BITalino (r)evolution ~~Lab~~ Home Guide

EXPERIMENTAL GUIDES TO MEET & LEARN YOUR BIOSIGNALS

ATTENTION

The present document includes experimental protocols to be shared
with customers who have PLUX products.
This document should not be distributed through alternative routes unless the customer chose to
acquire our biosignals acquisition systems.

The information contained in this manual has been carefully checked and were made every effort to ensure its quality. PLUX reserves the right to make changes and improvements to this manual, especially during the initial phases of the creation of this document.

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HOME-GUIDE #4

ELECTRODERMAL ACTIVITY (EDA)

Exploring Skin Signals

1. GOALS

After this lesson you will be able to understand the basic principle of Electrodermal Activity (EDA) and how changes in electrodermal activity are triggered and acquired with the given system.

In this Home-Guide you will explore the EDA signals in detail. The main goals of this lesson will be the following:

- Perform a set of EDA acquisitions in real-time.
- Test different electrode positions to examine changes in the signal and how they are triggered.
- Understand the change of signal after applying a stimulus.
- Getting familiar with parameters influencing the signal without a stimulus.

2. REVIEW HOME-GUIDE #3 & INTRODUCTION

All information of Home-Guide #3 can be found here: HOMEGUIDE#3. Complementary information can be found at bitalino.com

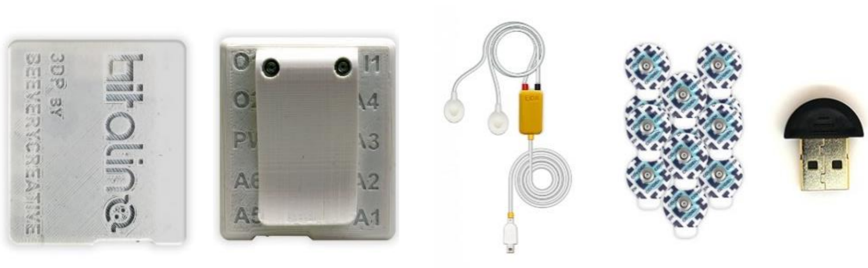
In the Home-Guide #3 we learned how to acquire brain signals using an EEG sensor. In this Home-Guide we will get to know skin resistance signals with an EDA sensor.

You have probably experienced sweaty hands during emotional situations which was either a positive or negative such as joy, nervousness, or a threat. These emotional stimuli trigger our eccrine sweat glands to activate due to change of activity of our sympathetic nervous system. These changes in electrical properties of the skin can then be measured with an EDA sensor.

3. MATERIALS

> *OpenSingals (r)evolution software is available on: https://bitalino.com/en/software*

- OpenSignals (r)evolution software
- 1 x BITalino (r)evolution Assembled Core BT
- 1 x Assembled Electrodermal Activity (EDA) Sensor
- 2 x Gelled Self-adhesive Disposable Ag/AgCl- Electrodes
- 1 x Bluetooth dongle



(a) (b) (c) (d) (e)

Figure 1: BITalino (r)evolution Assembled Core BT - Front View (a) and Back View (b); Assembled Electrodermal Activity (EDA) Sensor (c); Gelled Self-adhesive Disposable Ag/AgCl electrodes (d); and Bluetooth dongle (e).

** for each experiment you must use 2 gelled electrodes for the EDA sensor. Each time you want to repeat your experiment, or each time you see the electrodes are not in a good condition it is recommended to change them for new ones. Also make sure that you clean the skin area with alcohol before adjusting the electrodes to remove skin particles and improve the skin conductivity.*

4. RELATED DOCUMENTATION

BITalino (r)evolution Quick Start Guide

BITalino Assembled Core BT Datasheet

Assembled EDA Sensor Datasheet

EDA Sensor Datasheet

EDA Sensor User Manual

5. INTRODUCTION TO ELECTRODERMAL ACTIVITY (EDA)

5.1. EDA Basics

The activity of the eccrine sweat glands causes a change of skin resistance and is a measure for psychophysiological assessment. The density of sweat glands was found highest on the inner sides of the hands (palms), fingers and feet but are distributed with varying densities all over the body surface such as on the forehead, shoulder, neck, and wrists. The autonomous nervous system (e.g., Sympathetic branch) controls the activity of the sweat glands which lead to hydration of the skin and an electrical signal. This skin potential can be measured with an **EDA sensor, also known as Galvanic Skin Response (GSR) sensor**, from the skin surface. Stimuli such as psychological or thermal can trigger such activities. Examples of such stimuli are visually displayed images that trigger emotions, acoustic stimuli such as a scary sound, or haptic stimuli such as touching a hot glass of water. [1 2]

