Selected Methods for Automatical Classification of Psychophysiological States in Experimentally Controlled Psychical Load

R. Kliment, P. Smrčka, J. Jeřábek, M. Vítězník

Joint Department of Biomedical Engineering CTU and Charles University in Prague, Prague, Czech Republic
Email: radim.kliment@gmail.com

Abstract. *In this work we deal with acquiring and consecutive processing and last but not least with data analysis, acquired at the Charles University, Faculty of Science in real experiments. The data consists of psychological factors computed from psychological questionnaires helping to determinate level of dominance or submissiveness. The second part of data consists of electrophysiological parameters acquired in double tests, including stressful part and relaxation part. We discovered a correlation between psychological factors and few parameters of HRV analysis. The usage of psychological factors helps to better classify the stress part.*

Keywords: stress, HRV analysis, dominance, psycho-physiological correlates

1. Introduction

Detection of stress as one of important psychophysiological aspects could help in many areas of human activity, where a wrong decision can lead to very serious consequences, e.g. army or health care. By detection of stress we can improve the quality of life, because we know that long-term exposure to a stress has a destructive influence on cardiovascular system. These people exposed to long-term incidence of stress have higher probability of cardiovascular diseases [3][4]. The aim of this work is to prove correlation between psychological factors and parameters of HRV analysis. We want to add another piece to a mosaic of non-invasive measuring quantity of stress of organism and quantification of stress in real time.

The data are coming from experiments which were led by prof. Flégr at the Charles University. These real experiments are part of a research that monitors influence of parasite Toxoplasma Gondii on a human psychophysiology [2]. All probands in experiments are blood donors tested on Toxoplasma Gondii antigens. The experiments were composed from several parts. In the beginning probands had an interview with a psychologist. After that they filled out several psychological questionnaires which determined their submissiveness or dominance in different aspects of their lifes. After the questionnaires were filled out probands were connected to a wireless non-invasive telemetric measuring system VLV2 by a person of opposite sex. In the first part of measurement they were given crayons with different colors. They were asked to put them together side by side according to the colours and according to their own colour preferences. In the second part, the stress part, the person of opposite sex opened a case with BDSM stuff and took out of this case a inform consent on which the proband had to tick BDSM techniques which they are willing to practice. After that the proband had to sign this document. Once they signed that form, the probands were told by the person of opposite sex that the experiment is over. This was followed by a short conversation about proband's feelings that he had during the experiment. The Charles University is preparing a new wider cycle of experiments. It is necessary to technically optimize measuring units for those new experiments.

2. Subject and Methods

Bio-telemetrical system VLV2

For measuring experiments was on joint department of Biomedical Engineering CTU in Prague, Albertov, developed a modular telemetric units that are able to noninvasively measure signals. Units are wireless, working with wifi technology. A system is able to measure and record data in real time from twelve units at once. This is a benefit, it saves time. And it can be used in new experiments, where prof. Flégr wants to measure an influence between probands . As at the Charles University were planned new massive experiments, we had to technically optimize the measuring units, so we put a crypt module into the units. This module was added because it was important to secure measured data, which are personal, non-public. This module was created within a student grant. To encrypt was used a library Crypto++ [5], which was ported to our used architecture of microprocessor [6]. This library contains crypt algorithms (Blowfish, AES) that can be used for crypt in a real time. The module is built into the system – as it is visible in Figure 1.

