Advanced BME Laboratory (AM5019)
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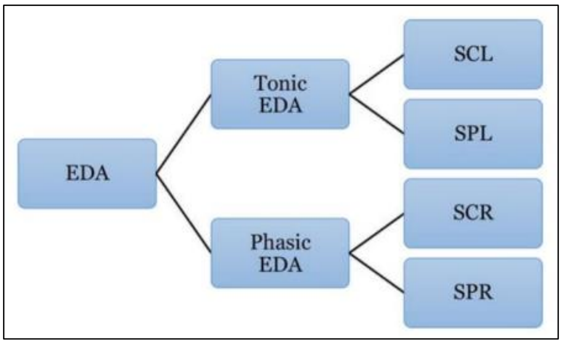
EXPERIMENT 2: Skin conductance response to virtual reality (VR) simulation.

AIM:
To find the tonic and phasic response of EDA signals acquired from a subject viewing a virtual reality simulation.

OBJECTIVE:
i. Record the EDA signal from the skin surface (electrodes placed on the index and middle finger) of an individual subjected to VR.
ii. Filter the EDA signal into tonic and phasic components.

THEORY:

Electrodermal Activity:
Electrodermal activity reflects the activity of the sympathetic nervous system and can be measured through the changes in the electrical properties of the skin. Historically, EDA has also been known as skin conductance, galvanic skin response (GSR), electrodermal response (EDR) and many other terms. EDA signals arise due to sweat gland activity that is controlled by the sympathetic nervous system. Skin resistance varies with the state of sweat glands in the skin. When the sympathetic branch of the autonomic nervous system is highly aroused, sweat gland activity increases, which in turn increases skin conductance. Different internal and external stimuli (psychological or physiological arousal) cause sweat glands to be produced in different amounts and result in varied EDA responses. Skin conductance can be a measure of emotional and sympathetic responses and this complex nature of EDA signals have resulted in extensive and continuing research in the field.
EDA is typically measured on the palms of the hands and finger tips. These sites are chosen because of the high density of eccrine sweat glands.

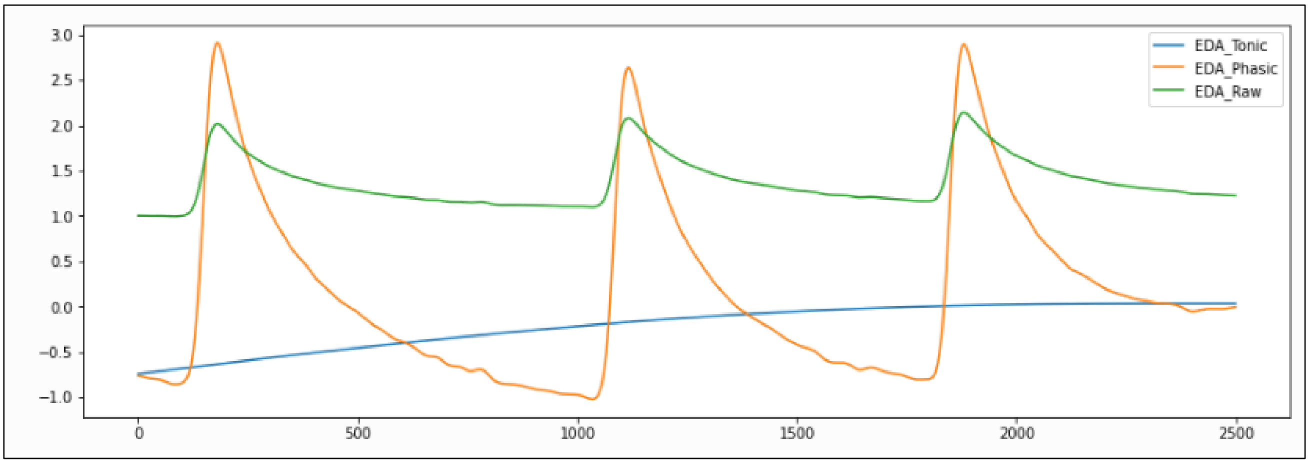


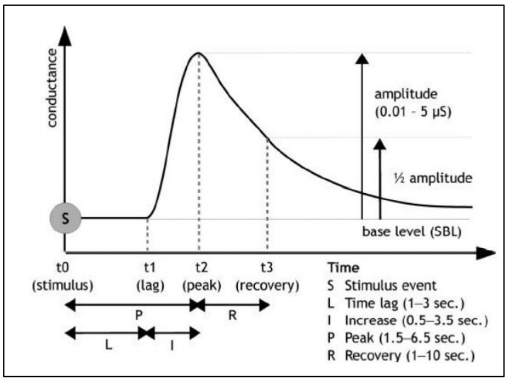
EDA is composed of two basic components:

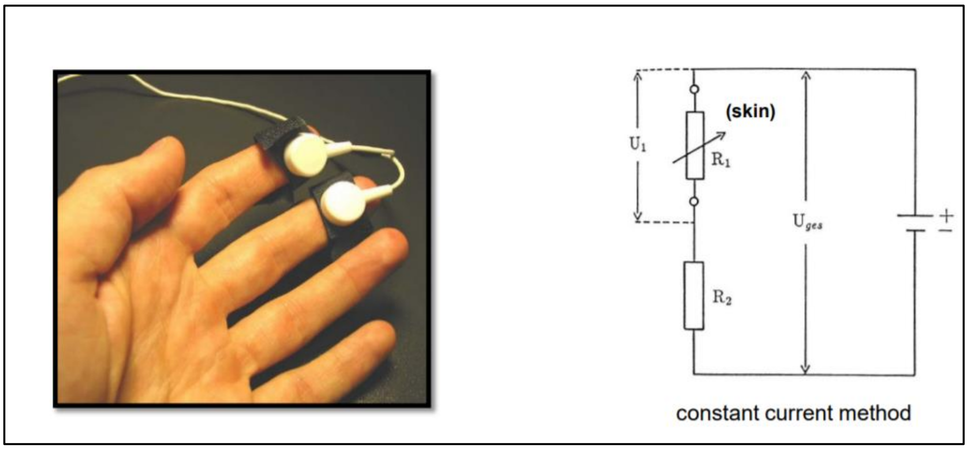
1. Tonic (level): Tonic EDA is represented by Skin conductance level (SCL) - slow-changing baseline level of the SC and skin potential level (SPL)- slow-varying baseline level of the SP.

2. Phasic (response): Phasic EDA is specified by a fast-varying component, known as the Skin Conductance Response (SCR) and skin potential response (SPR).

Both tonic (SCL and SPL) and phasic (SCR and SPR) have varying time scales and depend on various neural mechanisms and carry information about the dynamic activity of the autonomic nervous system.





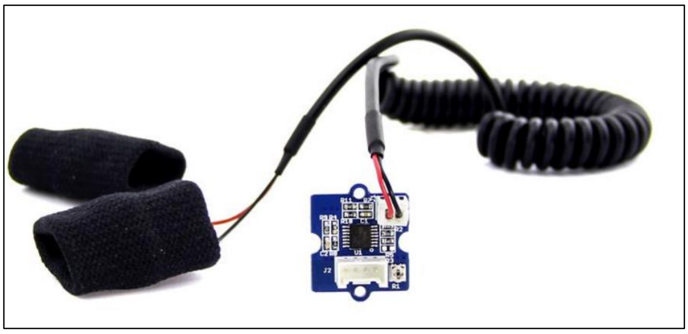


LEDA Lab

Types of electrodermal recordings:
1. Endosomatic recording: Potential differences originating in the skin are recorded without using any external source of current. The electrical energy is presumed to originate in the polarized membranes in the skin.
2. Exosomatic recording:
a. Using direct current (DC): The electrodermal system is supported with electrical energy from an external source, using either a constant voltage or a constant current. Models focus on passive properties of a system, in which capacitors are charged and changes in the signal are mainly due to resistive changes.
b. Using alternating current (AC): Responses of the electrodermal system to oscillatory signals are investigated, which also include changes in capacitors or charged membranes in the skin. This method is infrequently used.
Electrodermal phenomena and properties can be described theoretically using resistors and capacitors.
Variable resistors: Blood, ductal sweat, and interstitial fluid have changing conductivities, dependent on their ionic concentration.
Capacitors: Cellular boundaries formed by membranes are selectively permeable to flow of ions and forms an obstacle for the ions involved in the current flow. As a result, storage of ions at these boundaries is followed by the buildup of a potential difference across the cell membrane, the direction of which is opposite to the applied voltage (back EMF). Voltage sources localized in the skin and sweat glands represent polarized membranes. These can be regarded as charged capacitors.

APPARATUS USED:

Grove GSR sensor (electrodes), Arduino, connecting wires to acquire EDA signals.
Software used: NeuroKit (python software) to visualize and process EDA signals.



