Isolating the effects of emotional stimuli in EDA measurements

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Figure 1: edaMove Device

Introduction

One of the key reasons for measuring Electrodermal Activity (EDA, also known as Galvanic Skin Response) is its ability to assess the level of emotional arousal in an individual. As sweating is an involuntary action controlled by the sympathetic branch of the autonomic nervous system, the Skin Conductance Response (SCR) can be measured via electrodes placed upon the skin emitting and detecting a small current. These electrodes measure the resistance of the surface area of the skin, detecting the volume of sweat and indicating a level of high or low psychological and/or physical arousal. In an ambulatory setting there is a high risk of external variables influencing the level of SCR, thus making EDA measurements in isolation outside of a laboratory setting an unreliable measure of emotional arousal. Factors such as ambient temperature, humidity, and movement/exercise can mask the effect of an emotional stimulus on EDA. This report investigates a method to distinguish and isolate the effect of emotional stimuli on Electro-dermal Activity (EDA) in an ambulatory setting.

Methods

The movisens edaMove is a psycho physiologic ambulatory measurement system that is optimized for research applications. The sensor acquires the raw data of the EDA, and in addition the 3D acceleration and ambient temperature for up to two weeks. From this data secondary parameters such as skin conductance level (SCL), skin conductance responses (SCR) and activity intensity can be calculated with the movisens DataAnalyzer software (Fig. 3). The sensor is worn with a wrist band and is available with reusable and disposable electrodes. This particular evaluation assesses the reliability of the device to detect emotional stimuli through EDA (1) and isolate signals from external artefacts in real-life conditions (2). The primary focus of this study is the EDA-parameters, but for further investigation and refinement of the data, the physical activity of each subject and the ambient temperature were recorded using the accelerometers and temperature sensor incorporated in the edaMove. In addition to the EDA parameters, the ECG-parameters were also recorded independently using an additional sensor, in this case the movisens ekgMove sensor attached to a chest belt. The electrodes from the edaMove were attached on the palms of each subject’s dominant hand. Data acquisition started with a resting baseline of ten minutes. Then the subjects were asked to type text on a computer and also to shuffle a deck of cards to introduce motion artefacts. To further investigate the interactivity of motion artefacts and physical activity the subjects performed 5 minutes of walking followed by 5 minutes of running (Fig 2). In order to isolate the influence of physical exertion on the EDA signal without any motion artefacts the subjects rode for five minutes on an ergometer whilst keeping their hands stationary. After a second ten minutes rest to establish a baseline, the subjects were exposed to different room temperatures.

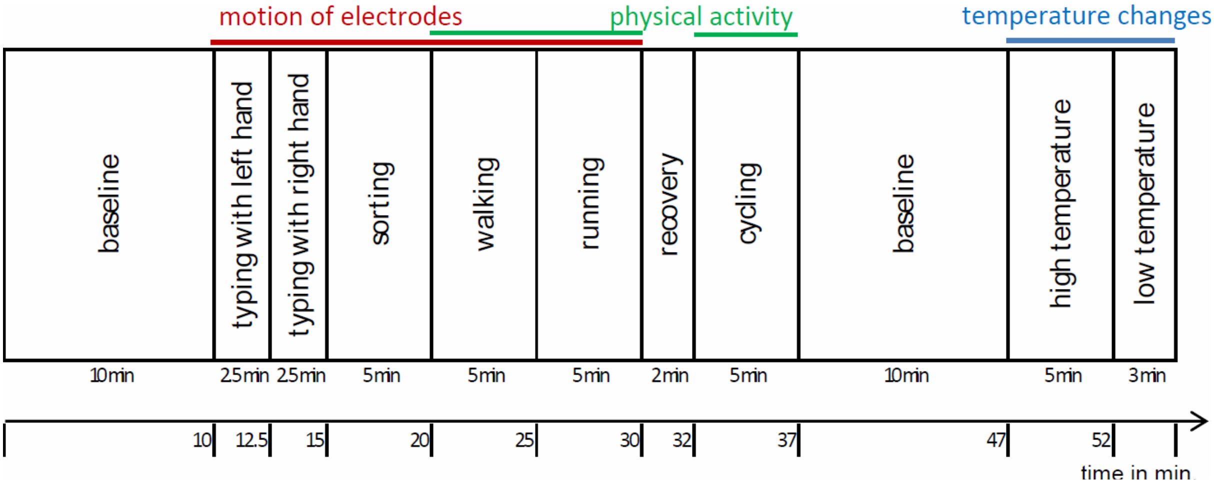

Figure 2: Study Procedure

Throughout all the different activities an emotional stressor was introduced at random intervals in order to trigger an EDA response. This stressor consisted of both an acoustic and a visual stimulus – the scream of a woman accompanied by an image of a creepy creature.
The data analysis included the data sets of all of the participants (n=29). The overall recording time for each subject was 55 minutes (Fig. 2). The movisens DataAnalyzer software (Fig. 3) was utilized to calculate the SCR parameter and to identify the amplitude of the normalized EDA signal. A reference marker for the SCRs was inserted manually by annotating the timestamps each time a response was observed in the raw signals.

