Available online at www.sciencedirect.com
ScienceDirect
Procedia Social and Behavioral Sciences 5 (2010) 483–487
Procedia
Social and Behavioral Sciences

WCPCG-2010

Heart Rate Variability (HRV) reflecting from oral reports of negative experience

Antti Rantanen[a] *, Seppo J. Laukka[a], Matti Lehtihalmes[b], Tapio Seppänen[c]

[a]*Learning Research Laboratory (LearnLab), P.O. Box 2000, 90014 University of Oulu, Finland*
[b]*Logopedics, Faculty of Humanities, P.O. Box 1000, 90014 University of Oulu, Finland*
[c]*MediaTeam Oulu, Information Processing Laboratory, Department of Electrical and Information Engineering, Faculty of Technology, P.O. Box 4000, 90014 University of Oulu, Finland*

Received January 2, 2010; revised February 3, 2010; accepted February 29, 2010

Abstract

We measured HRV in 25 females while they were evaluating and reporting 48 affective pictures, which appeared on the screen for 20 s in random order. After reporting the SAM, the participant orally reported to the experimenter, what she saw, what had happened, and what was going to happen in the picture. Spectral analysis was performed on the data using the fast Fourier transform. Preliminary results indicate that during negative pictures, LF/HF activity is significantly higher in the picture phase than in the speech phase.

Keywords: oral report, heart rate variability, international affective picture system.

1. Introduction

Earlier studies show that emotions are capable of being elicited quickly, effortlessly and subconsciously upon exposure to a relevant stimulus (Cacioppo et al. 2000). A human is limited by the level of awareness and by language for describing one's emotions accurately. More reliable indicators of emotion can be found in the central nervous system and in the autonomic nervous system. Stressors are associated with increased sympathetic activity, decreased parasympathetic activity and anxiety, and depression is associated with an overall decrease in parasympathetic activity (Berntson & Cacioppo 2004). Overall parasympathetic activity is associated with enhanced attention, effective emotion regulation and responsivity (Friedman & Thayer 1998).
The aim of this study was to explore the autonomic activity of subjects during positive, neutral and negative pictures while viewing, evaluating and reporting. The beat to beat interval was measured and HRV analysis was used to gain measures for sympathetic and parasympathetic activity. The main interests were the differences in HRV between positive, neutral and negative pictures in different phases, and the differences between the phases during positive, neutral and negative pictures.

*Antti Rantanen. Tel.: +358-8-5533624; fax: +358-8-5533600.
E-mail address: antti.rantanen@oulu.fi.

doi:10.1016/j.sbspro.2010.07.128

2. Methods

2.1. Participants

A total of 30 right-handed, (native fluency in Finnish and no reported history of speech disorder) Finnish speaking, undergraduate female students from the University of Oulu participated in the experiment. The students participated voluntarily in the experiment during their psychology studies. Eyesight was tested using the Snellen card and anxiety was measured using the State Trait Anxiety Inventory (STAI) (Spielberger et al., 1970). In addition, possible alexithymia was tested with TAS-20 (Bagby and Taylor, 1994), the validity of which has been tested in Finland too (Joukamaa et al., 2001). All subjects had normal eyesight ($\geq$ 1.0), and no anxiety (STAI score < 35) nor alexithymia (TAS-20 score < 51) was found. After the explanation of the experimental protocol, the subjects gave written consent.

2.2. Apparatus

The IAPS pictures (International Affective Picture System, Lang et al, 2005) were presented on the screen (17”) of a computer with an Intel Pentium 4 processor which was connected to a Tobii 1750 eye tracking system (Tobii Technologies AB, Sweden). The sample rate was 50 Hz, and the spatial resolution was 0.25 degrees. The eye tracking system located every fixation point and measured the duration of fixation, the pupil size variation and the distance of the eye from the computer screen. The heart rate variations were measured using beat-to-beat RR-intervals with a Polar S810i heart rate monitoring system (Polar Oy, Finland). The facial expressions were recorded with an IEEE 1394 firewire camera (Sony DFW-VL500, Japan). In addition, the subject’s speech was recorded using a wireless microphone system (Sennheiser HSP2, Denmark) (Fig. 1).