5.1.1. How does the Skin work? A Physiological Overview

The different glands of our skin are illustrated in Figure 2, namely eccrine, apocrine, sebaceous, and apoeccrine gland. The eccrine sweat gland (marked in blue) produces substances such as lactate, urea, and cytokines. When the water and volatile constituents of sweat reach the surface, they evaporate. [3 4]

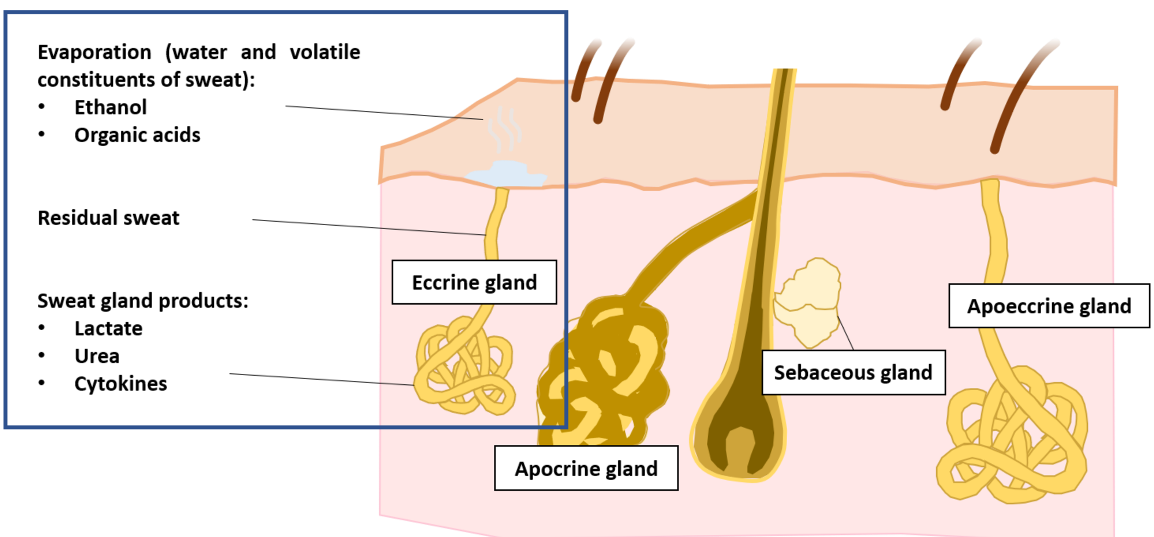


Figure 2: Skin layers with glands: eccrine (marked in blue), apocrine, sebaceous, and apoeccrine.

[1] *Jaime Vila, Psychophysiological Assessment, Encyclopedia of Applied Psychology, Elsevier, 2004, Pages 197-203, ISBN 9780126574104, https://doi.org/10.1016/B0-12-657410-3/00512-2.(http://www.sciencedirect.com/science/article/pii/B0126574103005122)*

[2] *van Dooren, Marieke, and Joris H. Janssen. "Emotional sweating across the body: Comparing 16 different skin conductance measurement locations." Physiology & behavior 106.2 (2012): 298-304.*

[3] *Baker, Lindsay B. "Physiology of sweat gland function: The roles of sweating and sweat composition in human health." Temperature 6.3 (2019): 211-259.*

[4] *Baker, Lindsay B., and Anthony S. Wolfe. "Physiological mechanisms determining eccrine sweat composition." European journal of applied physiology (2020): 1-34.*

The EDA signal, which is measured in micro Siemens [µS], can be decomposed to its Tonic and Phasic components as you can see in Figure 3 below. Tonic refers to the **Skin Conductance Level (SCL)** which constantly changes over time and varies strongly from person to person depending on different factors such as hydration. SCL is usually measured as a mean value over several measurements, such as several periods of rest and no stimuli. Phasic refers to **Skin Conductance Response (SCR)** and are short-lasting changes elicited by either distinct (specific) stimuli or in the absence of surrounding (nonspecific) stimuli.[5] [6]