Results & Discussion

Figure 4 shows the EDA response and Heart Rate (HR) for each activity and the corresponding emotional stimulus. From this we can assess the EDA response that is triggered by the emotional stimulus, as well as the transition between each activity. Whilst a high level of exertion produces an overall higher EDA response, the spike from the emotional stimuli is still discernable. The variance of the signal becomes more subtle during both high and moderate activity. A subtle fluctuation in the HR-signal occurs directly after the emotional stressor that quickly normalizes, whereas the activities (both moderate and high exertion), as well as the transitions between exercises show a more sustaining and easily discernable signal. The high acceleration signal that is produced whilst running allows this signal to be easily classified as a physical activity. However, the stationary cycling removes the ability to clearly determine the source of the increased EDA, due to no remarkable acceleration signal.
The only reliable way to determine that a physical activity is taking place is to utilize the HR data collected via the ecg monitor.
In the final phase of recording (not depicted in Fig. 4) the participants were subjected to extreme ambient temperatures, both hot and cold. Comparing the SCR events for each temperature condition with the baseline values, a large increase of the SCR counts can be detected. As the individuals had the same body position (sitting) and kept their hands calm during this phase of the recording, the differences in the signal can be associated with the impact of extreme temperatures. Apart from thermoregulatory processes, strong sweating and freezing can produce stress which causes emotional reactions.
The results show that phasic EDA, while the subject is exposed to emotional stimuli, is well suited for the identification of emotional arousal. An accurate measurement of EDA allows for the evaluation of films or commercials in terms of their emotional impact. It could also be utilized to identify learning disorders within a classroom setting by indicating emotional distress. However, when the EDA is obtained in isolation it is not possible to determine if the SCR level is due to emotional arousal, or an additional confounding factor. It is only through a multifaceted approach that the EDA signal

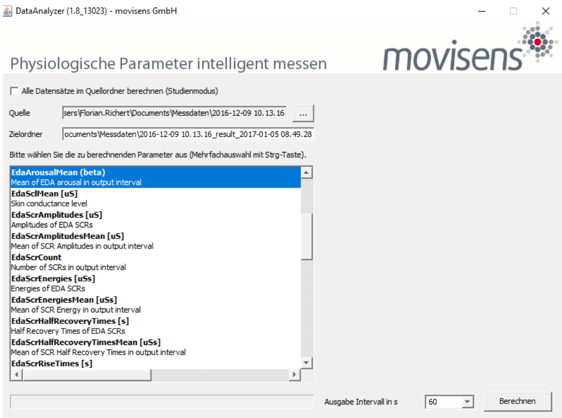

Figure 3: DataAnalyzer Software

can be properly isolated and assessed.
Through the use of accelerometers and temperature sensors, the edaMove allows a more precise identification of emotional arousal. When coupled with the data obtained from the ekgMove, the ability to compute the synchronized mean of several data sets in this study allowed an unprecedented level of accuracy for isolating the effects of an emotional stimulus on EDA.

Conclusion

This aim of this study was to investigate a method to distinguish and isolate the effect of emotional stimuli on Electro-dermal Activity (EDA) in an ambulatory setting.
The results show in addition to emotions, physical activity and ambient temperature have a huge influence on the EDA signal. Furthermore, movement artefacts such as electrode movement can cause errors in the signal. These factors need to be considered during data recording in field tests. Context information such as acceleration data or temperature can help to identify periods of physical activity and changes in temperature, thus refining the accuracy of the EDA measurement. In addition, cardiovascular information can be used to identify physical activity that is not linked with high acceleration but nonetheless induces a high EDA-response.
In summary: EDA measurement is well suited for the identification of emotional arousal and can be enhanced with acceleration, cardiovascular parameters and temperature. When used in a multi-faceted approach, the accurate detection of emotional arousal is possible even in an ambulatory setting.

Figure 4: EDA (orange line [High Freq-Phasic] and yellow line [Low Freq]), HR (pink line) signals and emotional stimuli (purple marks labeled with 1) during exercise

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