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Physiological Parameters Useful to Interface with Computers to Respond to Two Dimensional Emotions

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Abstract

Computers may be designed to regularly observe one's emotion and respond intelligently to his/ her negative emotion such as stress, fatigue, boredom, and etc. This certainly requires quantification of human emotion and this study aims to find out the parameters that may be useful to differentiate one's emotion. In this study, human emotion was artificially induced by having 26 undergraduate students exposed to four different types of emotion-evoking sounds and smells. Then the participants were asked to rate subjectively their emotion that was later categorized into one of the four quadrants made up by pleasantness vs. unpleasantness and arousal vs. relaxation. Physiological changes in EEG (F3, F4, P3, and P4), EDA, ECG and skin temperature were recorded and analyzed to differentiate among two dimensional emotions. As a result, a number of physiological measures were found in this study to successfully classify two dimensional emotions.

Category: Technical

Keywords: : emotion computer, emotion, computer, physiological parameters, EEG, GSR, SKT, HRV

Introduction

Although human emotion certainly plays a key role in one's daily life, little attention has been paid to designing computers that may understand and respond to one's emotion. It is often the case that we take into account one's facial expression, eye movement, skin color and etc while conversing with others in order to respond better to the changes in their emotion (Carlson, 1994).

This study aims to find out some parameters that may be useful to differentiate various human emotions. They may then be used as indicators of human emotion to facilitate duplex mode of communication between users and computers. While there has been some research that human emotion may well be measured either quantitatively or qualitatively, empirical evidence is less consistent to support the link between two methods of emotion quantification (Boucsein, 1992; Collet, et al., 1999; Harmony, et al., 1996; Lang, et al., 1993; Sutton, et al., 1997). We employed a number of physiological measures (e.g., EEG, ECG, GSR, skin temperature) and investigated their robustness in relation to subjectively reported human emotion.

Larson and Diener (1992) argued that there are two distinct levels of human emotion – valence and arousal. These two constructs can be mixed together to show eight different states of human emotion as shown in Figure 1. It is argued in this study that human may show different physiological responses in relation to the four quadrants made up by pleasantness vs. unpleasantness (valence axis) and arousal vs. relaxation (arousal axis).

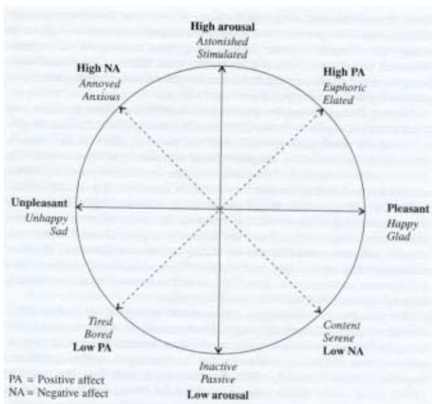

Figure 1. Two dimensional Emotion(from Larson and Diener, 1992)

Method

Subjects

26 undergraduates aged 21 on average participated in this study. They did not report any medical problems in hearing and sensing required to complete the experiment

of this study. They were also provided monetary incentives.

Stimulus for emotion induction

Stimuli to evoke two dimensional emotion in this study were of olfactory and auditory compound. Initially, we pre-tested 12 stimuli (half olfactory & half auditory stimuli) that appears to induce the emotion of this study. Each stimulus was presented to the participant for 60 seconds. In order to minimize the lasting effect of the stimuli, the participants were asked to take a rest of 30 seconds after the exposure to emotional stimuli. Then the participants were asked to rate their subjective emotion on an 11 point Likert scale (-5 to +5). Some of the stimuli used in the pre-test that showed high correlations with the two-dimensional emotion were selected to be used in the main experiment. They were (1) pendi and (2) etanol for olfactory stimuli and (3) siren and (4) Korean popular song for auditory stimuli.

Experiment

The evaluation of emotional stimuli was performed in the main experiment as was done in the earlier pre-test. The participants were presented with four compound stimuli and were subsequently asked to rate the level of their subjective emotion on an 11-point Likert scale. New stimuli were introduced only after the 60-second rest, twice the time allowed in the pre-test. We also recorded physiological response such as EEG (Electroencephalogram), ECG (Electrocardiogram), GSR (Galvanic skin response) and SKT (Skin temperature). EEG was recorded at F3, F4, T3 and T4 according to the 10-20 systems. All signals were sampled at 512 Hz/sec Biopac Tel 100(USA) was employed for any physiological measuring.

Data Analysis

All the signals were analyzed to obtain the parameters that would possibly discriminate between two-dimensional emotions as shown in Table 1.

