Physiological Differentiation of Emotional States Induced by Pictorial Stimuli of Positive And Negative Valence in Passive Viewing Mode

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시각 자극에 의하여 유발된 긍/부정 정서의 뇌파 및 자율신경계 반응의 차이

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Abstract

Autonomic and EEG responses of 38 college students were studied during 60-sec long presentation of International Affective Picture System (IAPS)slides evoking, according to subjective reports, negative (disgust, sadness, surprise) and positive (happiness, exciting) emotional states. Observed were significant heart rate (HR) deceleration, large skin conductance responses (SCR), moderate respiration frequency slowing, reduction of frontal (F 3, F 4) and occipital (O 1, O 2) fast alpha, and increases of theta, delta and beta relative spectral power values during the first 30 sec of exposure of IAPS pictures. Analysis carried out to differentiate emotion categories according to autonomic responses indicated that observed HR deceleration was larger in magnitude in surprise and sadness than in disgust, SCR amplitude higher in sadness than in disgust. EEG showed significant differences in theta (F 3, F 4) and delta (O 1) power increase in disgust vs. happiness, fast alpha (F 3, F 4) power was lower in surprise than in happiness, and slow beta power higher in happiness than in disgust (O 1). Despite some differences observed within discrete emotion conditions, overall responses pattern of monitored parameters exhibited similar profiles with few variations, most obvious in disgust state, which suggests that affective visual stimulation elicits stereotypical responses in a given passive viewing paradigm. However, the magnitude of physiological responses may vary to certain extent across discrete emotional states making it possible to differentiate among particular experimentally-induced emotional states, e.g., disgust vs. sadness by ANS responses or disgust vs. happiness by EEG measures.
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Introduction

The emotion-specificity of autonomic and cortical responses was always in the focus of psychophysiology, since ANS- and CNS-mediated physiological responses are intimately tied to emotions. However, the ability to differentiate among emotional states by their physiological manifestation still remains controversial [3,11]

Among the most affect-reactive physiological variables certain advantage should be given to simultaneous application of frontal EEG, electrodermal, cardiac and respiratory variables and their patterns in attempt to distinguish basic emotions [2, 4, 5, 8,9, 10].

Skin conductance response (SCR), one of the main electrodermal activity parameter, reflects specifically the arousal or activation aspects of emotion, while it is less sensitive to the valence [6] . The effects of emotionally charged stimuli on phasic and tonic components of electrodermal activity says for importance and usefulness of SCR implications in emotion research [3, 5].

Heart rate (HR) responses in emotions are more complex:

- facial expression, imagery, affective situation manipulation studies and some traumatic visual stimulation have shown acceleration of HR [1,5, 8,9,10];
- in passive viewing of affective pictures HR response showed phasic deceleration, greater for unpleasant pictures and least for pleasant pictures, i.e., varied with valence dimension [6].

Respiration has been shown to differentiate between emotions to certain extent and also modulate HR by well-known cardio-respiratory coupling mechanisms [2].

EEG activity recorded from anterior (frontal) regions of scalps was reported as sensitive to emotion-evoking manipulations and some parameters such as alpha asymmetry may differentiate emotional states [4]. Other EEG parameters are also reactive to emotional states [3].

The aim of the study was to test assumption that autonomic and EEG responses are specific during affective visual stimulation and assess capability of recorded ANS and CNS parameters or their patterns to distinguish discrete emotions in passive viewing paradigm.

Methods

Experimental procedure consisted in adaptation (10 min), baseline measurements (30 s), 10 trials with slides (60 s) for 5 emotions (selected from the International Affective Picture System/IAPS/) with 30 s inter-trial interval. The IAPS [7] pictures in 2 sessions were evoking according to subjective reports happiness #2340, #2040, sadness #2800, #3350 , disgust #3140, #3071 ,surprise #3170, #3051, exciting state # 4460, #4232. In-depth analysis was carried out for first 30 s of exposure of single picture (with highest subjective rating) from pairs selected for each emotion (##2340, 3140, 3350, 3170 4232).

Subjects participated in the study were 36 college students (20-26 years; men, N=16; women, N= 20).

