

DES535

Ubiquitous Computing

Dr. Pragma Kar
Assistant Professor
Department of Human-Centered Design



INDRAPRASTHA INSTITUTE of
INFORMATION TECHNOLOGY DELHI

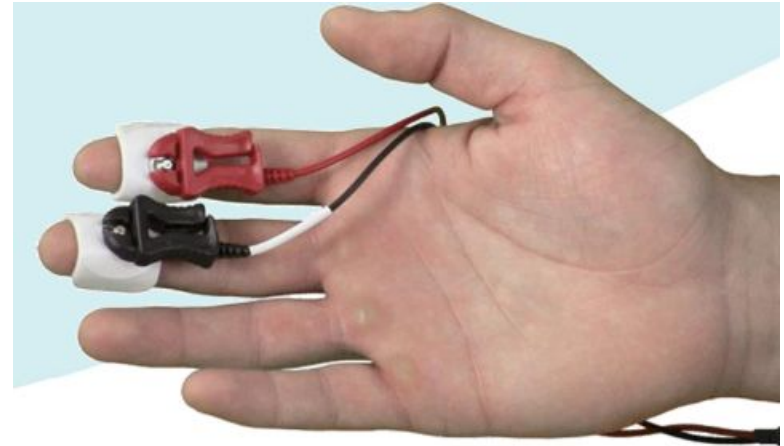
Google Classroom Code : pcwnf5t

Physiological Sensing

Module VI (Part I)

Electrodermal Activity (EDA)

- EDA—also known as Galvanic Skin Response (GSR)—refers to “*changes in electrical activity of palmar and plantar skin*” and is measured through electrodes on the surface of the skin of specific body parts.
- EDA is a measurement of **eccrine activity** that is influenced by **sympathetic nervous system** activity, resulting from **environmental stimuli**.
- EDA is an autonomic (involuntary) response.
- Stimulus types that elicit changes in EDA can be sourced via touch, sight, sound, odor and taste.



EDA - How does it Work?

- EDA is the measure of “the variation of the electrical properties of the skin”, which is a direct consequence of dermal sweat gland activity.
- These changes are due to the high quantity of electrolytes in sweat, leading to an increased conductance of the skin with increased perspiration.
- Even though most eccrine sweat glands are involved in regulating the body’s temperature (thermoregulation), plantar (on the foot soles) and palmar (on the hand palms) sweat glands are activated by the sympathetic nervous system.
- Increases in sweat gland activity in these areas are typically elicited by psychological and emotional states—also called “emotional sweating”. In particular, EDA is an indicator of arousal.

Image Source: Internet

https://dl.acm.org/doi/pdf/10.1145/3411764.3445370?casa_token=mUZN3TchkF8AAAAA:MjMJ_ezvm_ZqEwMxntLhVDrXxP3VwHQ7Y1yUk7AKqQ-xk5WQbG3ZyzcsW4FXugkLUv5ctYBUAbQ
<https://www.biopac.com/wp-content/uploads/EDA-Guide.pdf>

EDA - How does it Work? [Contd...]

- Arousal changes can be initiated by external sensory stimuli. Additionally, internal emotional states may modulate autonomic function and thereby produce overt changes in affect.
- Measuring EDA involves measuring skin conductance.

