Lesson 9

METHOD:
GALVANIC SKIN RESPONSE &
THE POLYGRAPH

Measuring Emotional
Responses to the Acoustic
Startle Reflex: Stimulus
Habituation & Sensitization

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I. INTRODUCTION

Electricity flows through an electrical circuit because of a difference in electrical pressure between the beginning and the end of a circuit. Electrical pressure or **electromotive force** \( (E) \) is measured in volts \( (V) \). The flow of electricity, called **current** \( (I) \), is measured in **amperes** \( (A) \) or amps for short. As electricity flows through the circuit, resistance to flow occurs. Electrical **resistance** \( (R) \) is measured in ohms \( (\Omega) \).

In a simple circuit of direct electrical current, the relationship between the electromotive force causing the electrical current, the resistance to flow of electricity, and the resultant magnitude of the current is described by Ohm’s Law.

**Ohm’s Law**: \[ I \text{ (Amps)} = \frac{E \text{ (Volts)}}{R \text{ (Ohms)}} \]

If two of the three variables are known, the unknown third variable can be calculated.

*For example*, if voltage and resistance values for a simple circuit are known, the above formula can be used to calculate the value for current; if the values for current and resistance are known, then the formula for computing voltage is \( E = IR \).

Ohm’s Law implies that if a constant current is applied across a resistance, changes in the resistance will produce a voltage change directly proportional to the resistance change.

*For example*, if a constant current of 1.0 ampere is applied across a resistance of 2.0 ohms, the measured voltage would be 2.0 volts \( (I = E/R, 1.0 \text{ ampere} = 2.0 \text{ volts} / 2.0 \text{ ohms}) \). If the resistance dropped to 0.5 ohm, the voltage would also fall to 0.5 volt \( (I = E/R, 1.0 \text{ ampere} = 0.5 \text{ volt} / 0.5 \text{ ohm}) \).

In this lesson, you will apply principles of Ohm’s Law and record changes in the electrical resistance of the skin.

The human skin displays several forms of bioelectric phenomena, especially in areas of the extremities such as the fingers, palms of the hands, and soles of the feet.

- **Galvanic skin resistance (GSR)** — When a feeble electric current is steadily applied between two electrodes placed about an inch apart, the recorded electrical resistance between them, referred to as the galvanic skin resistance (GSR), varies in accordance with the emotional state of the subject.

- **Galvanic skin potential (GSP)** — Similarly, if the electrodes are connected to a suitable voltage amplifier, but without any externally applied current, the voltage measured between them, referred to as the galvanic skin potential (GSP), varies with the emotional state of the subject.

The combined changes in the GSR and GSP related to the emotion of the subject constitute the **galvanic skin response**.

The physiological basis of the galvanic skin response is a change in autonomic tone, largely **sympathetic**, occurring in the skin and subcutaneous tissue in response to a change in the affective state of the subject. Changes in peripheral autonomic tone alter sweating and cutaneous blood flow, which in turn change GSR and GSP.

*For example*, if a painful stimulus such as a pinprick is applied to the skin in an area distant to the electrode, the stimulus will reflexively elicit a general phasic sympathetic discharge to sweat glands, increasing secretion. The increase in sweat, although generally small, lowers the electrical resistance of the skin because sweat contains water and electrolytes, both of which increase electrical conductivity of the skin.
As in the case of somatic sensory stimuli (e.g., pain, pressure, touch), changes in emotion elicit changes in peripheral autonomic tone and hence the galvanic skin response. A common example is the vasodilation of cutaneous blood vessels of the face (blushing) and increased sweating that often occur in the emotional state of embarrassment.

The detection and recording of the galvanic skin response is often combined with the detection and recording of other autonomic-dependent psychophysiological variables such as heart rate, respiratory rate, and blood pressure. The device that detects and records these variables is called a **polygraph**. Although many people think polygraph is synonymous with lie detector, the literal meaning is “many measures” (*poly* - many, *graph* – write). This lesson is a polygraph in the true sense of the word since it uses three types of measures: (a) GSR, (b) respiration, and (c) heart rate.

