S1: Analysis of Electrodermal Activity

Recordings in Pair Programming from 2 Dyads

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1 Introduction

As mentioned in Introduction, electrodermal activity (EDA) was also recorded during the pair programming sessions. EDA is a valuable addition to almost any psychophysiological experiment due to its ability to measure sympathetic arousal without being influenced by parasympathetic activation. Contrasted to the heart-rate variability (HRV) which is controlled by both branches of the autonomic nervous system (ANS), the combination of EDA and HRV produces the most complete picture of the ANS responses. EDA is temporally more responsive when compared to HRV as responses typically occur within 1-3 s after a stimulus onset [3] where as the time-scale for HRV is in minute-scale.

Unfortunately a large portion of the collected EDA data had to be discarded due to excessive artifacts in the data. However, we report here visual analysis
of two of the successfully collected dyads.

2 Methods, Results, and Discussion

The EDA was recorded in the experiment using the E4 wearable sensor (Em-
patica Inc., MA, USA) [4] attached to the wrist of the non-dominant hand. The
stainless steel electrodes were housed in the wrist-strap of the device and posi-
tioned on the ventral side of the wrist. The signal quality was first confirmed
visually by streaming the data over bluetooth but during the session the data
was stored in the on-board memory of the device for offline analysis. The signal
was registered at 4 Hz and synchronized with other measurement devices.

The collected EDA data was subjected to standard analysis by first de-
tecting and correcting motion induced artifacts through interpolation and then
decomposed into phasic and tonic components through Continuous Decompo-
sition Analysis (CDA) [1]. The phasic and tonic components represent the
skin conductance response (SCR) and skin conductance level (SCL) portions of
the signal respectively. Both artifact correction and CDA were performed in
MATLAB (MathWorks, Natick, MA, USA) using the Ledalab-toolbox (http:
//ledalab.de) Finally the significant peaks of the phasic response were com-
pared to the time course of the session. The detection threshold for significant
peaks was set to 0.25\(µS\) as suggested by the E4 manual.

Phasic component represents the arousal reaction to external stimuli and
emotionally arousing conditions whereas the tonic component describes the over-
all state of sympathetic arousal. Fig. 1 displays the raw data, phasic component
and the number of peaks from two dyads throughout the programming session.

From S1 Fig. 1 several observations can be made. First, all participants show
some level of phasic activity throughout the session (bottom left panel) indicating that the setup itself was emotionally arousing. Second, the participant 01b is
showing a clear pattern of increased phasic activity in coding blocks and reduced
activity in navigation blocks (bottom left panel). This pattern is clearly seen
Figure 1: The abscissa of each panel shows time in seconds for the experiment. Vertical lines indicate phases of coding activity for each member of the dyad, A and B. Top left: raw EDA data in $\mu S$ units for each member of the two dyads. Bottom left: phasic activity, or skin conductance responses (SCRs), the high frequency autonomic responding of the participants to external stimuli with the slow frequency tonic conductance level removed ($\mu S$ units separated by participants). Top right: number of SCRs over threshold in a given block time, per participant. Bottom right: cumulative SCRs per participant.

in the number of significant SCRs for 01b (top right panel), which are greater than literature values for non-stimulating conditions (1-3 peaks/min) [2] in 'B' (driving) but not 'A' (navigating) blocks. Third, dyad 2 (participant 02a, 02b) showed a reciprocal pattern of activations throughout the session as 02a decreases and 02b increases, this could be attributed to the task. The observed results can be summarized as follows 1) task modulated activity can be seen in the EDA signal, 2) colocated cooperating participants nevertheless respond differently (in terms of pattern and not just degree) to task stimulus. Together with the increased temporal resolution, we believe that EDA could indeed be used to complement HRV when studying the physiology of pair programming.

References