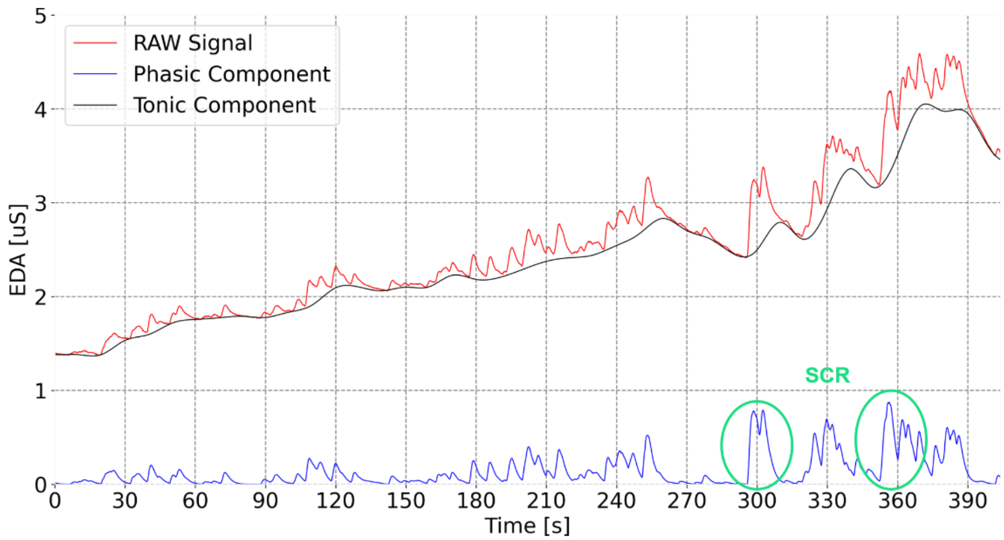


Figure 3: EDA Signal acquired with a PLUX sensor (index and middle finger) in micro Siemens with stimulus: poking the finger (~300s) and holding a hot glass of water (~360s) and other.

The phasic components are characterized by a rise with a latency of a few seconds after a stimulus. The SCR starts at an initial level and after reaching a peak it decreases slowly again almost to its initial level, see Figure 4. The initial level is usually not fully reached, and the recovery takes a longer period of time because of changes in the moisture due to the sweat elicited. The moisturized skin leads to higher conductivity. Hence the half-time recovery of around 50% or 63% is used as a measure of recovery.[6]

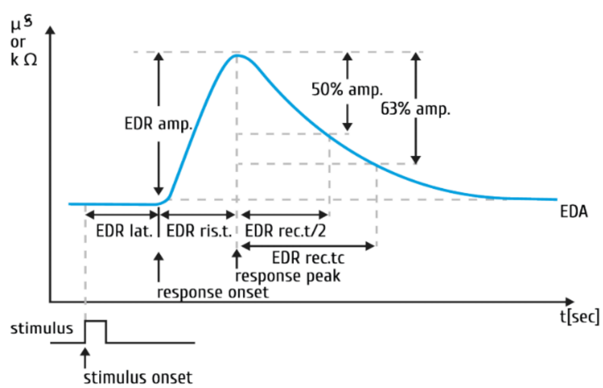


Figure 4: Skin Conductance Response (SCR): characteristic signal changes after stimulus onset.

[5] *Posada-Quintero, Hugo F., and Ki H. Chon. "Innovations in electrodermal activity data collection and signal processing: A systematic review." Sensors 20.2 (2020): 479.*

[6] *Society for Psychophysiological Research Ad Hoc Committee on Electrodermal Measures, Wolfram Boucsein, Don C. Fowles, Sverre Grimnes, Gershon Ben-Shakhar, Walton T. Roth, Michael E. Dawson, and Diane L. Filion. "Publication recommendations for electrodermal measurements." Psychophysiology 49, no. 8 (2012): 1017-1034.*

5.1.2. How to acquire an EDA?

The following image (see Figure 5) shows some examples of different body locations in which the skin conductance has been compared in previous studies with electrode positions in the armpit (1), on the fingers (2) and (11), on the palm of the hand (4), the wrist (3), (9), (10), the forehead (5), and more [2] [7]. We will have a closer look at some of these positions in the following experiments but first we will check out how to place the electrodes for the BITalino sensor.