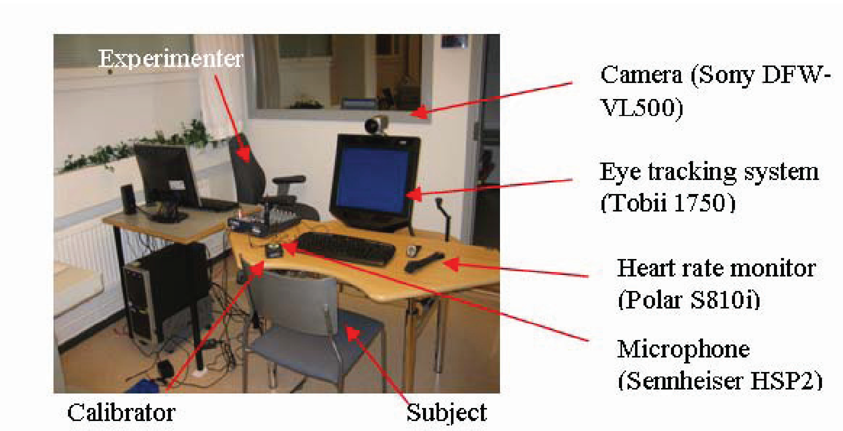

Fig. 1 The experimental design.

2.3. Materials

A total number of 48 International Affective Pictures (Lang et al., 2005) were used in the experiment[1]. The pictures were divided into three different groups; 16 pleasant, 16 neutral and 16 unpleasant pictures (se also Nummenmaa et al., 2006). The overall luminance levels of the pictures were adjusted with Adobe Photoshop 6.0 software.

---

[1] The number of the IAPS pictures used in the experiment were: positive (2050, 2057, 2070, 2091, 2165, 2209, 2216, 2340, 2352, 2550, 4608, 4601, 4653, 4700, 8490 and 2040); neutral (2190, 2191, 2215, 2235, 2393, 2487, 2516, 2745, 2840, 2850, 2870, 7493, 7496, 7550, 8311 and 9070); negative (2375, 2750, 2800, 2900, 3015, 3051, 3181, 3301, 3550, 6243, 6570, 6838, 9040, 9421, 9435 and 2095).

2.4. Procedure

The subjects were interviewed and STAI (Form 2) and TAS-20 questionnaires were presented before the experiment. Subsequently, the subject was able to practice the experimental procedure from “the paper version” with the experimenter. Thereafter, the subject practised the procedure with the computer. Before the actual experiment, the subject rested for 60 secs, while the heart rate monitoring system, audio and camera systems were combined to the eye tracking system. The subject’s eye movements were also calibrated into the eye tracking system.

In the experiment, the pictures were presented on the computer screen and the distance of the subject from the screen was 65 cm. At first, the subject had to look at the letter X, which appeared in the middle of the screen, for 30 secs. Sequentially either a pleasant or neutral or unpleasant picture appeared on the screen for 20 secs in random order. Immediately after the 20 secs, the SAM scale (Self-Assessment Manikin, Lang 2005) appeared. The subject’s task was to orally report the valence and arousal of the picture according to the SAM scale (1-9 categories). These categories were grouped according to their valence giving new categories: “positive” (1-3), “neutral” (4-6), and “negative” (7-9). This grouping was made to improve comparison with IAPS pictures (positive, neutral and, negative pictures).

After the report, the subject had to press the enter button in order to darken the screen. In this phase, the subject’s task was to orally report on what had been seen, what was happening and what was going to happen in the picture to the experimenter, who was sitting behind the computer screen. After the report, the subject had to press the enter button for the next picture to appear. After 48 pictures, the letter X appeared for 30 secs. Finally, the STAI (Form 1) questionnaire was presented. The experimentation was approved by the ethical committee of The Faculty of Education, University of Oulu. (see also Laukka et al., 2008).