One of the underlying principles involved in using the polygraph as a lie detector is that autonomic nervous system control of heart rate, respiratory rate, blood pressure and flow, and sweating cannot consciously be altered. Another principle is that changes in emotion associated with intentional falsification of answers to carefully selected and worded questions involuntarily and subconsciously alters autonomic output in such a way as to cause recognizable changes in recorded physiological variables.

In the experiments that follow, you will record respiration, GSR, and heart rate under various experimental procedures so as to gain a better understanding of polygraphy, its applications, and its limitations.

### II. EXPERIMENTAL OBJECTIVES

1. To become familiar with procedures for recording the galvanic skin response.
2. To observe and record changes in respiratory rate, heart rate, and skin resistance associated with emotional auditory sensory stimuli.
3. To observe and record changes in respiratory rate, heart rate, and skin resistance associated with habituation and sensitization of the acoustic startle reflex.

### III. MATERIALS

- BIOPAC disposable vinyl electrodes (EL503) – 3 electrodes per Subject
- BIOPAC Electrode lead set (SS2L)
- BIOPAC GSR setup
  - GSR transducer (SS3L) and Electrode gel (GEL1)
- BIOPAC Respiration transducer (SS5LB or older SS5LA or SS5L)
- Computer system
- Biopac Student Lab 4.0 for PC running Windows
- BIOPAC acquisition unit (MP36 with USB)
- BIOPAC wall transformer (AC100A)
- Auditory stimuli (description to be included after data collection is completed)
IV. EXPERIMENTAL METHODS

For further explanation, use the online support options under the Help Menu.

A. SET UP

**FAST TRACK Set Up**

1. You will use the recording computer to record your data and a computer for the stimulus presentation.

2. Make sure the BIOPAC MP36 unit is turned **OFF**.

3. **Plug the transducers in** as follows:
   - Respiration (SS5LB) — CH 1
   - Electrode lead set (SS2L) — CH 2
   - GSR (SS3LA or SS57L) — CH 3

4. **Turn the MP36 Data Acquisition Unit ON.**

5. **Attach** the respiratory transducer (SS5LB) to the Subject (Fig. 9.2).

**IMPORTANT**

If using the SS5LA transducer, you must be very careful to not pull or yank on the rubber bow tie portion that contains the sensor element.

**DETAILED EXPLANATION OF SET UP STEPS**

The log-in for the laptops is:
USER: \PSYALL password: Psychology1

The log-in for the desktop computers is:
USER: PSYNEURO password: Psychology1

**Fig. 9.1 Equipment Connections**

Attach the respiratory transducer around the chest below the armpits and above the nipples (Fig. 9.2). **The correct tension is critical.** The respiratory transducer must be slightly tight at the point of maximal expiration. The respiration transducer can be applied over thin clothing, such as a t-shirt.

**Fig. 9.2 SS5LB Placement**
6. Setup the GSR.

**SS3LA and GEL1**

Fill both cavities of the GSR transducer (SS3L/SS3LA) with gel and attach to the Subject (Fig. 9.4).

**IMPORTANT**

You must fill both sensor cavities with electrode gel (GEL1) before attaching to the fingers.

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**HINT**

For a good signal to be picked up, it helps if the subjects have a little sweat on their hands (not a lot, but enough so that their hands are not completely smooth or cold). If subjects wash their hands just prior to the recording or if they have been sitting in a cold room, then they must do something to activate the sweat glands before beginning calibration or recording. If subjects begin with colder hands, the scale will be diminished and the signal will be easily saturated once they “warm up” during the lesson.

You must fill each cavity of the SS3L/SS3LA GSR transducer with electrode gel to obtain accurate recordings.

The SS3L and SS3LA attach to the fingertips in an identical manner (Fig. 9.4) and should be in place for at least five minutes prior to the start of recording.

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**Fig. 9.4 SS3L/SS3LA attachment and connection**

The SS3L/SS3LA is typically placed on the index and middle finger of the left hand.

Position the transducer so that the sensor is on the bottom of your fingertip (the part without the fingernail) and wrap the Velcro® tape around the finger so the transducer fits snugly but not so tight that blood circulation is cut off. **It’s a fine line between tight and too tight.**
7. Set up the LEAD II recording.
   a) Place three disposable electrodes (EL503) on the Subject (Fig. 9.5).

   b) Attach the electrode lead set (SS2L) to the electrodes (Fig. 9.6).

