EMOTIONAL STIMULATION

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Abstract: This paper includes description and evaluation of measurements carried out to obtain changes in basic biological signal (Photoplethysmography) caused by emotional stimuli. Stimuli were emotionally colored images and pictograms presented to sample population. The response is evaluated using signal processing and statistic principles and altogether compared with results of questionnaire designed for this study.

Keywords: Emotional stimulation, visual stimulation, PPG, HRV, SAM, arousal

1. INTRODUCTION

Research (Kriebig, 2010) shows we are on the way to evaluate changes in emotional state of person from basic biological signals such as Electrodermal Activity, Photoplethysmography (PPG) and Electrocardiography and other biological signals functionally connected with activity of Autonomic Nervous System (ANS). Because emotions are highly complex, we try to approximate just basic emotions. In laboratory conditions we use basic Valence-Arousal (V-A) 2D space to display emotions, inspired by work of Russel (1980), Stickel et al. (2009). Two axes refer to valence and arousal coordinates. Its combination leads to point in certain area which can be assigned to certain emotion. [1] [2] [3]

The emotional states in laboratory conditions are induced by certain types of stimulation, mostly the visual or audio-visual stimulation. The response we took care about was Heart Rate Variability (HRV) derived from PPG which refers to arousal component in emotional space. As we can hardly judge emotions from processed signals the questionnaire follows the study. It is necessary to subjectively rate the stimuli by measured persons to assign certain changes to certain emotional states. In this paper the visual stimulation is mediated by basic pictograms and images together with changes in colorification. [1] [4] [5]

2. EXPERIMENT DESIGN

As it is described in introduction the emotional states highly correlate with response of ANS, therefore PPG for deriving HRV was chosen as they are under the influence of ANS and proper stimulation leads to response we can measure and evaluate. The BIOPAC® system and its equipment were used for signal acquisition. [3] [6]

2.1. STIMULI CHOOSING AND PRESENTATION

The presentation was made in Microsoft PowerPoint. It has three parts, first includes monochromatic images following RGB and CMYK colour models with black respectively white colour added, like the basic sources of all colours. Second part includes three basic pictograms: scull (negative stimulus), smiley (positive) and flower (neutral), for theirs clear message. These are again coloured in matter of RGB and CMYK. In last part three neutral images are chosen (nature, room and butterfly). They are coloured by certain schemes published in material Affective Image Colorification, which refers to changes in emotional states of neutral images with changes in its colorifica-

tion. There is 8 series of 5 images each, every image is presented for 10s with 3s of gap with neutral (grey) background. Overall the measurement last for 481s. [5]

2.2. PRESENTATION AND SIGNAL SYNCHRONIZATION

To assign right signal parts to certain images the synchronization was made by white noise impulse marks when stimulus image started to be presented. This impulse was transmitted via audio output and optocoupler to external input of BIOPAC® where due to grounding the constant 5 V voltage decreased to 0 V for 50 ms.

2.3. QUESTIONNAIRE

To assess the response the self-reporting questionnaire was filled by tested person to receive the rating for each image for further comparisons. The questionnaire has two parts for each image. First half is Self-Assessment Manikin (SAM) test and the other is V-A space. The reason is higher robustness since both of them should lead to same results since there is no clear linkage for tested person. These questionnaires are common so they are used complete even though arousal component is our point in this paper. [8]

3. SIGNAL AND QUESTIONNAIRE PROCESSING

Measured population had 10 samples (5 of each gender, M = 22.9 years, SD = 2.02 years). The population is biased by choosing only from university students for its easy availability. All of them were thoroughly instructed and gone through both measurement and questionnaire part of experiment.

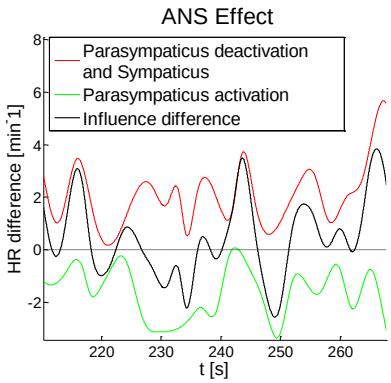

Figure 1: Graph of processed HRV signal

Signals were cut and processed using Matlab environment. Signal processing had following steps: filtration, drift exclusion and peak detection. Filtration was done with bandpass filter (15 – 25 Hz) and lowpass filter (5 Hz) to smooth the acquired signal. Drift exclusion was done as subtracting vector of the the minimum values inside moving window with 700 samples. The signals were properly extended to receive the signal of the same length. Peaks were detected as maxima between susceptible zero-level passes. Then the HRV was derived from time gaps between detected peaks, which were afterwards recounted to HR [min^{-1}]. Last step was counting the difference of susceptible HR, which led to better picture about accelerating or decelerating of HR. Cubic spline fit was used to receive HRV curve as approximation of ANS (sympaticus, parasympaticus) effect. Local maximum leads to parasympaticus deactivation together with low influence of sympaticus oppositely local minmum refers to parasympaticus activation. It is worth of knowing that most of the action is provided by parasympaticus activation and deactivation with low sympaticus effect since sympaticus reacts in long term period. [1] [7]

The effects of parasympaticus activation, parasympaticus deactivation and sympaticus were separated. The local maxima and minima were detected and separately cubic spline fitted and both received vectors subtracted, see Figure 1. Received curve shows which part of ANS activity domi-

nates. Result of subtraction higher than zero is parasympaticus domination – high arousal, oppositely the result lower than zero leads to parasympaticus deactivation and low sympaticus effect and low arousal or calming. Note: cubic spline fit is only approximation of ANS influence.

Afterwards the arousal rate is statistically evaluated. Four thresholds (5 levels) are initiated for comparison with 5 arousal levels of SAM and V-A questionnaire. Then t-test is used for comparing means for each image response with null hypothesis that certain threshold level is sample mean. The significance level is $p = 0.05$, if $p < 0.05$ we assign one of numbers from set {-2, -1, 0, 1, 2} inspired by 5 levels of arousal in SAM or V-A. The results of signal processing and statistics are compared with questionnaire arousal levels in both SAM and V-A test. See Table 1, where the number of matches of HRV processing and both questionnaire parts is compared.

	Match	Partial match	Mismatch
SAM	5	18	17
V-A	11	22	7

Table 1: Matches of questionnaire and HRV processing result (match – score fit, partial match – maximum difference 1, mismatch – difference higher than 1)

4. CONCLUSION

The PPG processing was done in the matter of comparison with questionnaire. There were overall 23 out of 41 matches or partial matches for SAM test and 33 out of 41 matches or partial matches for V-A test. Even though we used some approximations and separated one axis from 2D emotional space, there is some connection to see which is promising for further exploration of emotion and its physiological signs.

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