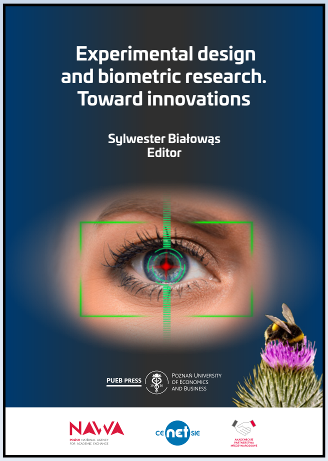

Experimental design and biometric research. Toward innovations

Sylwester Białowąs
Editor

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2.

RESEARCH ON ELECTRODERMAL ACTIVITY

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Abstract: In this chapter, a method of physiological measurements—that is detection of electrodermal activity based on the sectonic activity of eccrine sweat glands—is discussed. It is believed that the excretion of sweat, which is regulated by the nervous system acting independently of human will, is an indicator of a person's emotional arousal as a result of specific stimuli. Hence, the electrodermal reaction can be used in diagnosing emotional arousal caused by, e.g. specific products, advertisements or elements of the in-store space.

Electrical activity of the skin is caused by two types of stimuli: sustained and one-off. Sustained stimuli have a continuous effect on the body over a relatively long period of time. On the other hand, one-off stimuli have a relatively strong and very short-lasting effect. This type is defined as novel, unexpected, significant or aversive. Electrodermal activity is measured on the skin surface (Strelau, 2006).

Generally speaking, the measurement of electrodermal activity is one of the biometric measurements. Biometrics is a universal term that represents measurements of the body's physiological responses—not directly of the brain—to external stimuli that are felt through the senses (Pradeep, 2010; Berčík & Rybanská, 2017). The electrodermal method allows to measure either electrical resistance or its inverse, i.e. the electrical conductivity of the skin. These measurements are carried out while a small current flows through the skin from an external source.

Electrodermal activity measurement is performed with the use of special electrodes, electrode gels and recording devices. The available equipment for the analysis of electordermal activity is characterised by relatively low cost (compared to other devices for physiological measurements) of purchase and operation. Moreover, the electrodermal activity measurement is non-invasive and carries no risk to the health or life of the test subjects.

Keywords: customer research, electrodermal activity, emotional arousal, measurement devices, physiological measurement.

2.1. What is electrodermal activity and why consumers can be better understood by measuring it?

The electrical activity of the skin is known as electrodermal activity (EDA). Its essence lies in the electrical phenomena generated by the skin. The source of the skin's electrodermal activity are the so-called eccrine sweat glands (Cacioppo, Tassinary, & Berntson, 2007), which are mainly responsible for the secretion of sweat (*secretory theory*). Sweating is a source of conducting electricity.

The functioning of the eccrine sweat glands is regulated by the sympathetic nervous system that is part of the autonomic system (Zhai, Barreto, Chin, & Li, 2005). The centres of this system are located in the spinal cord and work on the basis of the reflex principle. This means that the increase or decrease in skin sweating (and thus the skin's electrical conductivity or resistance) is automatic and subconscious, and therefore, it cannot be influenced by a human (Cacioppo et al., 2007).

The sweat glands are distributed across nearly the entire body surface area (covering practically the entire surface of the body), totalling an amount of approximately 2 million. However, they are particularly concentrated on the forehead, cheeks, hands and feet. Glands play a thermoregulatory role in the human body. Under normal conditions, the glands excrete about 500 ml of sweat from the body per day (Sosnowski & Zimmer, 1993).

Nonetheless, thermoregulation is not the only cause of the sweat glands' work. Increased sweat excretion is also observed during the following situations (Boucsein, 2012):

1) eating meals;
2) physical impact on the skin;
3) taking medication;
4) spontaneous reaction of the glands;
5) and emotional arousal.

The sweat glands are stimulated by eating mainly acidic, very salty and spicy meals. Sweat, the source of which is food, appears primarily on the forehead, the top of the cheeks and the tip of the nose. The amount of sweat produced in this way can be considerable and thus, clearly visible. A local increase in sweating is also observed in areas of physical impact on the skin, for example, due to acupuncture, high temperature or radiation. The work of the sweat glands can also be stimulated pharmacologically (Boucsein, 2012).

However, what is really important within the context of costumer research, is the activity of sweat glands caused by the body's response to a specific type of stimuli coming from the environment. It is believed that the excretion of sweat, which is regulated by the nervous system acting independently of human will, is an indicator of the emotional arousal of a person as a result of specific stimuli. It ranges from a low-level during sleep to a high level during strong activation. It is assumed that all emotions (both positive and negative) cause increased sweating. **Hence, the electrodermal reaction can be used in diagnosing emotional arousal of consumers caused by, e.g. specific products, advertisements or elements of the in-store environment** (Galvanic Skin Response, 2016). That is why this type of sweating is called 'emotional sweating'. In other words, EDA can be used to **examine implicit emotional responses** that may occur without **conscious awareness** or are **beyond cognitive intent** (i.e., threat, anticipation, salience, novelty).

Emotional sweating, in particular, involves the glands that are located on the hands and feet. Therefore, their function is not strictly thermoregulatory. This function is revealed only at high temperatures, exceeding 30 degrees Celsius. However, in normal room temperatures, and assuming undisturbed thermoregulatory functions of the body, a high correlation was found between the work of the sympathetic nervous system and the electrodermal reactions of the skin (Wallin, 1981). It is for this reason that that their functioning is believed to be more susceptible to psychological stimuli than tasks related to thermoregulation of the body (Edelberg, 1972). An important feature of electrodermal reactions in the context of emotional arousal is their high sensitivity to stimuli of very low intensity (Boucsein, 2012).

Nevertheless, on the basis of increased sweating alone, it cannot be inferred whether the emotions evoked by a given stimuli are negative or positive (Cacioppo et al., 2007). Therefore, it cannot be precisely indicated that these changes are the result of, for example, anger, joy or fear.

2.2. Types of electrodermal activity

The electrical activity of the skin is caused by two types of stimuli (see Figure 1): sustained and one-off. Sustained stimuli have a continuous effect on the body over a relatively long period of time. On the other hand, one-off stimuli have a relatively strong but very short-lasting effect. This type is defined as novel, unexpected, significant or aversive (Cacioppo et al., 2007).

Sustained stimuli affect so-called tonic skin activity (Cacioppo et al., 2007, p. 171). Tonic activity represents relatively constant or slow changes in the electrodermal activity of the skin. This activity is known as SCL (skin conductance level). The so-called tonic activity also includes non-specific reactions (fluctuations), i.e. reactions occurring without the influence of a stimulus (Strelau, 2006). They are known as NS SCR (non-specific skin conductance response) (Cacioppo et al., 2007). It has been found that, for example, SCL is characterised by a gradual decrease in its level when a particular person is resting (i.e., not affected by stimuli and relatively still) (Strelau, 2006). On the other hand, it has been found that the increase in tonic electrodermal activity (SCL level and NS SCR frequency) is influenced by the performance of a specific task. Supporting studies were carried out by Lacey (Lacey, Kagan, Lacey, & Moss, 1963). As part of them, participants were asked to perform a variety of tasks, ranging from listening to irregular, loud sounds to solving arithmetic tasks. In the case of preparation by the participants for each task, an increase in the level of SCL in relation to the level at rest was noted. On the other hand, the performance of tasks led to a further increase in tonic level (Cacioppo et al., 2007, pp. 171–172).