PROCEDURE:

1. The EDA sensor was secured on the subject’s index and middle finger.
2. The subject was shown a VR simulation consisting of snakes and crocodiles. The EDA signal was collected simultaneously to study emotional arousal corresponding to the stimuli.
3. The collected EDA signal was processed using the NeuroKit library to separate tonic and phasic components.

RESULTS & CALCULATIONS:

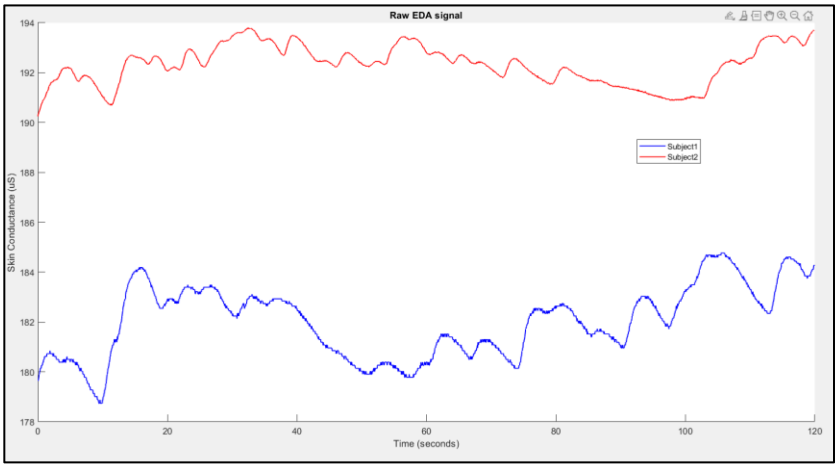


Fig 1: Raw EDA signal

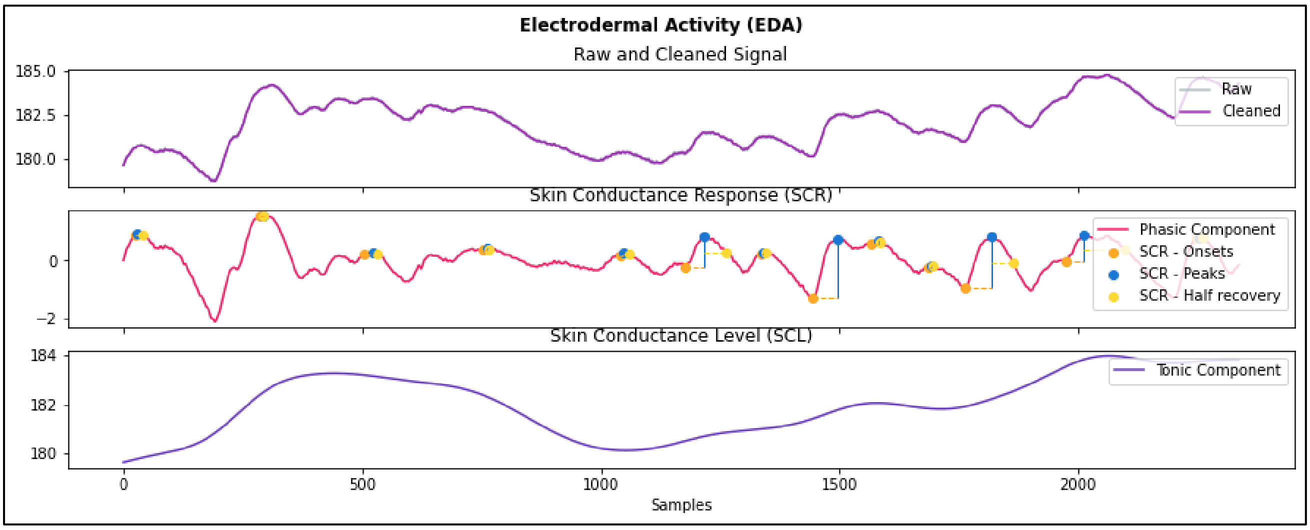


Fig2: Filtered EDA signal: Subject 1

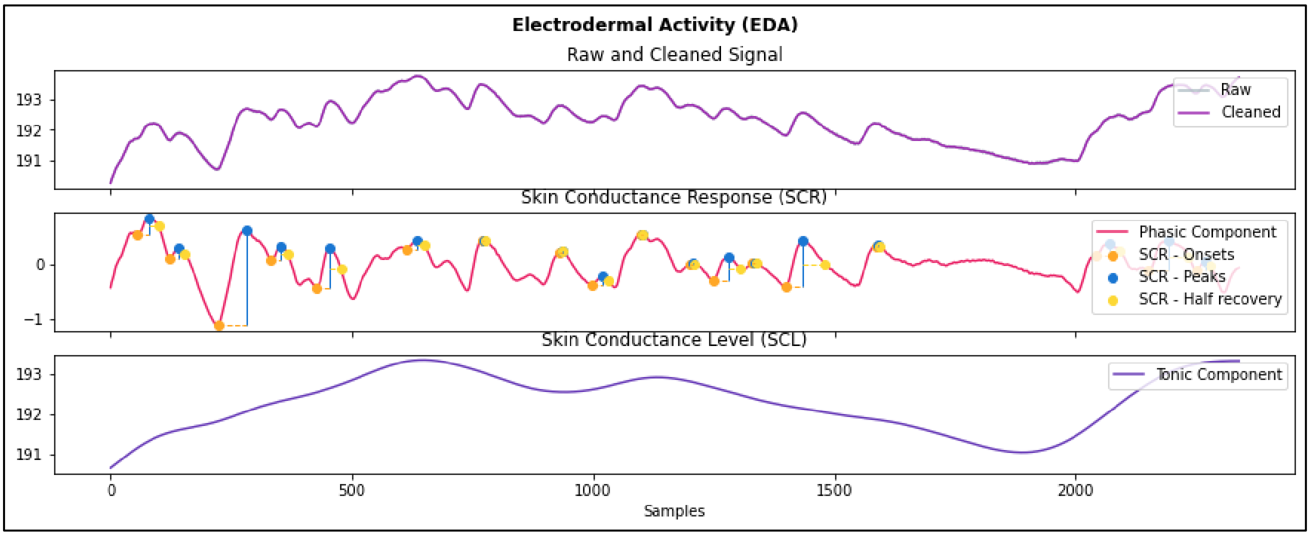


Fig3: Filtered EDA signal: Subject 2

The collected EDA signal is noisy. Thus, the filtering of the tonic and phasic component is not perfect. However, few peaks have been correctly identified as observed in Fig2 and Fig3.

In addition, the data was collected during the entire course of the VR simulation which contained few events of the park, people and arousing stimuli of snakes and crocodiles. The exact time point of the snake or crocodile in the simulation was not recorded. Thus, it is difficult to separate Event-Related Skin Conductance Response (ER-SCR) from Non-Specific Skin Conductance Responses (NS-SCR).

It can be observed that Subject2 showed a stronger emotional response to the same VR simulation since more peaks are observed. In addition, Subject2 has a higher skin conductance compared to Subject1.

The time course of the signal is considered to be the result of two additive processes: a tonic base level driver, which fluctuates very slowly (seconds to minutes), and a faster-varying phasic component (fluctuating within seconds). Changes in phasic activity can be identified in the continuous data stream as these bursts have a steep incline to a distinctive peak and a slow decline relative to the baseline level.