Equipment used in the experiment were Grass Neurodata, Acquisition system and BIOPAC MP100WS with AcqKnowledge III software.

Following physiological signals were recorded: EEG (O1,O2, F3,F4, monopolar), electrocardiogram, pneumogram, electrodermal activity (Ag/AgCl electrodes, Unibase isotonic gel, constant voltage 0.5 V to measure skin conductance)

ANS variables calculated for each condition were Heart rate (HR), Respiration rate (RSR), Skin conductance response (SCR) amplitude, while EEG variables were FFT relative power (in percents) for delta, theta, slow & fast alpha, slow &fast beta bands

Results and discussion

Affective stimulation in passive viewing mode evoked typical response pattern featured by HR deceleration, SCR, slight decrease of respiration rate, reduction of frontal and occipital alpha, increase of delta, theta and beta power. However, discrete emotions (sadness, disgust, happiness, surprise and excitation) exhibited certain differences in the magnitude of autonomic responses and in significance of changes vs. baselines (Figures 1-8).

HR deceleration was larger in magnitude in surprise and sadness than in disgust (Fig. 3), SCR amplitude higher in exciting than in disgust (Fig. 4). Disgust prompted least decreased HR, moderate and short-term amplitude increase of SCR, while sadness profile showed relatively more HR deceleration, more persistent and higher SCR. Highest amplitude of SCR was recorded in exciting stimulation with nude pictures (Fig.4). Respiration rate decrease happened to be valid only in surprise and sadness (Fig.2).

SCR responses among positive emotions were not uniform: SCR magnitude was greater for exciting than happiness evoking pictures (Fig. 4). Negative emotion profiles showed most significant differences in disgust-sad and disgust-surprise pairs (Fig. 3, 4).

Cortical effects were expressed in reduction of frontal and occipital fast alpha, and increase of theta, delta and beta relative power during first 30 s of affective visual stimulation (Fig. 5-8) . EEG showed significant differences in frontal theta and occipital delta increase in disgust vs. happiness, fast alpha (F3,F4) power was lower in surprise than in happiness(Fig. 6), and slow beta power higher in happiness than in disgust (Fig 7).

Observed changes are not sufficient to prove ability of selected ANS & CNS parameters differentiate emotional states, but support assumption that affective visual stimulation evokes specific response pattern expressed in HR deceleration, respiration slowing, SCR and reduction of frontal and occipital fast alpha, increase of theta, delta and beta power spectra values in given experimental situation.

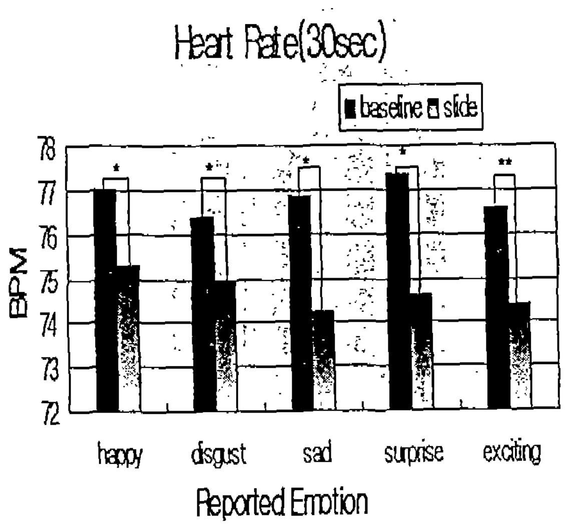


Figure 1. Mean heart rate in baseline resting state and during presentation of IAPS slides for 5 reported emotion (N=35). (* $p<0.05$, ** $p<0.01$)