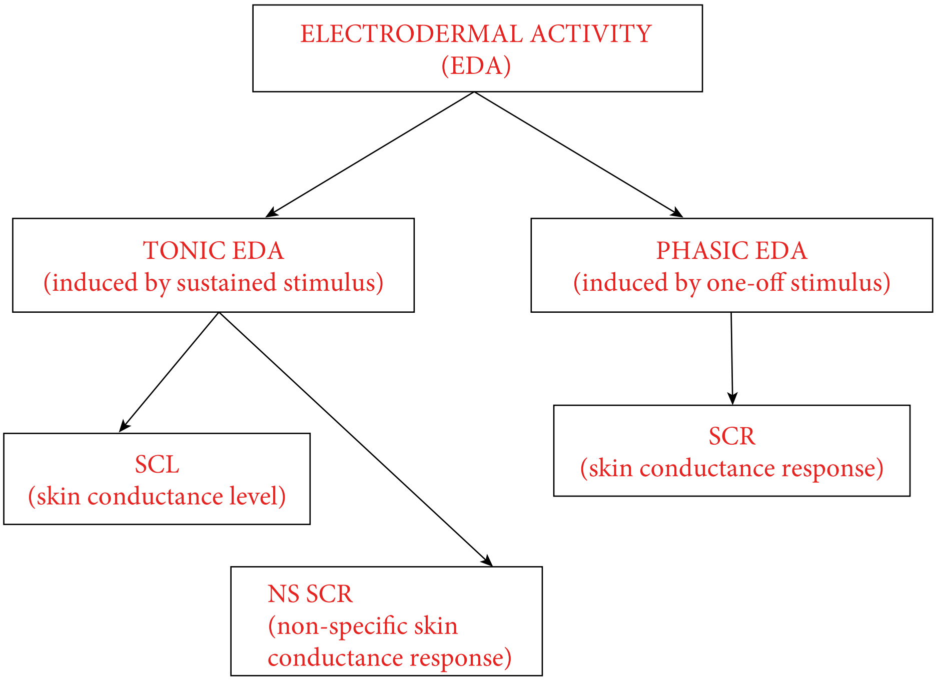


Figure. 1. Types of electrodermal activity

Source: Author's own elaboration based on (Benedek & Kaernbrach, 2010).

The electrical activity of the skin can also be phased. Phase activity reflects a sudden response to a short-term but intense stimuli through a jump in sweating. This activity is known as SCR (skin conductance response) (Cacioppo et al., 2007).

Phase electrodermal activity is a manifestation of both the orientation reflex and its habituation. The orientation response is defined as the body's response to a stimulus. The function of this reaction is to facilitate the reception of the stimulus while stopping other activities that may hinder the perception of the stimulus. The orientation reflex manifests itself simultaneously in several areas. The first of them are changes in external behaviour, manifested by stopping the tasks being performed, directing the whole body, and thus the sense organs towards the stimulus. The second area of change in physiological systems occur, for example, by increased skin sweating, slowing of heart rate, dilation of blood vessels in the head, pupil dilation, etc. The orientation response is reduced until complete disappearance (habituation) in the event of repeated specific stimulus.

Concluding, it should be stated that tonic activity reflecting slow electrodermal changes is caused by stimuli of sustained nature. On the other hand, phase activity is a relatively violent electrodermal reaction to a relatively short-term intense stimulus.

2.3. Measurement of electrodermal activity

What is actually measured?

Generally speaking, measurement of electrodermal activity is considered a biometric measurement. Biometrics is a universal term representing measurements of the body's physiological responses—not of the brain directly—to external stimuli that are felt through the senses (Pradeep, 2010; Berčík & Rybanská, 2017).

It is worth noting that emotional arousal can be detected in two ways. First, via electrical conductivity of the skin. The higher it is, the greater the sweat secretion and the greater emotional arousal. The second way is based on inverse electrical conductivity, i.e. electrical resistance. In this case, the lower the resistance, the greater the sweat secretion and emotional arousal (Białowąs & Szyszka, 2019).

Furthermore:

1) an increase in skin electrical conductivity means—a decrease in electrical resistance of the skin = emotional arousal;
2) a decrease in skin electrical conductivity means—an, increase in electrical resistance = lack of emotional arousal.

Both conductance and resistance are expressed in specific units. Thus, conductance is expressed in simens, or more often in microsiemens (mS), while resistance—in ohms (more often in kilohms) (Strelau, 2006).

Below, a description of skin conductance measurement is given.

It should be taken into account that the phase and tonic electrodermal reaction (described in the previous chapter)—manifested by an increase in skin conductivity—are measured differently.

Measuring the phase electordermal reaction to a stimulus (and thus, emotional arousal), two groups of parameters are considered: parameters characterising the size (amplitude) and duration of the reaction. The first group includes the amplitude of the reaction. That is the level to which the level of EDA has increased as a result of the influence of a specific stimulus. The second group of time parameters include (Sosnowski & Zimmer, 1993, Cacioppo et al., 2007):

1) latency time, that is, the period from the stimulus onset to the electrodermal response; there is usually a 1-4-second so called 'latency window', hence, any SCR that begins between 1 and 4 s, following stimulus onset, is considered to be elicited by that stimulus;
2) rise time, that is the temporal interval between SCR initiation and SCR peak;
3) recovery time, that is the temporal interval between SCR peak and point of complete SCR amplitude recovery.

As the recovery time is relatively extended over time and thus, there is a risk that the electordermal activity of the skin may not return to the baseline level before the onset of the next stimulus, therefore, in the research, a substitute parameter is widely used—half recovery time, temporal interval between SCR peak and point of 50% SCR amplitude recovery (Sosnowski & Zimmer, 1993, Cacioppo et al., 2007).

The analysed parameters are graphically presented in Figure 2.

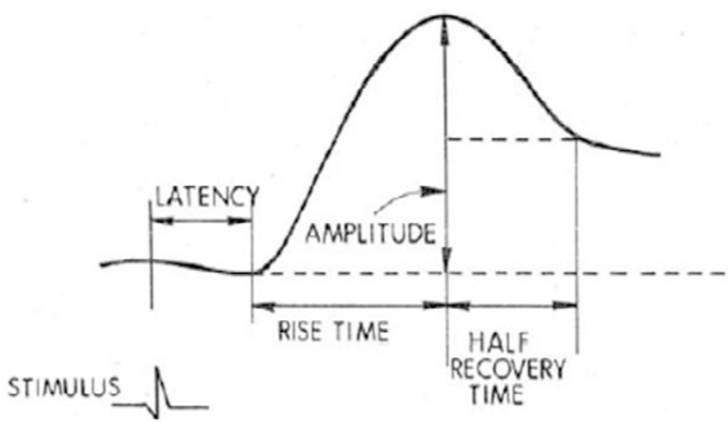


Figure 2. Parameters of phase electrodermal reaction

Source: (Cacioppo et al., 2007, pp. 165–166; Jaśkowski, 2004).

The parameters of the phase electordermal activity indicate certain regularities (Boucsein, 2012):
1) the more important a given stimulus is for a given person, the greater the amplitude of the reaction and the longer its recovery time;
2) the higher amplitude of the phase electrodermal reaction, the stronger emotional arousal is;
3) the longer recovery time a phase reaction is, the more increased the attention to a specific task.

In addition to measurement of the phase electrodermal response caused by the short-term stimuli, it is also possible to measure the response caused by the sustained stimuli (lasting over a long period of time). In this case, the change in tonic level (SCL) requires measurement. The change in tonic level is defined as the difference in its level between at least two points in time.

The measures of the tonic and phase electrodermal activity have specific, typical values (Table 1). It should be noted, however, that the electordermal reaction is very individual. It depends, inter alia, on: age, sex, race or the characteristic properties of the skin regarding the person under study (Cacioppo et al., 2007).

Table 1. Electrodermal measures, definitions and typical values

Measure	Definition	Typical values
Skin conductance level (SCL)	Tonic level of skin electrical conductivity	2–20 microSiemens
Change in SCL	Gradual changes in SCL measured at two or more points in time	1–3 microSiemens
Frequency of NS-SCRs	Number of SCRs in absence of identifiable eliciting stimulus	1–3 per minute
SCR amplitude	Phasic increase in conductance shortly following stimulus onset	0,1–1 microSiemens
SCR latency	Temporal interval between stimulus onset and SCR initiation	1–3 seconds
SCR rise time	SCR rise time	1–3 seconds
SCR half recovery time	Temporal interval between SCR peak and point of 50% SCR amplitude recovery	2–10 seconds

Source: (Cacioppo et al., 2007, p. 165).

Where is electordermal activity measured?

Electrodermal activity is measured on the skin surface (Strelau, 2006). Due to the fact that the highest sweat gland densities are on the hands and feet, these parts of the body are the main place for physiological measurements. However, the clear advantage of the hand in this respect is a consequence of the much easier usage of the measuring equipment. There is no clear suggestion in the literature as to on which hand the skin's electrical activity should be measured. The most often, the non-dominant hand is used for practical reasons. Nonetheless, the areas of the hand on which the measurement should be performed are relatively, precisely defined. These are the distal phalanges and the middle phalanges on the index and middle fingers, as well as the ball of the thumb and the little finger. Alternatively, the measurement can be carried out on the wrist. The measurement is taken by attaching electrodes to skin surface. The areas of the hand on which it is possible to measure electrodermal response (attach electrodes) are shown in Figure 3.