Scientists investigate the latency and amplitudes of the phasic bursts with respect to stimulus onset when investigating EDA signal changes in response to sensory stimuli (images, videos, sounds).
When there are significant changes in EDA activity in response to a stimulus, it is referred to as an Event-Related Skin Conductance Response (ER-SCR). These EDA peaks, can provide information about emotional arousal to stimuli. Other peaks in EDA activity that are not related to the presentation of a stimulus are referred to as Non-Specific Skin Conductance Responses (NS-SCR). By using the skin conductance values, or the number of EDA peaks, it is possible to add quantitative data to studies of emotional arousal.

CONCLUSIONS:

The EDA signals have been acquired from a subject viewing a virtual reality simulation. The signal has been separated to tonic and phasic components using the NeuroKit library.

CRITICAL REMARKS:

1. The collected EDA signal is noisy. Thus, the filtering of the tonic and phasic component is not perfect. Proper placement of electrodes and avoiding motion artifacts can improve the signal quality.

2. In addition, the data was collected during the entire course of the VR simulation which contained few events of the park, people and arousing stimuli of snakes and crocodiles. The exact time point of the snake or crocodile in the simulation was not recorded. Thus, it is difficult to separate Event-Related Skin Conductance Response (ER-SCR) from Non-Stimulus Skin Conductance Responses (NS-SCR).
3. If the exact time point of stimulus was recorded, it would be possible to study the latency and recovery of the EDA peaks for different subjects to make remarks on their emotional arousal.