2.5. Heart functioning and emotions

Resting heart rate varies widely in different individuals due to physiological stresses like exercise and is also dependent on physical fitness and age related factors (Hainsworth, 1995). Heart rate is normally determined by the rate of depolarization of the cardiac pacemaker. In a healthy individual, the heart rate represents the net effect of parasympathetic and sympathetic nerves. Mostly parasympathetic or vagal stimulation slows the heart rate, but a small amount stimulation may cause an increase in the heart rate. Increased activity in sympathetic nerves causes an increase in HR (Hainsworth, 1995).

There are many reflexes influencing heart functioning. Bradycardia is caused by stimulation of baroreceptors, carotid chemoreceptors, coronary chemoreflex, and lung hyperinflation (Hainsworth, 1995). Tachycardia is caused by stimulations of atrial receptors, aortic chemoreceptors, muscle receptors and moderate lung inflation (Hainsworth, 1995). Also respiratory influences have an effect on HR. The respiratory sinus arrhythmia (RSA) refers to variation in HR due to respiration. Generally HR increases during inhaling and decreases during exhaling (Jorna, 1992; Ahmed, Harness & Mearns, 1982). Further, there is evidence that speech has a decreasing effect on the inhaling/exhaling ratio, which results as an increase in sympathetic activity (Beda, Jandre, Philiphs, Giannella-Neto & Simpson 2007).

2.6. Data analysis

The obtained RR data was examined for abnormal beats and any found artifacts were removed. HRV analysis was executed using the HRV Analysis software (University of Kuopio, Finland). Spectral analysis was performed on the data using the fast Fourier transform to extract powers of the spectral components relating to sympathetic and parasympathetic activity per subject in each condition. Paired t-tests with Bonferroni corrections were used to compare the differences between the phases and the pictures.

Spectral analysis of the HRV signal is usually performed on stationary records of at least 200-500 consecutive heart beats (Cerutti, Bianchi, Mainardi 1995). This range is chosen to obtain sufficient frequency resolution and the stationary condition. The classical frequency analysis is based on the Fourier transform, which can be evaluated through the FFT algorithm. The expression of PSD (Power Spectral Density) as a function of the frequency P(f) can be obtained from the time series y(k), described below as a periodogram expression (Cerutti, Bianchi, Mainardi 1995):

$$P(f) = \frac{1}{N\Delta t}\left|\Delta t \sum_{k=0}^{N-1} y(k) e^{-i2\Pi fk\Delta t}\right|^2 = \frac{1}{N\Delta t}\left|Y(f)^2\right|$$

$$\Delta t = sampling \quad period$$
$$N = number \quad of \quad samples$$
$$Y(f) = DFT$$

The PSD shows three essential frequency ranges contributing to the total power. Long period rhythms are found at very low low-frequency (VLF, 0-0.04 Hz). VLF accounts for long-term regulation, probably related to thermoregulation, reninangiotensin system and other humoral systems (Cerutti, Bianchi, Mainardi 1995). The low frequency rhythms (LF, 0.04-0.15) are usually found around 0.1 Hz. Both sympathetic and parasympathetic activity may be involved, but an increase in LF is mostly considered to be related to a sympathetic effect (Cerutti, Bianchi, Mainardi 1995). The high frequency rhythms (HF, 0.15-0.4) are related to breathing activity mediated by the vagus nerve. Therefore it is generally accepted as an indicator of parasympathetic activity (Cerutti, Bianchi, Mainardi 1995). The LF/HF ratio is used for measuring autonomic balance considering the overall activity of sympathetic and parasympathetic nervous system.