Figure 3. Locations for recording electrodermal activity

Source: Training materials of the NuroDevice company.

When deciding on the places where electrodermal activity is recorded, the following conditions should be taken into account:
1) recording the electrodermal activity from the subject's fingers gives a good signal (good data acquisition) but may prevent the subject from moving his/her hand freely;
2) recording the electrodermal activity from the subject's wrist makes it less difficult for the subject to move the hand, but gives a weaker signal (poorer data acquisition).

What equipment is used to measure electrodermal activity?
Measurements of electrodermal activity is performed while a small current is flowing through the skin from an external source. Therefore, this measurement cannot be done without dedicated equipment. It requires the use of special electrodes, electrode gels and recording devices. Its main element is the so-called biological signal acquisition station. The electrodes are connected to this station by a wire which, in turn, are attached (most often) to the hand of the participant under study. The obtained data is sent from the acquisition station to a computer, on which appropriate software is installed and allows for analysis. Such a set of apparatus allows to conduct research during which the participants are not required to move around.

On the other hand, research conducted in natural conditions, requiring the movement of people (e.g. inside a store), requires a slightly different configuration of the apparatus. In that case it is impossible to connect the electrodes directly to a small device that is attached to the subject's forearm with a band. It records electordermal activity data. Then, this data is sent to the computer (see: Figure 4).

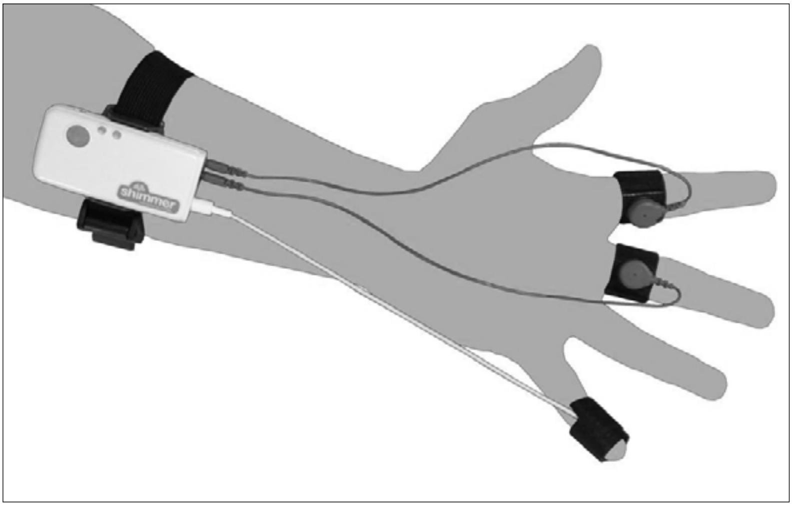


Figure 4. Example of the device used to detect electrodermal activity

Source: (Hernando-Gallego, Artés-Rodríguez, 2015).

The available equipment for analysis of electordermal activity is characterised by a relatively low cost (compared to other devices for physiological measurements) of purchase and operation. After the initial expense related to the acquisition of the measuring equipment itself, further use requires periodic purchases of appropriate consumables (gel or electrodes). Moreover, the EDA measurement is non-invasive and carries no risk to the health or life of the test subjects.

What needs to remembered when conducting electrodermal activity research?
The proper use of psychophysiological methods—including measurement of electrodermal activity—requires the application of several fundamental principles (Białowąs & Szyszka, 2019). First of all, one needs to **design an experiment in such a way that makes it possible do determine whether a given SCR is event-related (experiment related) or non-specific.** If the criteria in the experiment are too loose, one risks including non-specific SCRs into the analysis for event-related SCRs, and erroneously, this could led to misleading results. On the other hand, strict criteria may end in missing many ER-SCRs to meet the adopted criteria by wrongly discarding or misclassifying them as NS-SCRs (Braithwaite, Watson, Jones, & Rowe, 2015). Apart from a proper experiment design, there is also a set of good practices that facilitate electrodermal activity testing. They are the following:

1) the device should be put on the participant a few minutes before the test—this will improve the contact of the electrodes with the skin;
2) the respondent should be asked to perform an exercise, e.g. breathe in and out deeply (this will increase the EDA signal);
3) the right temperature should be set in the room—optimally, 22–24°C;
4) the number of artifacts related to movement should be reduced;
5) the presence of physiological activities of the body should be noted (coughing, deep inhalation, conversation)—they cause the generation of SCR;
6) a larger number of people should be recruited for the research—approx. 10% of the population is hyporesponsive.

After the examination, attention should also be paid to the record of the obtained electrodermal activity. Recordings that raise doubts should be excluded. Below, in Figure 5, a correct record of electrodermal activity is presented. In red, phase reactions are indicated. Each of them are marked with a 'drop'. Whereas in Figure 6, an erroneous record is shown. It results from the loss of contact between the electrodes and the palm of the participant at some point of the test.

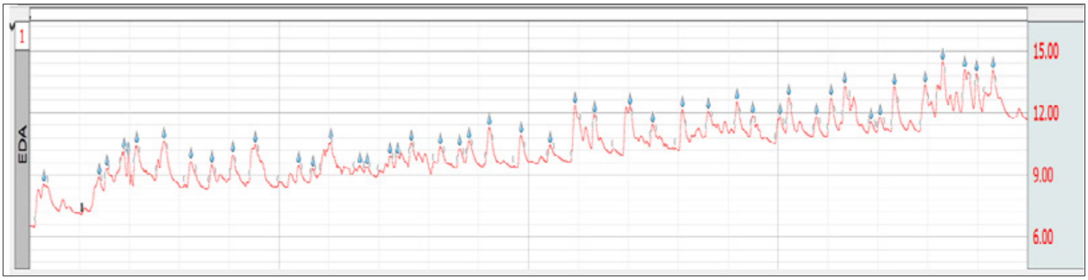


Figure 5. Record of correct tonic and phase electrodermal reaction

Source: (Pierański, 2019, p. 184).

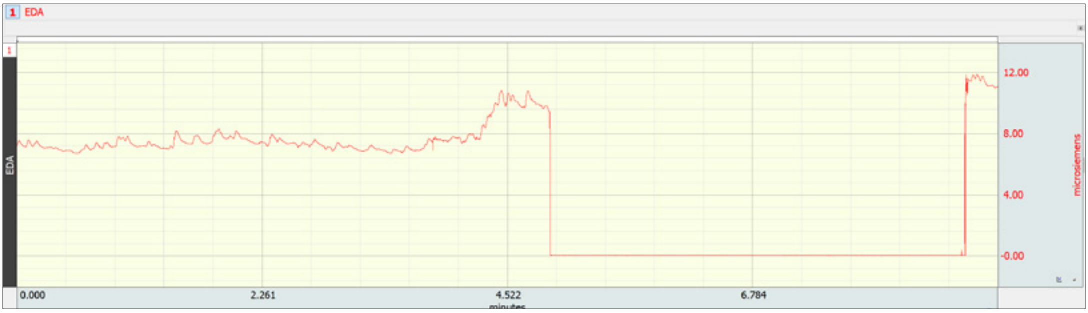


Figure 6. Record of electrodermal reaction indicating loss of contact between electrodes and skin of the participant

Source: (Pierański, 2019, p. 181).

What data can be obtained from measuring electrodermal activity?

Three measurements are used to extract information from events. These event measurements can provide quick summaries of event information, compute mean intervals between event types, and detail other operations.

There are three types of measurements of electrodermal activity:

1) Event Amplitude Measurement—extracts measurement results where events are defined:
   - Sum of amplitudes of all electrodermal reactions—presents the sum of the value for all events within the selected period of time;
   - Mean amplitude from all electrodermal reactions—presents the average amplitude value for all events within the selected period of time;
   - Minimum amplitude from all electrodermal reactions—presents the minimum amplitude value for all events within the selected period of time;
   - Maximum amplitude from all electrodermal reactions—presents the maximum amplitude value for all events within the selected period of time;
   - Median value of amplitude from all electrodermal reactions—presents the median amplitude value for all events within selected period of time;
   - Peak to peak interval of the set of amplitudes from all electrodermal reactions—takes the peak-to-peak difference from the set of amplitudes for all events (max–min);
   - Standard deviation of amplitudes from all electrodermal reactions—presents the standard deviation of the set of amplitudes for all events.
2) Event Count Measurement—evaluates the number of electrodermal reactions within the selected period of time.
3) Event Location Measurement—extracts information about the times of electrodermal reactions.