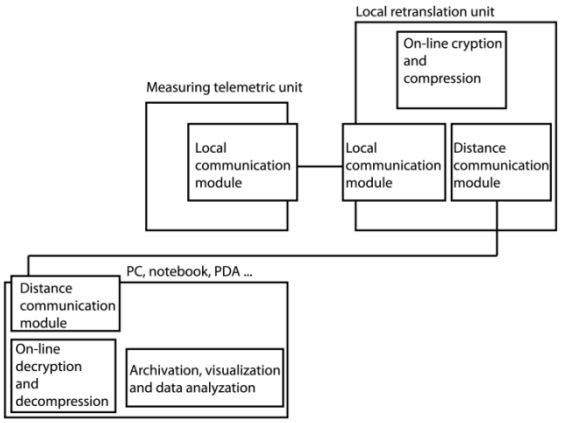

Fig. 1. Block diagram of crypt module

Measured data

The data were measured in real experiments at the Charles University. We measured 71 probands, 25 men, 46 women. The probands filled out few questionnaires, from these questionnaires the psychological factors were computed out of these questionnaires. We computed a cardiotachogram from ECG. Detection of QRS complex was performed by QRSDET plugin which is a part of VLV system [7]. In final analysis we worked with psychological factors and parameters from HRV analysis, computed from cardiotachogram in Kubios [1] software. Prof. Flégr computed psychological factors, which were based on psychological questionnaires. The questionnaires were intended to find affection to dominance or submissiveness in various aspects of human life. Table 1 shows these factors.

Table 1. Psychological factors

Factor	Nature	Range
Shawl	Proband likes tying?	-2,65 – 1,68
Democrat	Proband cling on equality?	-2,32 – 2,89
Non-dominance	Proband is non-dominant?	-2,4 – 1,95
Judith	Dominance on psychologist	-2,09 – 3,63
Film	Excitement from dominance in film?	-3,68 – 2,18
Cattell	Dominance by Cattell test	-2,73 – 1,98
Non-cooperation	willingness to cooperate	-2,44 – 2,36

Results

We studied an influence of these factors separation to a relax state and stress state with individual HRV parameters. Factors were used like filters. In Microsoft Excel was created a framework that allowed application of filters and creating of graphs in real time. With boxplot graphs (figure 2) we were looking for a parameters that separate both states (stress, relax).

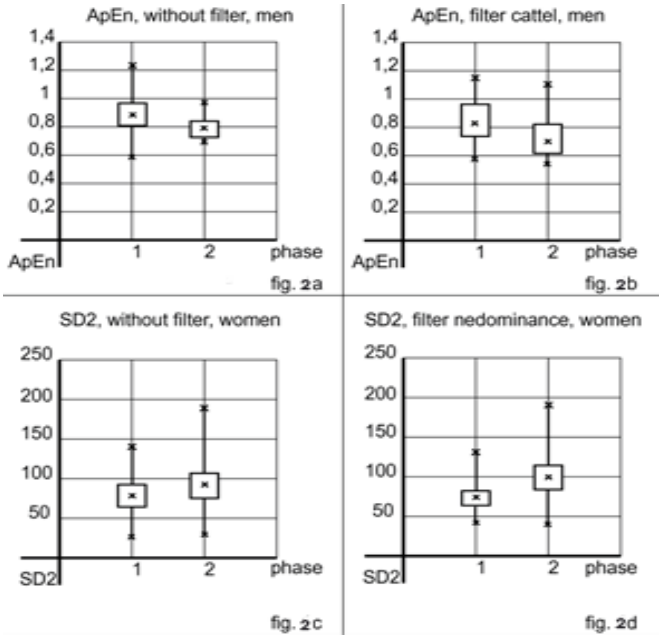

Fig. 2. Boxplot graphs HRV parameters with filters and without filters

The best HRV parameter for detection of stress for men was parameter ApEn (fig 2a) and SD2 (fig 2c) for women. These two parameters are able to separate both states. Better separation of relax and stress state can be achieved by using of psychological factors. The best ability of separation of states for women had "non-dominance" factor on HRV parameters HF/LF and SD2 (fig 2d). The best ability of separation for men had factor "Cattel" on ApEn parameter (fig 2b). Table 2 shows filters and HRV parameters, which have the best separation of states.

Table 2. Psychological filters

Filter	Adjustment	Sex	Parameter*	Classification Error
Non-dominance	(-10) – (-0,07)	Women	SD2	29,46%
Non-dominance	(-10) – (-0,07)	Women	LF/HF	30,88%
Non-dominance	(-10) – (-0,07)	Men	Shannon	21,64%
Non-cooperation	0,18 – 10	Women	SampEn	29,16%
Cattel	0,1 – 10	Man	ApEn	31,18%

* **SD2** – Non-linear Poincare plot parameter; **LF/HF** – Low frequencies / High frequencies; **Shannon** – Shannon entropy coefficient; **SampEn** – Sample Entropy is the negative natural logarithm of an estimate of the conditional probability that subseries (epochs) of length *m* that match pointwise within a tolerance *r* also match at the next point. [12]; **ApEn** – quantifies the unpredictability of fluctuations in a time series such as an instantaneous heart rate time series [12].