Table1: Physiological-parameters analyzed in this study

Signal	Parameters
EEG	Delta, Theta, Alpha, Beta Power Spectra
ECG	LF, MF, HF of Heart Rate Variability
GSR	Latency, Peak time, Peak amplitude, Peak area, Half recovery
SKT	Mean

EEG was filtered at 35 Hz and analyzed by FFT (Fast Fourier Transform) to get delta (1-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), and beta (13-30 Hz) waves. We analyzed ECG and its time variation to produce R-R intervals. HRV (Heart Rate Variability) was analyzed by FFT to get power spectra for low frequency (LF: 0.01-0.09Hz), medium frequency (MF: 0.09-0.15Hz), and high frequency (HF: 0.15-0.5Hz). The peak of GSR was detected after stimulus to get latency, peak time, peak amplitude, peak area, and half recovery. Skin temperature was averaged for the duration of stimulus presentation. All the parameters were normalized to overcome scaling problems (i.e., to see the degree of deviation of he 'stimulus state' from the 'rest state'). Normalization was performed with the formula of (stimulus state – rest state) / rest state. Based on the subjective ratings of the participants, all the parameters were classified into one of the four quadrants made up by pleasantness vs. unpleasantness and arousal vs. relaxation. The parameters ranked -1,0, and +1 were removed from further analysis since those subjective ranks were assumed to be neutral state of emotion. Paired t-tests were performed with SPSS for Windows 9.0.

Results

The results of t-tests revealed a number of physiological parameters that could differentiate significantly ($p<0.05$) between two-dimensional emotions as shown in Table 2.

Table 2: Significant physiological-parameters to differentiate between emotions

	Pleasantness-arousal	Pleasantness-relaxation	Unpleasantness-arousal
Pleasantness-relaxation	F3 EEG beta, P3 EEG theta, p4 EEG beta F4 EEG theta, F4 EEG beta, peak time of, half recovery time of GSR, hf of, mf of, lf/hf of HRV		
Unpleasantness-arousal	F3 EEG beta, peak time of, half recovery time of, peak area of GSR, hf of, mf of, lf/hf of HRV	hf of, mf of HRV	

Unpleasantness-relaxation	P3 theta, alpha, beta of, F4 beta of EEG, mf of HRV, latency of, peak time of GSR, lf of HRV	P3 EEG alpha, P3 EEG theta, latency of, half recovery time of, peak area of GSR, lf of, mf of HRV	F3 EEG beta, P3 EEG beta, latency of, amplitude of, half recovery time of, peak area of GSR, lf of, mf of HRV

As shown in Table 2, six pair comparisons were performed for both the emotions that existed on a single dimension (i.e., pleasantness vs. unpleasantness & relaxation vs. arousal) and the emotions that ran across the states (e.g., pleasantness-arousal vs. unpleasantness-relaxation). We found a number of parameters that may be useful to discriminate different states of human emotion. It should be, however, noted that many of these parameters were found to be significant only with two dimensional emotion. Thus, the parameters that appeared to significantly discriminate two completely different emotions such as pleasantness-arousal vs. unpleasantness-relaxation were obtained from EEG, GSR, and ECG while the ones discriminating unpleasantness-arousal vs. pleasantness-relaxation were only from ECG.

Conclusion and Discussion

The main conclusion of this study is that we found a number of physiological parameters that may significantly differentiate four different types of human emotions. It should also be noted that any one of parameters should not be used as a dominant indicator of all types of human emotions. Also, some of the parameters were revealed its significant role as we employed two dimensional emotions. For example, arousal may relate to different physiological recordings with another dimension of human emotion - pleasantness vs. unpleasantness. It suggests that two dimensional-emotions be employed in further study. Lastly, there were two opposite emotions in this study and HRV was found to significantly differentiate one of the two opposite emotions - pleasantness-relaxation vs. unpleasantness-arousal. Note that EEG did not play a significant role here, not so much as it did for differentiating other types of human emotions. On the other hand, the other opposite emotion, unpleasantness-relaxation vs. pleasantness-arousal, could be classified by parameters of both EEG and autonomic nervous system (GSR, ECG). This suggests that parameters from autonomic nervous system may be employed to differentiate some opposite types of human emotions.

In summary, this study found a number of physiological parameters in relation to human emotion. They may be used in designing a computer that understands human emotion and respond to it better. Further study is prompted to replicate the results of this study. It is also questioned the way individual differences affect physiological changes upon different human emotions.

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