2.4. How to successfully conduct experiments on EDA (step-by-step guide)

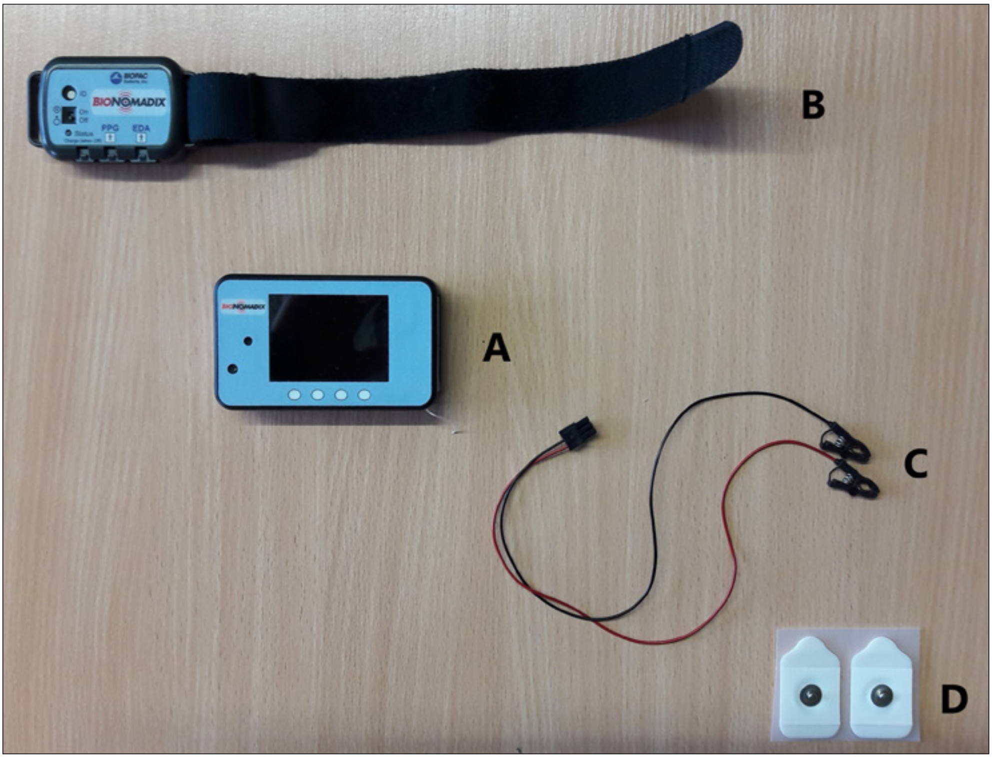
In this chapter, BIOPAC systems and software (AcqKnowledge) for EDA analysis are presented.

2.4.1. Equipment preparation

The first step in conducting experiments is to prepare relevant equipment. The research equipment that is described in the chapter consists of the following elements (see Figure 7):

1) logger—that wirelessly acquires and stores biometric data (EDA included);
2) transmitter—that applies electrical potential between two points of skin contact and measures the resulting current flow between them;
3) wire—that connects electrodes with the transmitter;
4) electrodes—two of them.

This set is suitable for conducting experiments in natural conditions, requiring the movement of people (e.g. inside a store).



A – logger, B – transmitter, C – wire, D – electrodes

Figure 7. Components of equipment used to measure EDA

Source: Own compilation.

At the initial stage of each experiment, a wireless connection between the logger and transmitter needs to be established. In order to do so, please follow the instructions presented in Figures 8–11.

Figure 8. Preparing equipment—step 1

Source: Own compilation.

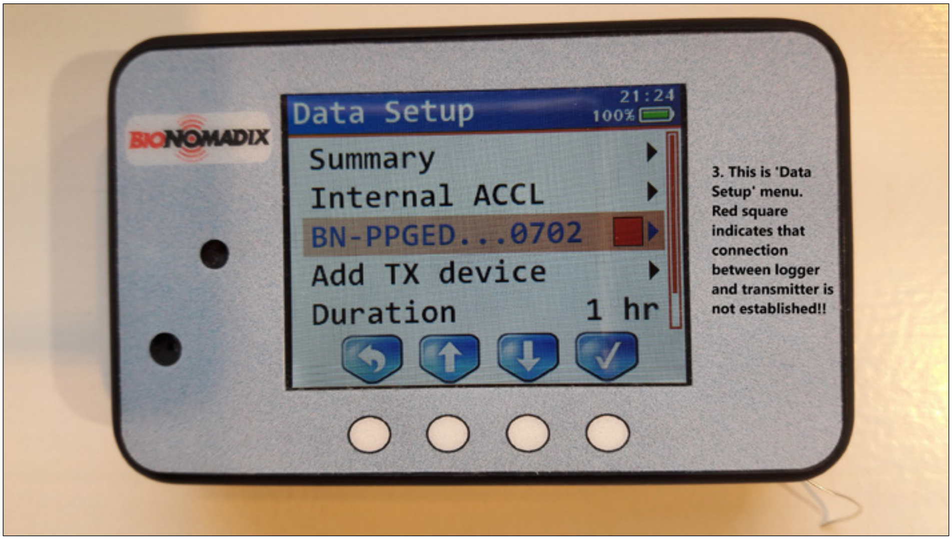


Figure 9. Preparing equipment—step 2

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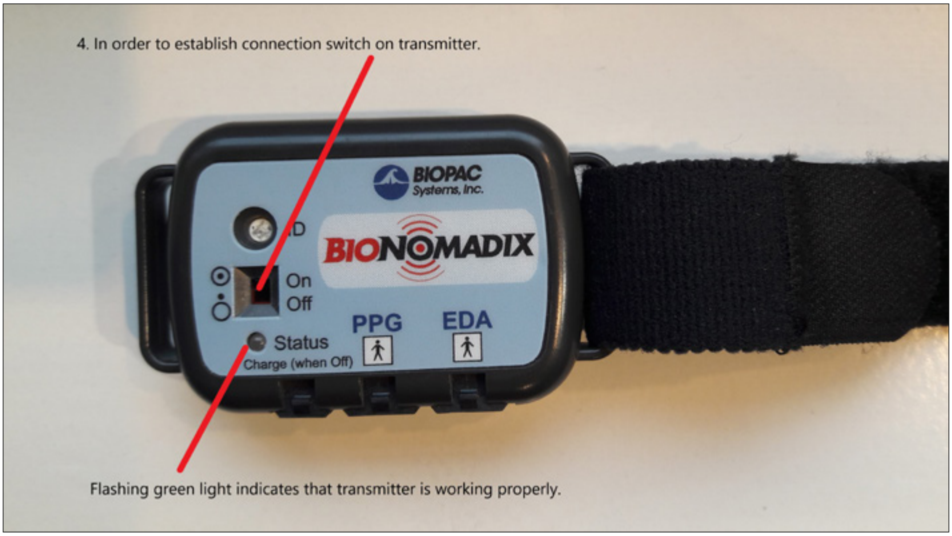


Figure 10. Preparing equipment—step 3

Source: Own compilation.