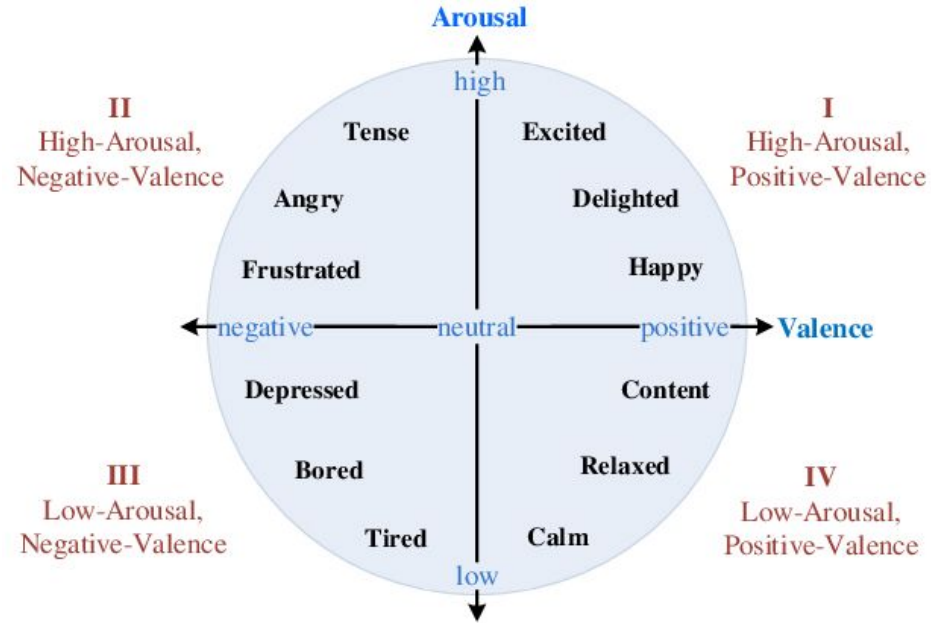


Image Source: Internet

EDA Signal - Collection and Structure

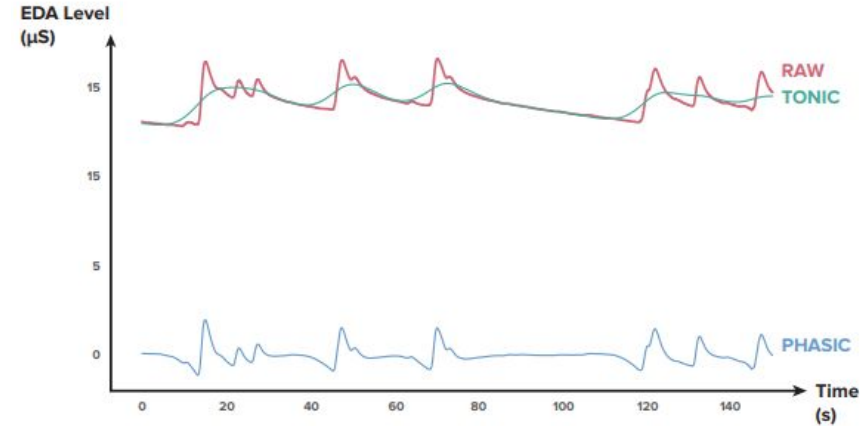
- Two categories of methods have been proven effective in measuring the EDA signal:
 - **Exosomatic approach**
 - Uses an externally applied constant voltage source that is connected to the body via electrodes.
 - Using Direct Current, the device measures the skin resistance or conductance; OR
 - Using Alternating Current, the device measures the skin admittance or impedance.
 - **Endosomatic approach**
 - The endosomatic approach measures the skin potential directly without applying any voltage.
 - It requires an electrode on an active site (e.g. palm) and one reference electrode on an inactive site (e.g. forearm) of body.
 - The device measures the natural electrical potential generated by the skin, called “skin potential”.

Image Source: Internet

https://dl.acm.org/doi/pdf/10.1145/3411764.3445370?casa_token=mUZn3TchkF8AAAAA:MjMJ_ezvm_ZqEwMxntLhVDrXxP3VwHQ7Y1yUk7AKqQ-xk5WQbG3ZyzcsW4FXugkLUv5ctYBUAbQ
<https://www.biopac.com/wp-content/uploads/EDA-Guide.pdf>

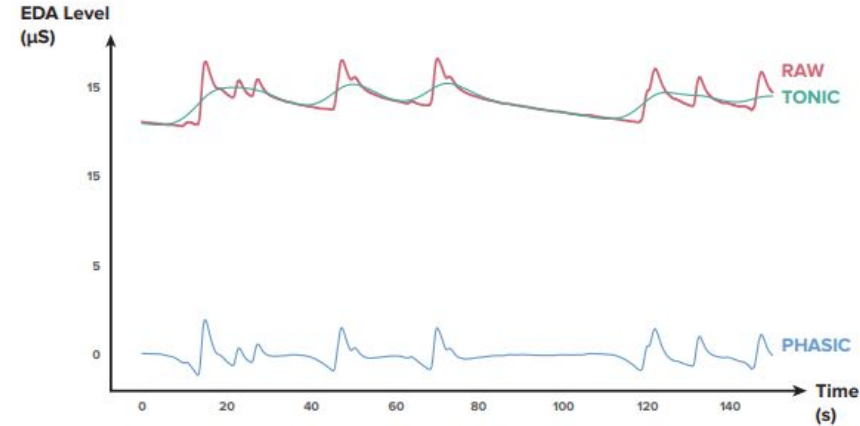
EDA Signal - Collection and Structure [Contd...]

