" group's recovery was processed much more dynamically and led to significant reduction of basal skin conductivity and thus resulted in lower tonic arousal level. SCL in control group has the same tendency as "1/f music" group but with less values of parameters reflecting recovery.

Analysis of HR and respiration pattern shift during process of recovery from IAPS evoked negative emotional states on the background of positive emotions also revealed significant changes. The pattern be described as follows: the significant increase of respiration rate during stress is featuring further temporal increase in "1/f music" conditions followed by decrease in post stimulation period, while during "white noise" conditions RSR decreases immediately with the signs of profound rebound effect, the tendency similar to control "no sound" condition. The latter is characterized by less profound values comparable with post-music respiration rate. The heart rate dynamics has somewhat different pattern, namely in "1/f music" condition it shows significant decrease of HR followed with mild post-stress restoration, while in "white noise" condition initial moderate decrease is followed by further dramatic decrease excessing even control group values. However, the interpretation of HR decrease in above conditions should be carried out with caution since several different mechanisms might be involved, namely, orienting reflex evoked in "white noise " stimulation, as well as enhancement of "sensory intake" processes during the exposure to "1/f music" might be the case.

Further studies with simultaneous recording of cortical, cardiovascular, respiratory and somatic parameters are planned to extend dimensions of interpretation of physiological patterns associated with emotional responses elicited by sensory stimulation and their possible interactions. Special attention should be given in this regard to the comfort emotional states and their positive influences on enhancement of the restoration of the pre-stress activity levels of monitored physiological parameters.

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