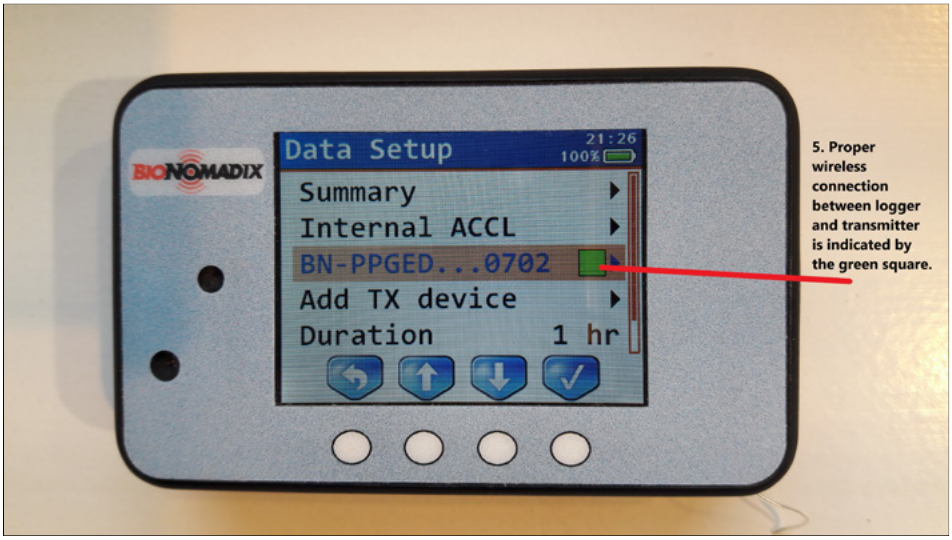


Figure 11. Preparing equipment—step 4

Source: Own compilation.

Once a connection between the logger and transmitter is established, the next step is to put the equipment on the participant's forearm. To do this correctly, please follow the sequence presented in Figure 12.

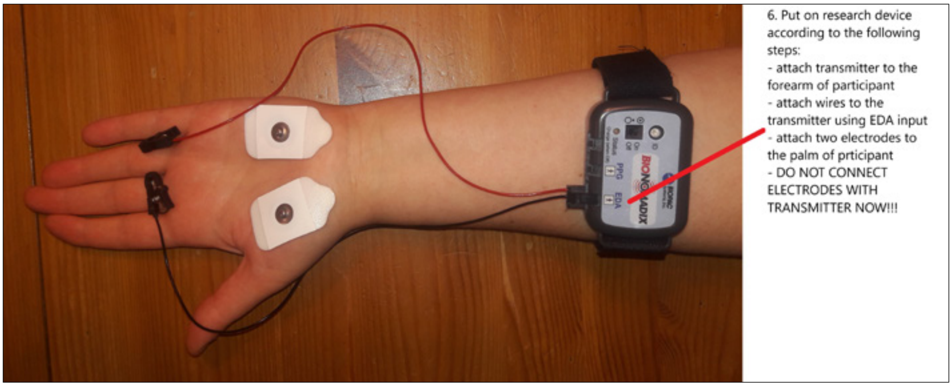
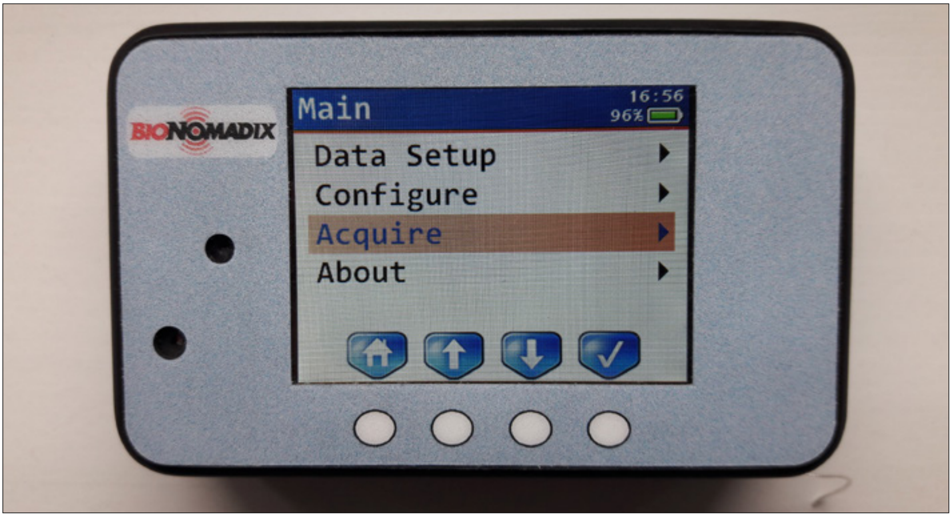


Figure 12. Preparing equipment—step 5

Source: Own compilation.

2.4.2. Acquiring EDA data

After establishing a wireless connection between the transmitter and logger, as well as putting the research device on the participant's forearm, the next part of the experiment is data acquisition. In order to record the required data, please follow the steps described in Figures 13–19.



Note: From the main menu, choose 'Acquire' by pressing the far right button.

Figure 13. Data acquisition—step 1

Source: Own compilation.

Note: From the 'Acquire' menu, choose 'Start' by pressing the far right button.

Figure 14. Data acquisition—step 1

Source: Own compilation.

Note: Confirm data acquisition by pressing the far right button.

Figure 15. Data acquisition—step 3

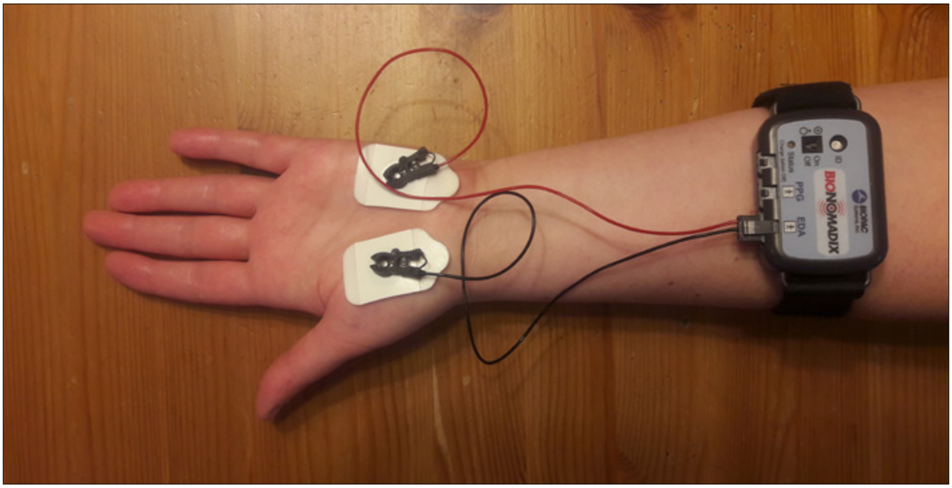
Source: Own compilation.

Note: This is what the logger screen should look like during the process of data recording.

Figure 16. Data acquisition—step 4

Source: Own compilation.

After starting the recording, electrodes can be connected to the transmitter (see: Figure 17).



Note: Proper connection of electrodes to transmitter.

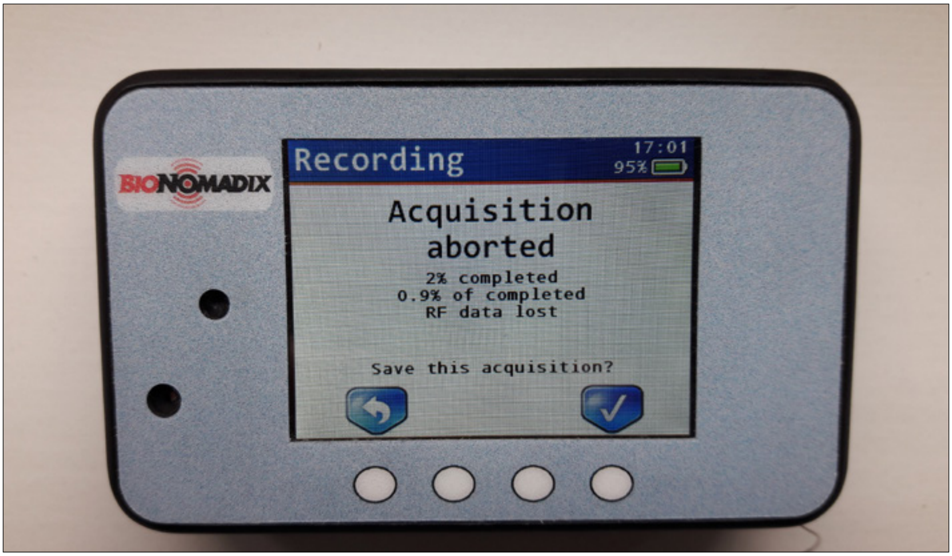
Figure 17. Data acquisition—step 5

Source: Own compilation.

Note: In order to terminate data acquisition, first press and hold the far left button for a few seconds, then press the far right button.

Figure 18. Data acquisition—step 6

Source: Own compilation.