3. Results

Fig. 2a shows that the viewing phase LF/HF ratio was significantly higher during unpleasant pictures (M=1.96, SD=1.01) than during pleasant (M=1.43, SD= 0.73), t(20) = -2.45, P <.05 and neutral (M=1.41, SD= 0.63), t(20)=-2.33, P<.05 pictures. In the evaluation phase, the LF/HF ratio was significantly higher during unpleasant pictures (M=1.72, SD=1.01) than in neutral pictures (M=0.89, SD=0.57), t(20) = -2.69, P <.05. In the report phase, the LF/HF ratio was lower during unpleasant pictures (M=1.36, SD=0.71) than during neutral (M=1.72, SD=0.22) and pleasant pictures (M=1.43, SD=0.73), but the difference was not statistically significant (Fig. 2a). Fig. 2b indicates that there was a significant decrease in the LF/HF ratio from the picture viewing phase (M=1.96, SD=1.01) to the evaluation phase (M=1.24, SD=0.12), t(21) = -2.75, P<.05 and to the report phase (M=1.36, SD=0.71), t(20) = -2.64, P< .05, during unpleasant pictures. The LF/HF ratio was nearly at the same level in the evaluation and in the report phase during unpleasant pictures. During pleasant pictures, there were no significant differences between the phases. With neutral pictures, the LF/HF ratio was significantly lower during the evaluation phase (M=0.89, SD=0.57) than in the picture viewing phase (M=1.14, SD=0.65) t(20) = 4.40, P<.05, and in the reporting phase (M=1.72, SD=1.01), t(20) = 3.93, P<.05 (Fig. 2b).

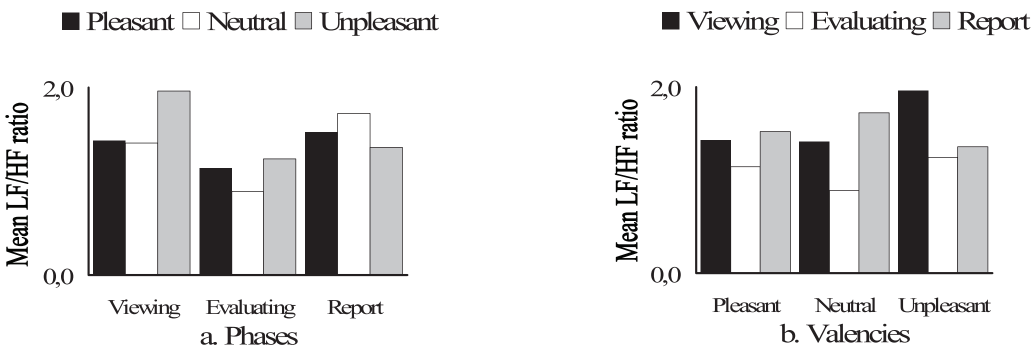

Fig.2. Low frequency (LF)/High frequency (HF) ratio in different phases (a) and with pleasant, neutral and unpleasant pictures (b).

4. Conclusion

The preliminary results show that unpleasant pictures produce higher LF/HF than neutral and pleasant pictures. Further, LF/HF decreases in the report phase after viewing an unpleasant picture, but not after a neutral or a pleasant picture. An unpleasant stimulus produces a strong emotional response during the picture viewing phase, and a mild response during the evaluation and the report phase. A pleasant stimulus produces mild emotional response during the picture viewing phase, the evaluation phase and during the report phase. Neutral stimulus produces a mild emotional response during the picture viewing phase, decreases during the evaluation phase and increases significantly during the report phase. These results indicate that talking about a neutral experience is calming and talking about a negative experience is accelerating.

One of the most essential analyses is to examine the subject's strategic plan used to carry out the whole experimental task (view the pictures, evaluate, and report them). Neutral pictures produce a lower sympathetic response than unpleasant pictures while viewing, but a higher response while reporting of the pictures. It seems that there is a difference in the emotional organization of the subjects between the pictures. Unpleasant pictures produce a strong emotional experience, and emotion processing is emphasized. Emotion processing is shown as a decrease in the LF/HF while reporting on unpleasant pictures. Neutral pictures produce less emotional experience and task orientation is emphasized. Task related stress is shown as an increase in LF/HF while reporting.

