Fine Grained Stress Assessment in Ecological Conditions

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***Abstract*— Wearable technology has seen substantial advances in recent years, mainly triggered by the need for non-invasive ways to monitor physiological signals outside the lab, in ecological/naturalistic context. In this study, the Zephyr HxM^{TM} system, a wearable heart rate monitor, was used, in 12 volunteers during the Trier Social Stress Test (TSST). The main objective was to assess whether any HRV metric enables the distinction of stressful moments in short time scales. Results show consistent differences between TSST phases for the AVNN and confirm the potential to enable a fine-grained evaluation of experienced stress in real-life scenarios.**

I. INTRODUCTION

Stress recognition remains one of the main research topics in the area of physiological computing. The aim of the present study was to evaluate whether a wearable device, the Zephyr HxM^{TM}, can be used to detect stress and non stress conditions on short time frames in ecological settings. The TSST is a strandardized stress-inducing protocol. During the TSST, the RR peaks, from the electrocardiogram were recorded by the Zephyr. The HRV was calculated in short time windows, in order to obtain a fine-grained measure of HRV changes over time, and hence more insight concerning intermediate levels of stress [1]. Time and frequency domain HRV metrics were estimated using the Physionet HRV toolkit [2], and were standardized (mean=0 and stdv=1 for each subject) in order to eliminate the intra-individual factor.

II. METHODS

The TSST comprises two phases: the Baseline (with no stressor) that consists of a period of silence followed by the reading of a neutral newspaper text; the Experiment phase (period with mental stress) in which the subjects deliver a free speech and perform a mental arithmetic task in front of an audience (Fig. 1). The STAI questionnaires allow the self-assessment of psychological stress. Twelve healthy subjects (9 male/3 female, age range 20-26 years) participated in the study, after providing informed consent.

III. RESULTS

Statistical analysis was conducted using SPSS (version 20). The nonparametric Wilcoxon test was applied to investigate the HRV differences between TSST phases. STAI scores present higher values in state stress after the Experiment compared with Baseline condition. In order to evaluated the four TSST moments a 50 second window was chosen which provide a level of smoothing that allows the essentially discrete stress measurements to approximate a continuous signal. Fig. 2 represents the AVNN (average of all normal interbeat intervals from ECG) along of TSST.

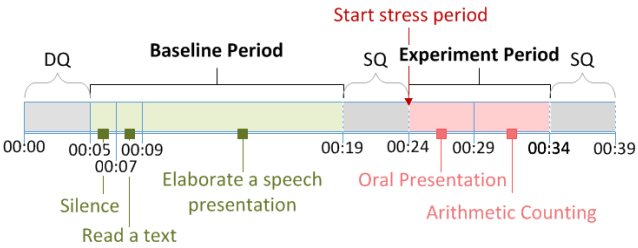

Fig. 1. Timeline of TSST phases (DQ: demographic questionary, SQ: STAI questionary).

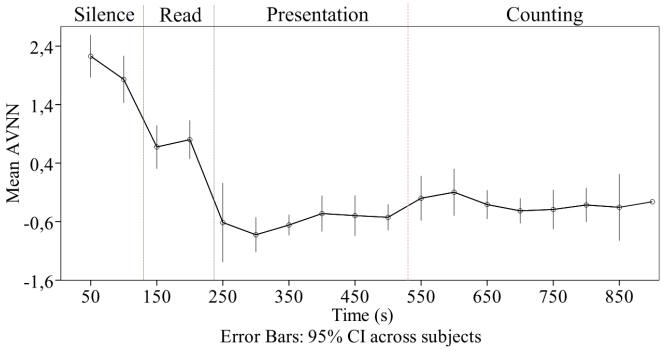

Fig. 2. Standardized mean AVNN for all subjects along the TSST.

IV. CONCLUSIONS

This work shows that a little intrusive heart sensor like Zephyr can provide data that enables distinguishing stressful moments. The AVNN parameter shows significant differences ($p<0.01$) between all the TSST phases. The short-time analysis enables fine-grained stress assessment.

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