Note: Save acquired data by pressing the far right button.

Figure 19. Data acquisition—step 7

Source: Own compilation.

2.4.3. Analysing EDA data

After acquiring data, the next step is its analysis. The logger must be connected to a computer with downloaded AcqKnowledge software. And then, follow the steps described in Figures 20–25.

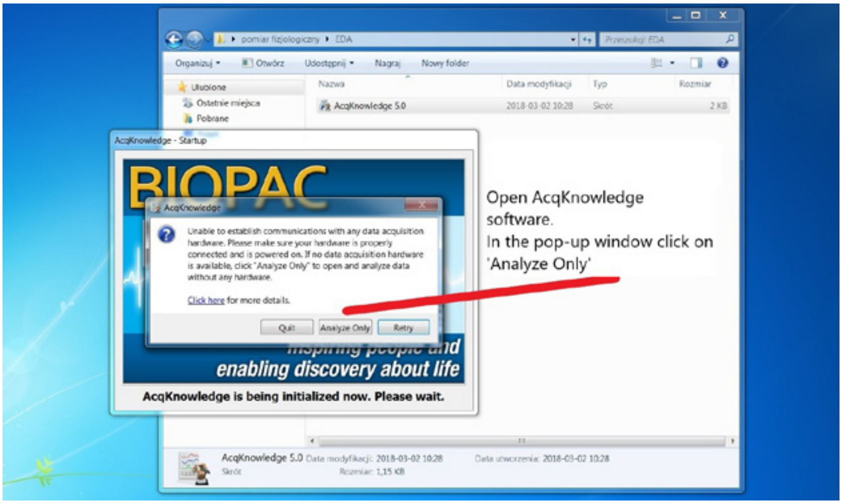


Figure 20. EDA data analysis—step 1

Source: Own compilation.

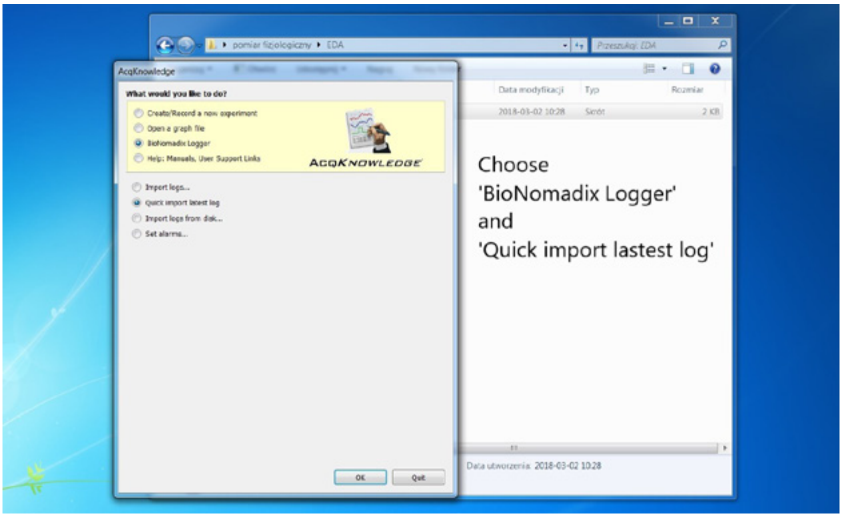


Figure 21. EDA data analysis—step 2

Source: Own compilation.

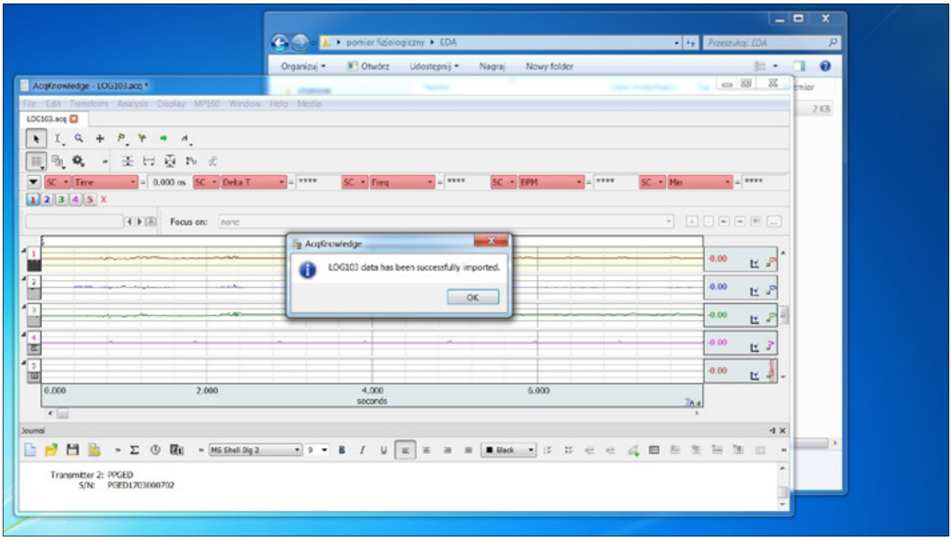


Figure 22. EDA data analysis—step 3: importing EDA data from logger to AcqKnowledge software

Source: Own compilation.

After importing data from logger, several channels (graphs) may be presented in the AcqKnowledge software. In order not to analyse graphs that not relate to electrodermal activity (in Figure 23, graphs: X, Y, Z and PPG), from the pop-up menu, select 'Channels' and unclick unwanted channels (only EDA channel should be marked). In this case, only EDA channel remains on the screen and can be analysed.

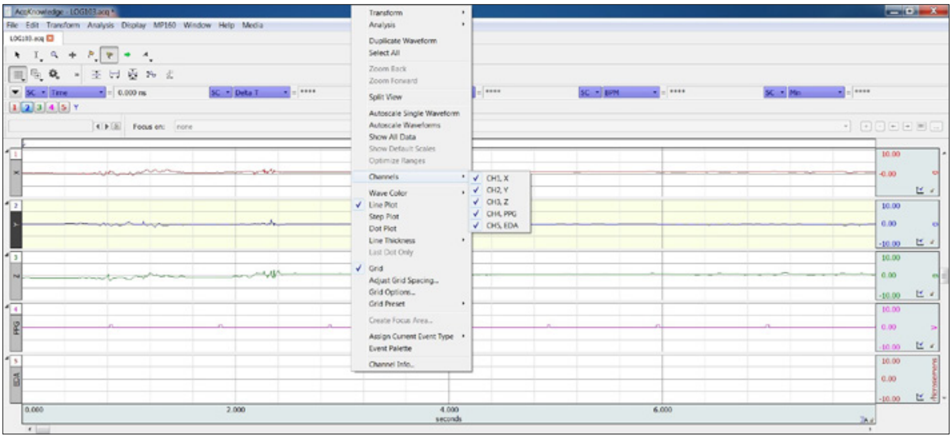


Figure 23. EDA data analysis—step 4: selecting EDA channel

Source: Own compilation.

To establish emotional response to experimental stimuli, Phasic EDA needs to be analysed. This type of electrodermal activity has to be derived from tonic EDA, that is—by default—recorded by logger. In Figure 24, the process of obtaining Phasic EDA (from the EDA channel) is presented.

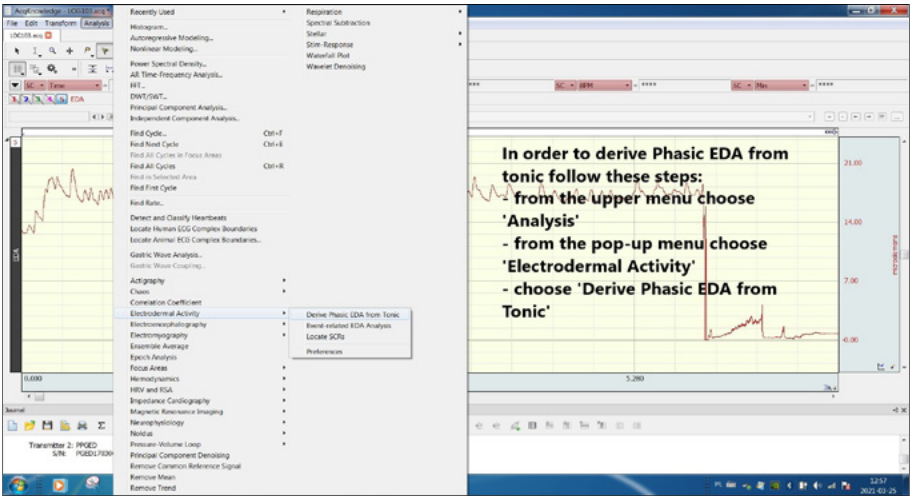


Figure 24. EDA data analysis—step 5: deriving phase EDA from tonic

Source: Own compilation.