It should be noted that the effect of breathing and speech on HRV were not controlled in this study. This may produce effects on HRV, especially an increase in LF due to respiratory influences. Exhalation slows and inhalation accelerates the HR. Talking is shown to increase LF and this should result as an additional increase in the LF/HF ratio (Beda et. al 2007). Despite this increasing effect on LF, the difference in HRV between the picture viewing phase and the report phase is evident during unpleasant pictures.

References

Ahmed, A.K., Harness, J.B., & Mearns, A.J. (1982). Respiratory control of heart rate. *European journal of applied psychology,* 50, 95-104.

Bagby, M., Parker, J., and Taylor, G. (1994). The Twenty-Item Toronto Alexithymia Scale-I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research,* 38, 23-32.

Beda, A., Jandre, F.C., Philips, D.I.W., Giannella-neto, A., & Simpson, D.M. (2007). Heart-rate and blood-pressure variability during psychophysiological tasks involving speech: Influence of respiration. *Psychophysiology,* 44, 767-778.

Berntson, G.G., & Cacioppo, J.T. (2004). Heart rate variability: stress and psychiatric conditions. In M. Malik & J. Camm (Eds.), *Dynamic electrocardiography* (pp.57-64). New York: Futura publishing company.

Cacioppo, J. T., Berntson, G. G., Larsen, J. T., Poehlmann, K. M., & Ito, T. A. (2000). The psychophysiology of emotion. In M. Lewis, & J. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 173-191). New York: Guilford Press.

Cerutti, A. M., Bianchi, L. T., & Mainardi, L. (1995). Spectral analysis of the heart rate variability signal. In M. Malik, & J. Camm (Eds.), *Heart rate variability* (pp. 63-74). New York: Futura publishing company.

Friedman, B.H., & Thayer, J.F. (1998). Autonomic balance revisited: Panic anxiety and heart rate variability. *Journal of psychosomatic research, 44*, 133-151.

Hainsworth, R. (1995). The control and physiological importance of heart rate. In Malik, M., Camm, J. (Eds.). *Heart rate variability*, 3-19. New York: Futura publishing company Inc.

Joukamaa, M., Miettunen, J., Kokkonen, P., Koskinen, M., Julkunen, J., Kauhanen, J., Jokelainen, J., Veijola, J., Läksy, K., and Järvelin, M.R. (2001). Psychometric properties of the Finnish 20-item Toronto Alexithymia Scale. *Nordic Journal of Psychiatry,* 55, 123-7.

Jorna, P. G. A. M. (1992). Spectral analysis of heart rate and psychological state - A review of its validity as a workload index. *Biological psychology,* 34, 237-257.

Lang, P.J., Bradley, M.M., and Cuthbert, B.N. (2005). International affective picture system (IAPS): Affective rating of pictures and instruction manual. *Technical Report A-6*. University of Florida, Gainesville, FL.

Laukka, S.J., Rantanen, A., Zhao, G., Taini, M., & Heikkilä, J. (2008). Affective pictures and emotion analysis of facial expressions with local binary pattern operator: Preliminary results. In T. Vanhala & J. Anttonen (Eds.), *Proceedings of EHTI´08: The First Finnish Symposium on Emotions and Human-Technology Interaction* (pp. 19-22). University of Tampere, Department of Computer Sciences: Series of Publications A, A-2008-3, May 2008. (http://www.cs.uta.fi/reports/dsarja/D-2008-3.pdf).

Nummenmaa, L., Hyönä, J., and Calvo, M.G. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion*, 6, 257-268.

Spielberger, C.D., Gorsuch, R., and Lushene, R. (1970). *The State-Trait Anxiety Inventory (STAI) test manual.* Palo Alto, CA: Consulting Psychologists Press.