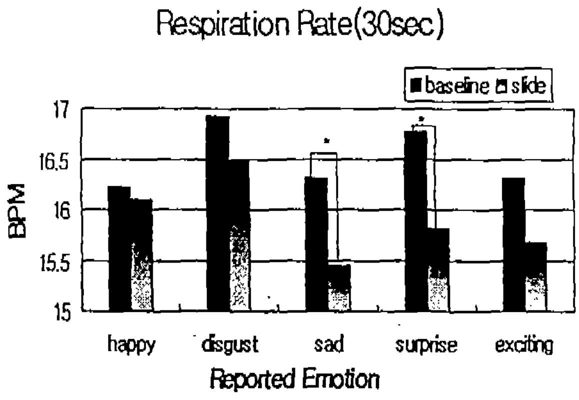
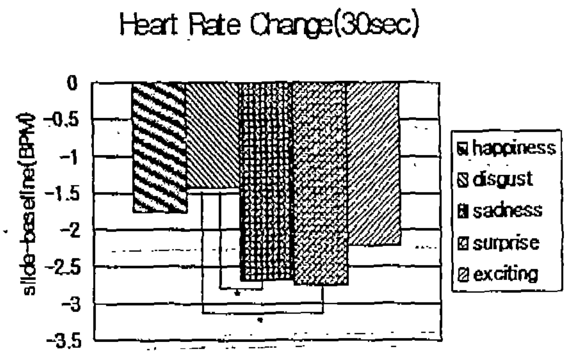


Figure 2. Mean respiration rate in baseline condition and during presentation of IAPS slides evoking 5 different emotions (N=35). (* $p<0.05$)

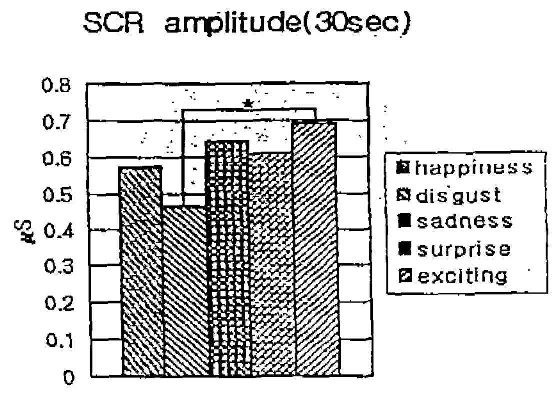
Figure 3. Heart rate changes in beats per minute



(bpm) calculated as mean changes compared to relevant resting baselines.

(* $p<0.01$)

Figure 4. Comparison of SCR amplitude mean values



for 30 s of IAPS based stimulation. Only exciting-disgust pair shows significance of differences. (* $p<0.01$)

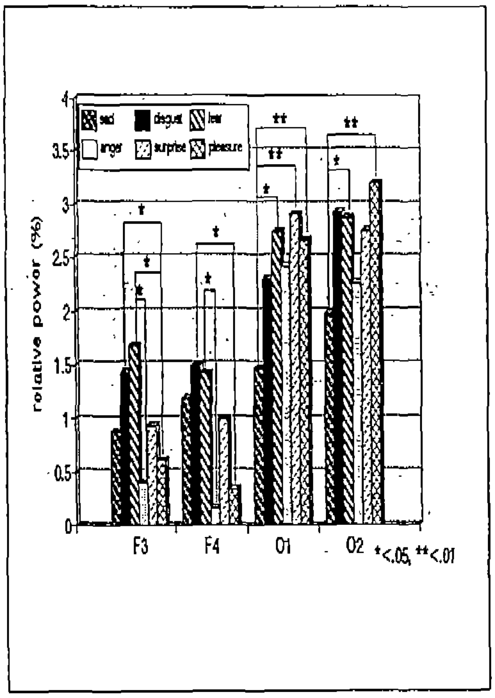


Figure 5. Changes in theta relative power values associated with IAPS picture induced emotions

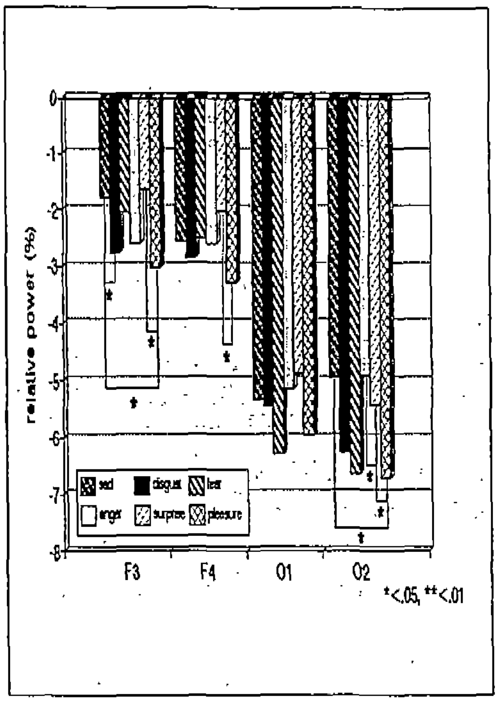


Figure 6. Changes in fast alpha relative power values associated with IAPS picture induced emotions