What the screen should look like after deriving Phasic EDA from tonic is presented in Figure 25. There must be two channels: EDA and Phasic EDA (Phasic EDA is highlighted in yellow).

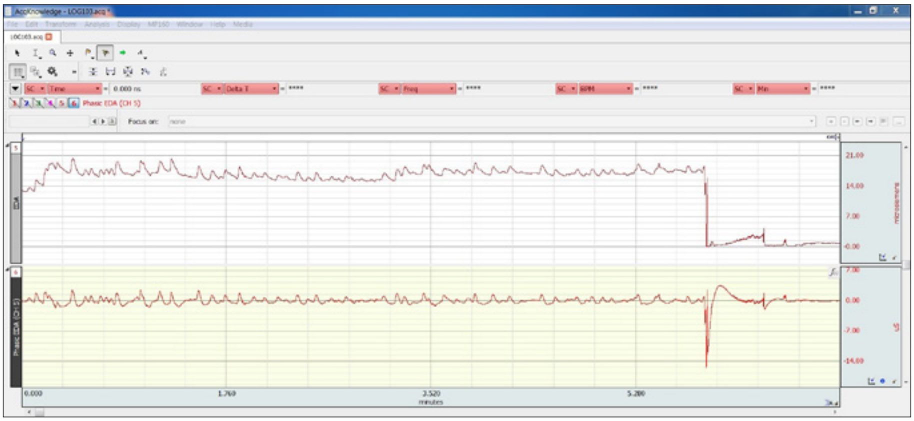


Figure 25. EDA data analysis—derived Phasic EDA (graph highlighted in yellow)

Source: Own compilation.

There are a few main ways of exploring and analysing EDA data. The most commonly used is the so-called I-Beam procedure. I-Beam analysis is based on number of electrodermal activity measurements that can be selected by the researcher. The procedure starts by choosing the required measurements from 'measurement boxes'. In Figure 26, the location of measurement boxes is provided. Please note that each measurement can be assigned to a specific channel (each graph represents one channel). In Figure 26, it can also be seen where the required channel can be set. The best option is to choose 'SC', which stands for 'selected channel'. The channel selection can be done by selecting a specific graph (by clicking it and making it highlighted in yellow). It is recommended to assign all measurements to one channel only. In Figure 27, it can be observed which measurements can be selected for each measurement box.

To provide information in measurement boxes, specific regions of the signal need to be highlighted for analysis using the I-Beam tool. This tool works in conjunction with the measurement boxes (which provide output from the region highlighted by the I-Beam tool) (Braithwaite et al., 2015). In Figures 28 and 29, it is explained how to proceed in this case.

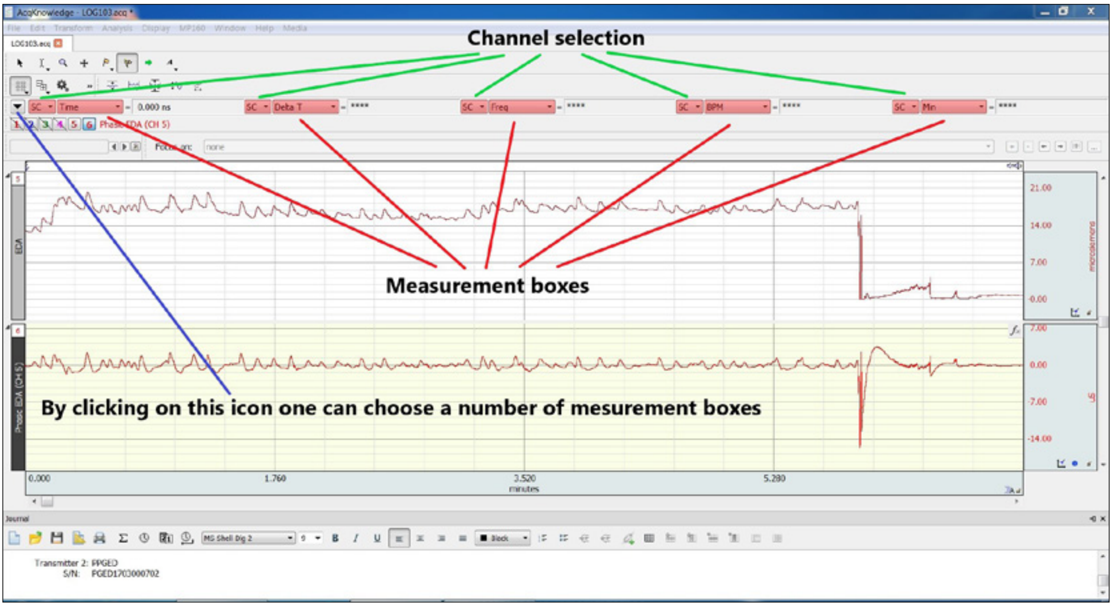


Figure 26. EDA data analysis—step 6: selecting measurement boxes and channels

Source: Own compilation.

Please note: The list pop-ups when clicking on specific measurement box.

Figure 27. EDA data analysis—step 7: choosing EDA measurements

Source: Own compilation.

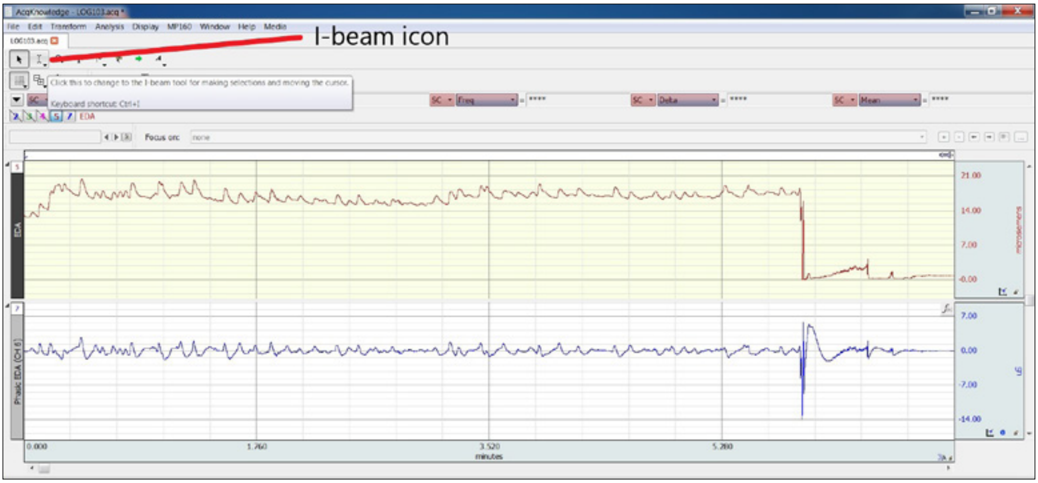


Figure 28. EDA data analysis—step 8: choosing I-Beam analysis

Source: Own compilation.