8. Start the Biopac Student Lab program.

9. Choose Lesson 9 (L09-Poly-1).

10. Type in your filename. Click OK.

    END OF SET UP

Place three electrodes at the positions shown (Fig. 9.5).

- medial surface of right leg, just above the ankle bone.
- medial surface of left leg, just above the ankle bone.
- right anterior forearm just above the wrist (same side of arm as palm of hand).

To establish a LEAD II electrode configuration, each of the pinch connectors on the end of the electrode cable must be attached to a specific electrode position. Follow Fig. 9.6 to ensure that you connect each lead (color) to the proper electrode. The pinch connectors will only latch onto the nipple of the electrode from one side of the connector.

Use your last name and initials as your filename.

This ends the Set Up procedure.
B. CALIBRATION

The Calibration procedure establishes the hardware’s internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. Pay close attention to the Calibration procedure.

**FAST TRACK Calibration**

1. Seat the **blindfolded Subject** in a comfortable position with hands palm down on the countertop.

2. Click **Calibrate**.

3. Three seconds into the recording, a beep will sound and **Subject** should inhale and exhale deeply for one cycle, then return to normal breathing.

4. **Wait** for the Calibration to stop.

5. **Check** your calibration data.

- **If similar**, proceed to the Data Recording section.
- **If different**, **Redo Calibration**.

**DETAILED EXPLANATION OF CALIBRATION STEPS**

The **Subject** should be seated in a relaxed, comfortable position. The left hand with the GSR electrodes should rest on the lab bench countertop with the palm and fingers placed face down on the countertop. The subject should be wearing the headphones and the blindfold.

The **Calibrate** button is in the upper left corner of the screen.

The program needs to see a change in the GSR recording during calibration.

The Calibration will run for 10 seconds and then stop automatically, so let it run its course.

At the end of the 10-sec calibration recording, your screen should resemble Fig. 9.8.

![Figure 9.8 Sample Calibration Data](image)

All three recording channels should show some fluctuation. There should be some variation 4-6 seconds into the GSR recording from the deep inhale.

If a channel does not show fluctuation, the transducer may not be connected properly or the **Subject** may not have inhaled deeply enough. **IT IS EXTREMELY IMPORTANT THAT YOU CAN SEE SMOOTH MOVEMENT OF THE RESPIRATION CHANNEL (red line) & THAT YOU CAN SEE THE GSR (green line) DURING THE ENTIRE CALIBRATION. IF NOT, THEN REDO THE CALIBRATION AND ADJUST THE RESPIRATION BELT.**

Click **Redo Calibration** and repeat the entire calibration sequence until your data resembles the sample data.
C. RECORDING LESSON DATA

FAST TRACK Recording

1. Prepare for the recording.

DETAILED EXPLANATION OF RECORDING STEPS

Hints for obtaining optimal data:

a) The **Subject** must stay alert, quiet, and motionless during the 10 minute test.

b) The environment must be quiet.

c) Sensory input besides the recording must be kept at a minimum since almost any change in the environment may evoke a response.

d) **Subject** should be at his/her resting heart rate in a relaxed mental and physical state, and should not have performed any recent physical or mental exertion.

BEGIN RECORDING

2. Click on **Record**.

3. Begin the test by opening either ASR-Stimulus1 or ASR-Stimulus2 on the stimulus presentation computer. It is important to open the stimulus with the CoolEdit program so you can visually see when the startle and midpoint stimuli are going to occur. You will need to insert markers for each stimulus and the midpoint stimulus.

On the stimulus presentation computer, open the audio sample on the desktop “ASR-Stimulus1” or “ASR-Stimulus2” depending on the assignment of the subject in the pair. It should open in a program called CoolEdit and begin playing. If it does not begin playing there is a play button in the lower left corner of the window.

As soon as the sample opens, it will begin playing. You will see a moving cursor on the audio sample.

**Insert a marker (F9) for each tone. IMPORTANT: There is a change in stimuli at the 5 minute mark.** Insert a marker here at minute 5 for both Stimulus1 and Stimulus2.

4. Click **Suspend**.

After returning to baseline following the last tone, press suspend to pause the recording.