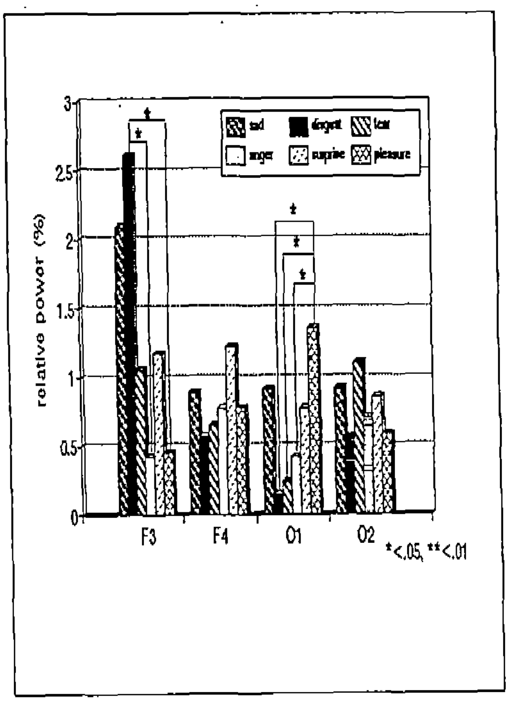


Figure 7. Changes in slow beta relative power values associated with IAPS picture induced emotions

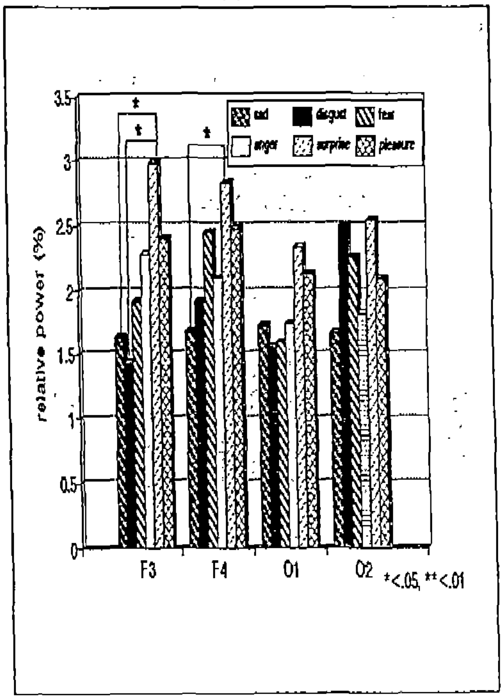


Figure 8. Changes in fast best relative power values associated with IAPS picture induced emotions

Conclusions

Affective visual stimulation exhibited few differences of the magnitude of physiological responses: HR decrease was larger in surprise and sadness than in disgust, SCR amplitude higher in sadness than in disgust, frontal fast alpha was lower in surprise than in happiness, slow beta higher in happiness than in disgust, difference in increase of frontal theta and occipital delta in disgust vs. happiness. However, obtained pattern was an uniform one and was featured by transient HR deceleration, moderate respiration slowing, SCR, reduction of alpha and increase of delta, theta and beta relative spectral power values.

Despite some differences observed within discrete emotion conditions, the overall responses pattern of monitored parameters exhibited similar profiles with few variations, most obvious in disgust state, which suggests that affective visual stimulation elicits stereotypical responses in a given passive viewing paradigm. Nevertheless, magnitude of physiological responses vary to certain extent across discrete emotional states making it possible to differentiate among particular experimentally-induced emotional states, e.g. disgust vs. sadness by ANS responses, or disgust vs. happiness by EEG measures.

Further studies with more variable situational context would be rather feasible to demonstrate reproducibility of emotion-specific autonomic and cortical response profiles and their ability to differentiate among basic emotions.

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