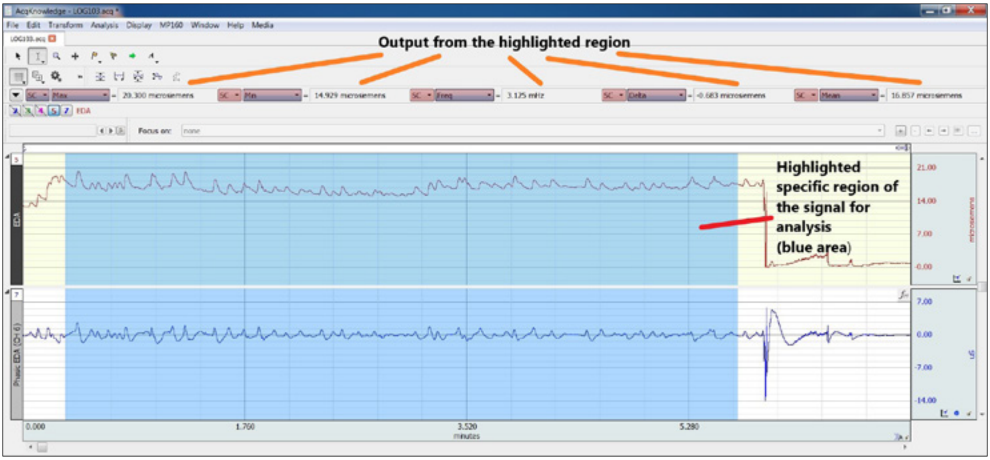
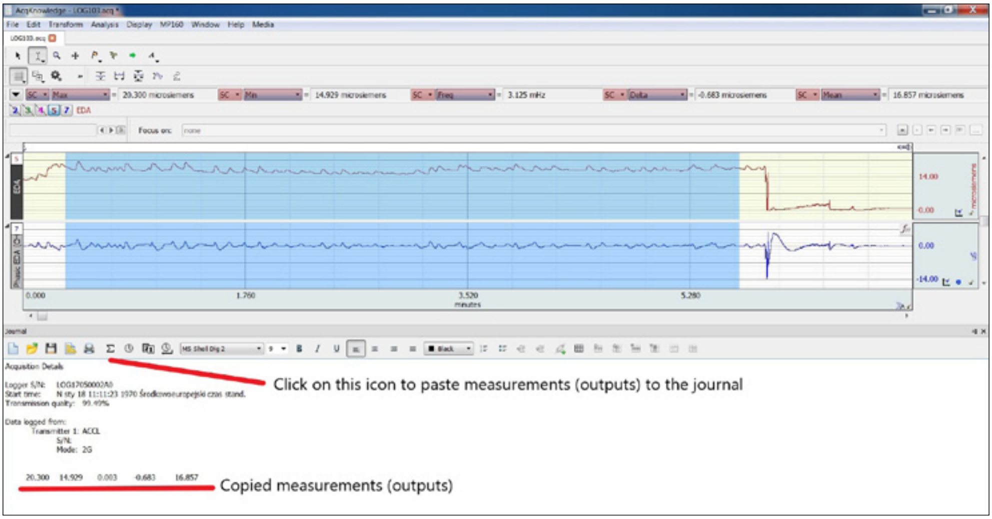


Figure 29. EDA data analysis—step 9: example of highlighted region of signal and corresponding measurement boxes providing output from the highlighted area

Source: Own compilation.

The final part EDA data analysis is to copy selected measurements to the so-called 'Journal'. This is a part of AcqKnowledge software (visible at the bottom of the screen) that allows to export data to statistical software for advanced analysis (see: Figure 30).



Please note: In Figure 30, all measurements refer to the EDA channel that is highlighted in yellow.

Figure 30. EDA data analysis—step 10: copying selected measurements to the journal

Source: Own compilation.

2.5. Case study—Perception of a humanoid robot[1]

In an effort to streamline client services in selected branches, a financial institution operating on the Slovak market wanted to find out how people react to interaction with a humanoid robot. The goal of the humanoid robot was to act as a navigator to guide the client with respect to the problem/service the client needs to solve. The institution decided to carry out a qualitative ad-hoc survey using biometric tools in order to reveal real perception and emotional feedback due to interaction with the robot.

The main objectives of the project were defined as follows:

1) information about real emotional feedback;
2) identification of stressful parts regarding the interaction;
3) comparison of the declarative part through in-depth interviews and unconscious perception.

The testing was performed using in-depth interview and biometric tools (eye-tracking and measurement of electrodermal activity), as well as by implementing the neuroimaging method of mobile electroencephalography (EEG). The experiment included 8 participants, with whom an initial interview was conducted immediately after their arrival and then, they visited the particular branch in order to interact with the robot. During the interaction with the robot, immediately after arriving to the branch, the subjects were monitored for visual and emotional feedback. After completing the practical interaction, a second in-depth interview was conducted with the respondents.

From the graph presented in Figure 31, it is possible to note the average values of skin resistance recorded during interaction with the robot. A more significant decrease in resistance and thus, a higher level of emotional arousal (nervous irritation), can be observed during eye contact with a humanoid robot and subsequent communication with it (event indicated with a red vertical line). These results can be largely influenced by the uncertainty of the respondents as to how the whole process of interaction/solution of the banking operation will take place (entering a request on the display, real communication with the robot, etc.).

The aim of the graphs in Figure 31 is to demonstrate which parts of solving the banking process were more frustrating for participants in comparison to others. The statements of 7 respondents indicating that they would appreciate if this technology became a common and everyday part at the branch of the institution, are also the proof of this.

In Figure 32, the individual values of male skin resistance are shown, in which the technology of the humanoid robot did not work properly (rotation of the head

[1] Please note that in the following case study, skin resistance was measured. In that case, the lower the level—the higher the emotional arousal.

and speech failure of the robot) due to disconnection of the remote control. Based on the observed range, one can state that this moment was very emotional for the respondent (decrease of skin resistance at approximately 1,000 kOhm).

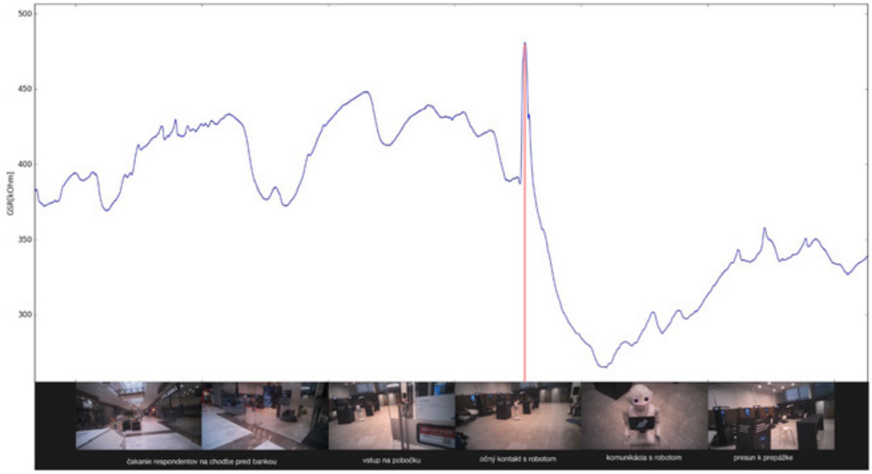


Figure 31. Average value of skin resistance (kOhm) when interacting with a robot

Source: Own compilation based on research from 2019.

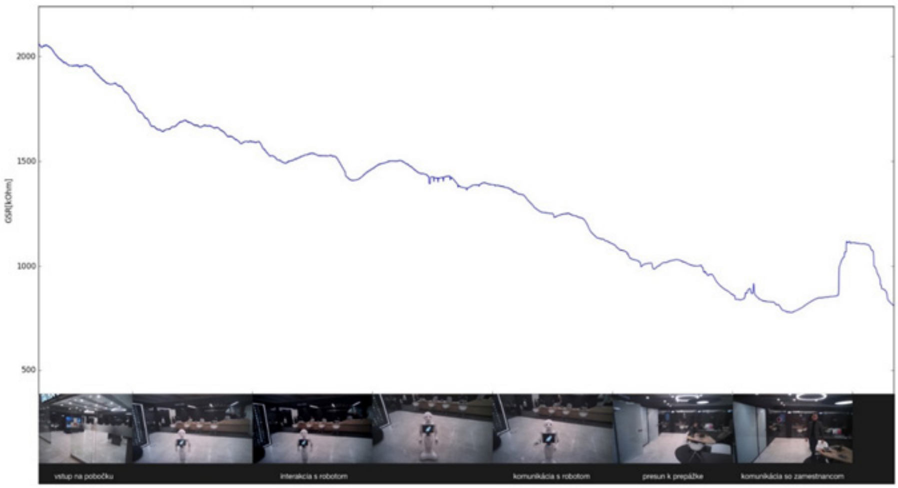


Figure 32. Average value of the skin resistance (kOhm) for an individual when interacting with a robot that did not work properly

Source: Own compilation based on research from 2019.

Although the traditional research tools are effective, there are situations in which other forms of innovative approaches are needed, mainly focused on subconscious perception. The combination of traditional and biometric tools, which include the measurement of skin resistance, appears to be an effective tool for obtaining a realistic image of human perception.

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