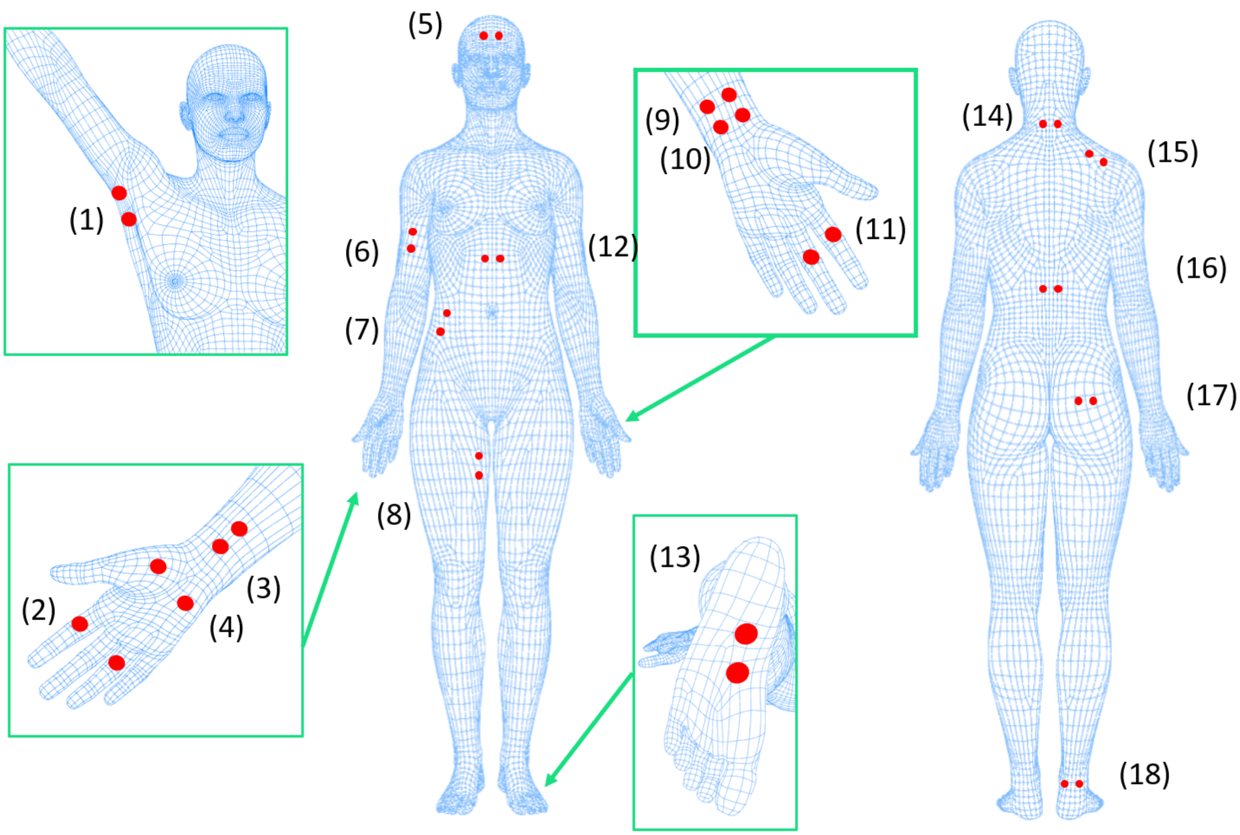


Figure 5: EDA –Electrode position examples over the body to measure and compare electrodermal activity: armpit (1), fingers (2,11), wrist (3,9,10), hand palm (4), forehead (5), arm (6), abdomen (7), thighbone (8), chest (12), foot (13), neck (14), shoulder (15), back (16), buttock (17), and calf (18).

[7] *Poh, Ming-Zher, Nicholas C. Swenson, and Rosalind W. Picard. "A wearable sensor for unobtrusive, long-term assessment of electrodermal activity." IEEE transactions on Biomedical engineering 57.5 (2010): 1243-1252.*

5.1.3. How to acquire an EDA with BITalino?

Lets have a look at your asembled EDA from the inside, see Figure 6. The sensor contains a bipolar measuring setup with two measuring pins (IN + and IN-). These two pins are connected to cables to enable the connection between the pre-gelled electrodes placed at the body surface and the sensor as we have already learned in the previous guides.