- Both methods produce a signal that can be decomposed in two, namely the phasic and tonic components.
- Tonic Component**
 - Tonic skin conductance is generally considered to be conductance activity encountered in the absence of any discrete environmental event or external stimuli.
 - A participant's tonic skin conductance level can slowly vary over time depending upon psychological state, hydration, skin dryness, and autonomic regulation.



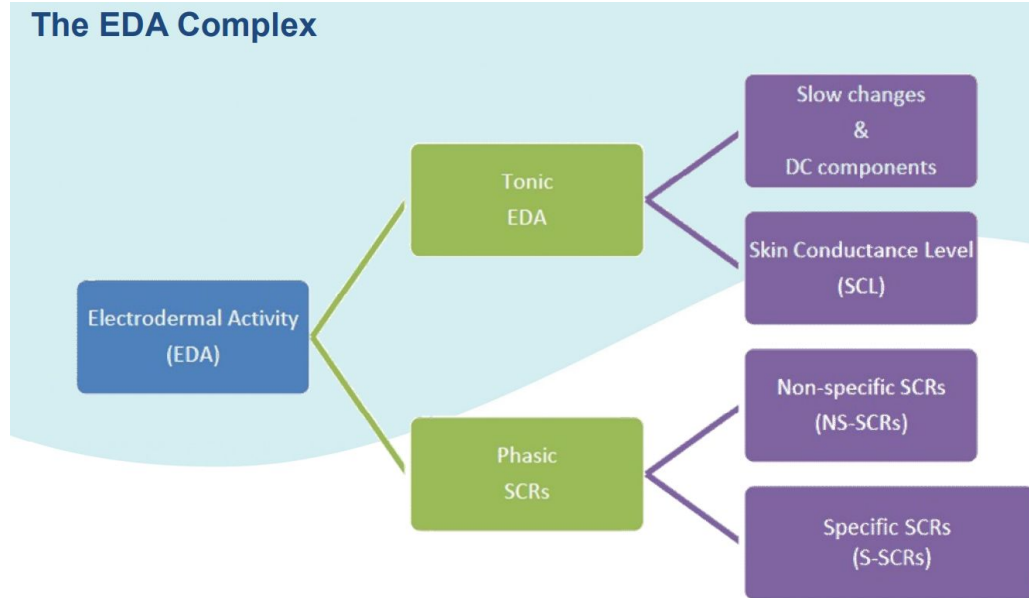
EDA Signal - Collection and Structure [Contd...]

- Both methods produce a signal that can be decomposed in two, namely the phasic and tonic components.
- Phasic Component**
 - Phasic skin conductance measurements are typically associated with short-term events and occur in the presence of discrete environmental stimuli (sensory stimuli and cognitive processes that precede an event such as anticipation, decision making, etc.).
 - Phasic changes show as abrupt increases, called "peaks," in the skin conductance.



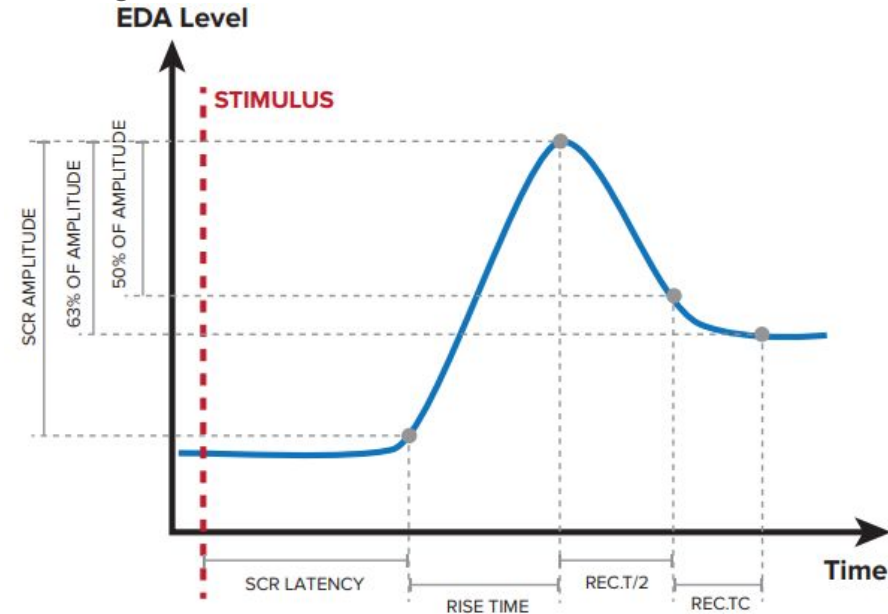
EDA Parameters

- A typical EDA signal exhibits Skin Conductance Responses (SCR) and Skin Conductance Level (SCL).
- The **tonic** component of the EDA signal is usually operationalised as the **SCL**, which can be measured during a non-stimulus rest period and mathematically calculated by taking the mean of a series of measurements.