Make sure that your data is GOOD before quitting the experiment. SEE FIGURE 9.12 on next page for an example of good data.

A pop-up window with options will appear. Make your choice, and continue as directed.

If choosing the “Record from another Subject” option:

a) Attach the sensors per Set Up Steps 5, 6, and 7 and continue the entire lesson from Set Up Step 10.

Each person will need to use a unique file name.

5. Click **Done**.

6. Remove the sensors and clean-up.

**END OF RECORDING**

Remember to disconnect the GSR electrode and wash all of the gel out of the insets before replacing in the recording room.
V. DATA ANALYSIS

**FAST TRACK Data Analysis**

1. Enter the **Review Saved Data** mode and choose the correct file.

   Note Channel Number (CH) designations:
   - **Channel** Displays
     - CH 41 Heart Rate
     - CH 40 Respiration
     - CH 3 GSR

2. Setup your display window for optimal viewing of the first 5 seconds of the recording.

3. Set up the measurement boxes as follows:
   - **Channel** Measurement
     - CH 41 mean
     - CH 40 BPM
     - CH 3 p-p
     - CH 3 delta T

4. For each acoustic startle stimulus and the sensitization stimulus at minute 5, you will measure heart rate, respiration, and GSR

**DETAILED EXPLANATION OF DATA ANALYSIS STEPS**

Enter **Review Saved Data** from the **Lessons** menu.

The following tools help you adjust the data window:

- Autoscale horizontal
- Horizontal (Time) Scroll Bar
- Autoscale waveforms
- Vertical (Amplitude) Scroll Bar
- Zoom Tool
- Zoom Previous

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and value. The first two sections are pull-down menus that are activated when you click on them. The following is a brief description of these specific measurements.

**mean:** displays the average value for the channel for the selected area.

**BPM:** In this lesson, the BPM measurement stands for Breaths Per Minute and calculates the difference in time between the end and beginning of the selected area (same as ΔT), then divides this value into 60 seconds/minute.

**p-p:** displays the amplitude value from the minimum to the maximum point of the selected data.

The “selected area” is the area selected by the I-Beam tool (including the endpoints).

For each measurement, you will need to record a response and a baseline in the GSR Individual Data EXCEL sheet available on the course website. The Excel sheet will calculate the change from baseline. You should then and “paste special – values” those values into the GROUP data sheet.
5. MEASURING RESPIRATION:

Beginning with the first stimulus, using the I-Beam cursor, select an area from the start of the first inhale after the stimulus marker indicating the stimulus to the start of the next inhale (Fig. 9.14), and record the respiration rate (BPM) for stimulus 1a. Then, measure the distance between the start of the first inhale before the stimulus to the start of the previous inhale (i.e. a baseline measurement before the stimulus is delivered) and record the respiration rate (BPM) for stimulus 1a baseline.

Record these values on your data sheet.

The respiration transducer records chest expansion (inhalation) as positive values, and chest deflation (exhalation) as negative values. Therefore, the start of inhalation is recorded as the beginning of the ascending positive waveform.

**Note:** This measurement may be difficult to perform, depending on your data, because small dips in chest expansion can occur within the normal cycle. You must be able to distinguish the small dips from the big dips.
6. **MEASURING GSR & HEART RATE:**
   Also for the first stimulus, using the I-Bean cursor, select the data from the marker indicating stimulus 1 past the top of the GSR response to the stimulus (I would recommend 15s). Record the mean Heart Rate and the p-p GSR values on your data sheet. **NOTE THE DELTA T value.** You must now select an equivalent length (same delta T) area of the baseline prior to the stimulus and record a baseline Heart Rate and GSR.

7. Repeat Steps 5 & 6 for each of the 6 stimuli before the sensitization stimulus at minute 5, the sensitizations stimulus itself at 5 minutes, and the 6 stimuli following the sensitization stimulus.

    The Individual GSR Data sheet should automatically calculate your percent change from baseline and link to the cells in the row to copy and paste into the group data sheet. Enter your subject initials, year, sex (1=female, 2=male), and stimulus set (1 or 2) in the yellow highlighted row. Select those cells and in yellow and copy. Go to the GROUP data sheet on GOOGLE DOCS and use the EDIT → PASTE VALUES ONLY command to paste your data into the sheet.