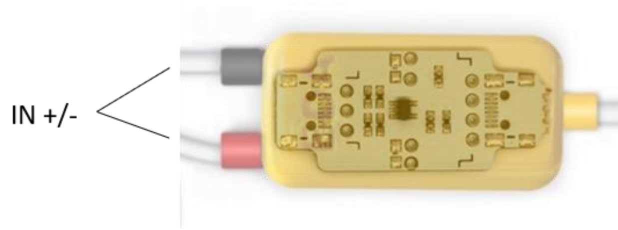


Figure 6: Assembled EDA sensor from the inside and pins for electrode connections.

The two measuring electrodes can be placed for example on the fingers, see Figure 7 in which the positive electrode (red) is placed on the index and the negative electrode (black) on the middle finger.

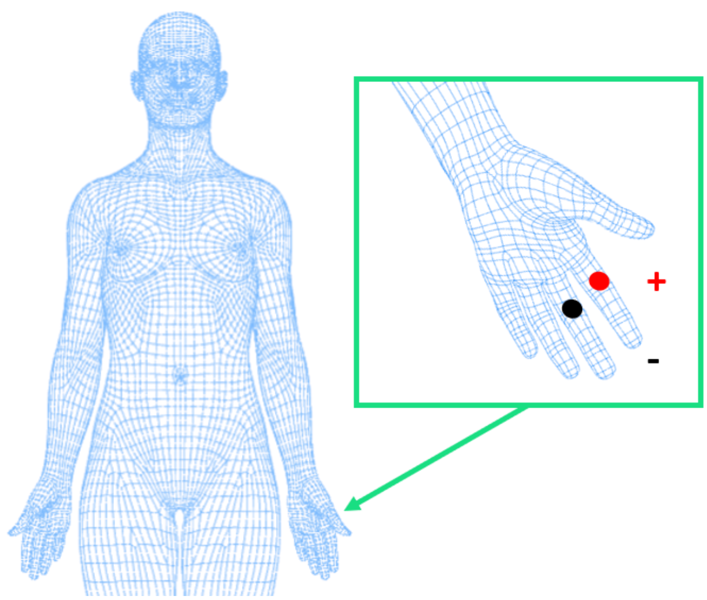


Figure 7: BITalino EDA Sensor: electrode placement example on the left hand (index and middle finger).

IMPORTANT NOTES:

- ✓ In the case of EDA recording, we need to consider that artefacts such as movements and other (such as the heartbeat) can influence our signal. To avoid the capturing of ECG related info you can adapt the sampling rate to 10Hz considering our extremely small EDA bandwidth (0-3 Hz).

5.2. Applications – What is EDA used for?

Applications in which EDA is used are for example to measure the activity of the autonomous nervous system for example in psychological research. It is used to examine cognitive and emotional states and to indicate stress level and anxiety. Skin conductance level and response are being used in research of emotional states of people with Borderline Personality Disorder (BPD) such as in this study and in behavioural research of people with Autism Spectrum Disorder (ASD) such as in this study. EDA signals are also studied in robotics in which human-robotic interactions (HRI) are examined regarding users affective states, see this study in which the focus is on children-robotic interactions.

Did you know?

➔ ***That you can influence Sweat with watching Images/Videos?***

The Center for Emotion and Attention (CSEA) at the University of Florida developed the International Affective Picture System (IAPS). It's a database of standardized photos for studies of attention and emotions that can be used in the research field of psychology. It is possible to ask permission to access the images for research purposes, see this website.

6. PROTOCOL

6.1. Body Sensor Setup on the Hand and Fingers

As the density of sweat glands is very high on the inner side of the hands and feet, the following electrode positionings are suggested to acquire an EDA signal with the assembled BITalino sensor, see Figure 8.