EDA Parameters [Contd...]

- A typical EDA signal exhibits Skin Conductance Responses (SCR) and Skin Conductance Level (SCL).
- When a surprising stimulus is perceived, the **phasic** component of the EDA signal expresses a number of changes in amplitude after the stimulus, resulting in an **SCR**.
- Phasic parameters include
 - The amplitude of the response,
 - The response latency,
 - The rise time until the amplitude is reached
 - The recovery time
- In case an SCR (used for measuring the phasic response) cannot be directly linked to a stimulus, it counts as a “non-specific skin conductance response” (NS.SCR).



Applications of EDA



- EDA in a VR climbing environment to measure anxiety and stress.
- Sense of body ownership in realistic and non-realistic VR environments.
- Measuring users' arousal in different settings of a multi-sensory VR environment.
- Measuring the impact of using questionnaires inside vs. outside the VR environment on users' presence using EDA.

- Measure elements of the player experience, such as emotion and positive enjoyment.
- EDA to improve the game design process by comparing the EDA signal recorded from players and the EDA desired by the designers.
- Approach in which players could interact with the game by deliberately trying to affect their EDA signal.
- EDA in a biofeedback loop to adapt game mechanics according to players' EDA signal.
- A method for visualizing players' EDA signal as an indicator of arousal in games.



Applications of EDA



Commonly Used Devices

Empatica (E4, E3)
Custom-built device
NeXus-10 MKII
Shimmer 3 GSR
Biopac MP150
ProComp Infiniti system
BITalino (r)evolution Board Kit
Affectiva Q Sensor
Thought Technology's Triple Point Sensor
g.tec medical engineering
Flexcomp Infinity hardware
Varioport-B
Personal Input Pod
NeuroDyne MEDAC System/3
ADInstruments PowerLab
Grove GSR sensor device
H124SG Covidien
Microsoft Band

Effects of Parameters on EDA

Caffeine and medication consumption, temperature and relative humidity have significant impacts on EDA signals, so they should be controlled for and reported.

Movements, physical activities, like grasping, speech, and brisk movements, such as driving walking, nursing, playing an instrument, climbing, and running.

Speech, deep inhalation

Psychological Constructs

- **Arousal**

- Arousal is the most common construct measured with EDA in psychology.
- Arousal is the “state of feeling awake, activated, and highly reactive to stimuli”
- EDA is an indicator of lower levels of arousal, which is mostly caused by cognitive processes.
- SCL and NS.SCR frequency are tonic measures widely used to measure arousal.

- **Stress**

- EDA is controlled by the sympathetic nervous system, which is the branch of the nervous system predominantly responsible for feelings of stress.
- NS.SCR frequency as a valid measure of stress.

Psychological Constructs [Contd...]

- **Orienting Response**

- An orienting response is the physiological reaction of the body to a stimulus or to changes in a stimulus.
- In this type of study, researchers monitor phasic SCRs while participants observe a stimulus to study the impact of that stimulus on the participants.
 - If participants exhibit SCRs after perceiving the stimulus, it suggests that the stimulus is novel to them.
 - The intensity of a stimulus can then be measured using the SCR amplitude—more intense stimuli cause higher SCR amplitudes.

- **Cognitive Load**

- Cognitive load is defined as a “multidimensional construct that represents the load that performing a particular task imposes on the cognitive system of a learner”
- SCR is considered a reliable index of cognitive resource demand.

Threats to Validity

- **Skin preparation**
- **Placement of the device on skin**
 - The wrist is a very popular site for EDA recording in; however, there is some evidence in the literature that sweat gland activity on the skin of the wrist is mostly representative of thermoregulatory activity, rather than EDA and several validation studies reported unreliability of EDA recordings from wrist measurements
- **Physical activities** can affect EDA recordings in two ways:
 - destabilising electrodes and
 - increasing body heat.