Discussion

The aim of this work was to acquire a process for classification of stress from cardiotachogram recording. We found markers in HRV analysis that demonstrably carry information about stress. These markers were found on women and men, too. For better

classification of stress can be used psychological factors, computed from psychological questionnaires. We designed and constructed new optimized versions of units for next experiments at the Charles University. Our next work is aimed to automate and improve the process of classification. We want to create accurate and fully automated system for detection stress state, which can be calibrated for particular cases, by psychological parameters.

Acknowledgements

Supported by projects No. FR—TI3/703 and FT-TA5/135 (Ministry of Industry and Trade of the Czech Republic) and project No. VG20102015002, Ministry of the Interior of the Czech Republic and CTU internal student grant No. OHK4-045/10.

References

[1] Biosignal analysis and Medical imaging group „HRV analysis software“: http://kubios.uku.fi/.

[2] FLEGR, J. Effects of Toxoplasma on human behaviour. *Schizophrenia Bulletin*, 2007: 33, 757-760.

[3] Paul A. Landsbergis, Susan J. Schurman, Barbara A. Israel, Peter L. Schnall, Margit K. Hugentobler, Janet Cahill, and Dead Baker: Job stress and heart disease, Scientific Solutions, Summer 1993.

[4] Schnall, P. L, Landsbergis, P. A. Baker, D. "Job Strain and Cardiovascular Disease," *Annual Review of Public Health,* 1994 (under review).

[5] Wei Dai: Crypto++ ® Library 5.6.0 [online]. 2004 [cat. 2010-01-31] at. WWW: <http>//www.crzptopp.com>.

[6] Horňáková, A. : Encryption and compression in real-time biological data transfer. 2010

[7] Pavel Smrčka, Jan Kašpar, Karel Hána, Jiří Brada, Jan Mužík: Multiparametrické mobilní zařízení pro snímání biologických signal, funkční vzor TZ-FVZ- 144233-VLVH2 1.0.

[8] Bayevski et al.: HRV Analysis under the usage of different electrocardiography systems (Methodical recommendations), Committee of Clinic Diagnostic Apparatus and the Committee of New Medical Techniques of Ministry of Health of Russia - protocol №4 from the 11-th of April, 2002.

[9] Smrčka, P. - Hána, K. - Kašpar, J. - Brada, J. - Fiala, R.: Multifractal Analysis of Heart Rate Variability in Sleep Deprivation and Alcohol Intoxication. In: The 3rd European Medical and Biological Engineering Conference — EMBEC´05 [CD-ROM]. Praha: Společnost biomedicínského inženýrství a lékařské informatiky ČLS JEP, 2005, vol. 11, s. 2583–2586. ISSN 1727–1983.

[10] Roman Bittner, Pavel Smrcka, Miroslav Pavelka, Petr Vysoký, Lubomir Pousek: Fatigue Indicators of Drowsy Drivers Based on Analysis of Physiological Signals, in: Medical Data Analysis, Second International Symposium, ISMDA 2001, Madrid, Spain, October 8-9, 2001, Proceedings. Lecture Notes in Computer Science 2199 Springer 2001, ISBN 3-540-42734-1, pp. 62-68.

[11] Nedělka - Smrčka - Jeřábek: ROLE ROVNOVÁŽNÉHO ÚSTROJÍ V REGULACI AUTONOMNÍCH FUNKCÍ, Neurol. prax, 2007; 6: 346 – 348.

[12] Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng CK, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. *Circulation* 101(23): e215-e220 [Circulation Electronic Pages; http://circ.ahajournals.org/cgi/content/full/101/23/e215]; 2000 (June 13).