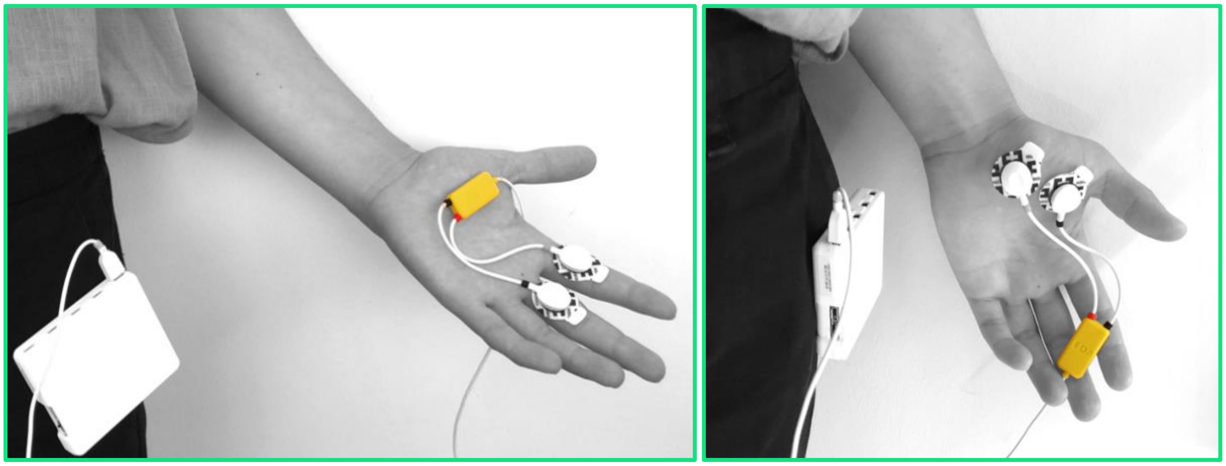


Figure 8: Electrode placement for the assembled EDA sensor with measuring electrodes IN -/+ on the index and middle finger (left) or on the thenar eminence below the thumb (right).

6.2. Data Acquisition

Review: Follow the device setup (1-2) as already explained in Home-Guide #0 and continue with steps 3-12.

1. Connect your BITalino (r)evolution Core BT
2. Testing your set-up

Live Skin Resistance with Electrodermal Activity (EDA):

3. Connect the Assembled EDA Sensor to one of the analog channels available.
4. Place the Gelled Electrodes on the two snaps of the assembled EDA ensor.
5. Place the two electrodes on the index and the middle finger as illustrated in Fig. 3 (left).
6. Start recording data on OpenSignals (r)evolution (if needed, check Home Guide #0 Section 2 to recall how this is done). Set your sampling frequency to a value that is appropriate to the sensor bandwidth according to the Nyquist Shannon sampling theorem.
7. Start recording a signal baseline with low noise, no movements, no talking, eyes closed and normal breathing for 3 minutes.
8. Perform an apnea phase in which you hold your breath for about 20 seconds.
9. Record another baseline phase of 30 seconds.
10. Perform a phase in which you hold on to a glass of hot water for a few seconds.
11. Record another baseline phase of 30 seconds.
12. Choose a stimulus of your choice to try to trigger the SCR.
13. Stop the recording and save your data.

6.3. Repeat Activities for different Locations.

Preform an acquisition using different electrode locations:

1. Fingers (index and middle)
2. Palm of the hand below thumb
3. Wrist
4. Choose one location of your interest for which you think the signal will be very distinct.

For additional information review the last Home-Guide which is available here:

HOMEGUIDE#3 and the documentation available on the previous section "RELATED DOCUMENTATION"

6.4. Elaborate your Report and answer the Quiz.

Write a report on the performed acquisitions of each brain area, following the acquisition steps mentioned in section 2. Finally, fill out the quiz and check out the additional documents for help.

IMPORTANT NOTES:

If you want to learn more about EDA:

- ✓ Check out the "Publication recommendations for electrodermal measurements"
- ✓ Check out our Publications in which our EDA sensors were used in various research fields.
- ✓ Check out this review on signal processing methods on how to extract tonic and phasic components.

7. QUIZ

In this section you can find some questions for you to work on during your Home Session and to explore the EDA sensor.

Q1. Which are the significant frequencies for EDA acquisitions?

Q2. Which kind of sources can influence the signal?

Q3. Which part of the EDA signal will be influenced by a specific stimulus? Which part can you not influence?

Q4. Show a screenshot of a relevant portion of EDA data within the experiment proposed. Does this signal correspond to what you expected? Why?

Q5. Are there any differences in the signals of the electrode locations you tested? Was the signal of you location of interest very distinct compared to the other locations?

Q6. To the best of your knowledge, does the EDA amplitude equal to the level of sweat?