Psychophysiology

In this experiment, you will examine techniques that are intended to measure psychological responses to stimuli. You will measure skin conductance, skin temperature, and heart rate, and see if you can use these signals to interpret autonomic responses.

Background

Psychophysiology is the study of physiological responses to behavioral stimuli. In general, psychophysiologists attempt to correlate a physiological measure, such as heart rate or electroencephalogram, with a behavioral or emotional measure as the independent variable (Stern et al., 2001). Physiological parameters commonly measured by psychophysiologists include electrodermal activity, heart rate, skin temperature and respiration rate. These variables are of interest because they respond to signals from the autonomic nervous system, which is not under conscious control.

Electrodermal activity, sometimes called the galvanic skin response (GSR) or skin conductance level (SCL), has been used as a psychophysiological measure ever since it was popularized by Carl Jung in the early 20th century (Jung, 1907). Eccrine sweat glands, present on the palmar surfaces of the hands and on the bottom of the feet, are innervated by the sympathetic branch of the autonomic nervous system. These glands act as variable resistors; as they fill with fluid, skin resistance decreases. Sympathetic activity causes an increase in sweat production, thereby increasing skin conductance. Skin conductance is expressed in microsiemens (µS), a common unit of conductance.

Skin temperature is another physiological parameter often studied by psychophysiologists. Circulation in the microvasculature is under autonomic control, and can be varied in order to regulate temperature and oxygen supply to tissues. Absolute skin temperatures differ among individuals as a function of metabolism, cutaneous fat, and health factors. However, a change in skin temperature can be brought about by a change in emotional state. Stress responses that activate the sympathetic nervous system usually result in a reduced peripheral circulation, causing a lowered skin temperature. On the other hand, a strong signal from the parasympathetic nervous system can cause a localized increase in peripheral circulation: blushing.

Lie detector tests are an example of people trying to interpret psychophysiological data. By asking someone a variety of questions and examining their physiological responses, it may be possible to determine if a person is answering a question truthfully. In most lie detector tests, sometimes referred to as polygraph tests, the examiner will record breathing, eye movement, muscle activity, heart rate, skin conductance and skin temperature. However, there is much debate as to the validity of lie detector results because many people believe that these instruments can be fooled by skilled volunteers, or are administered by biased examiners.

Required Equipment

Chart software
PowerLab
Bio Amplifier
GSR Amplifier
GSR electrodes
Thermistor Pod
Skin temperature thermistor probe
Bio Amp patient cable
Three shielded snap-on lead wires
Disposable pre-gelled ECG electrodes
Abrasive pads/gel
Deck of playing cards
Medical tape

Procedures

Set up and equipment calibration

1. Make sure the PowerLab is turned off and the USB cable is connected to the computer.

2. Connect the GSR Amplifier to the PowerLab by first attaching the I^{2}C cable from the "I^{2}C Bus" on the back panel of the PowerLab to the "Input" socket on the back of the GSR Amplifier (Figure 1). Then connect the BNC to BNC cable from the "Signal Output" port on the back of the GSR Amplifier to the BNC socket of Input 1 on the front panel of the PowerLab.

3. Connect the red and black GSR finger electrodes to the front of the GSR Amplifier (Figure 2). Do not attach the electrodes to the volunteer.

4. Turn on the PowerLab. **Note:** The GSR Amplifier must be connected to the PowerLab before turning on the PowerLab.
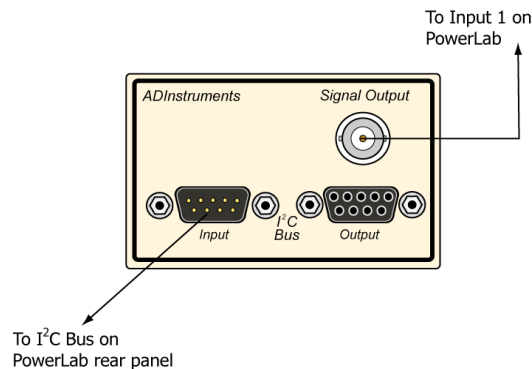

Figure 1.The rear panel of the GSR Amplifier, showing connections for the I^{2}C cable and BNC cable.

Exercise 1: Skin conductance and the startle response

In this exercise, changes in skin conductance associated with the startle response will be examined. If possible, conduct this exercise in a quiet room, away from distractions.

Zeroing the GSR Amp

The GSR Amplifier must be zeroed before starting this exercise:

1. From the Channel 1 Function pop-up menu in Chart, select **GSR Amplifier**. A dialog will appear.

2. Make sure that the GSR finger electrodes are disconnected from the volunteer, and click the **Open Circuit Zero** button in the GSR Amplifier dialog.

3. After performing the open circuit zero, attach the GSR electrodes to the volunteer as shown in Figure 3. Make sure that the volunteer removes any jewelry and has clean, dry hands.

4. Click the **Subject Zero** button in the GSR Amplifier dialog. When the zeroing process finishes, click **OK** to close the dialog and return to the Chart View.

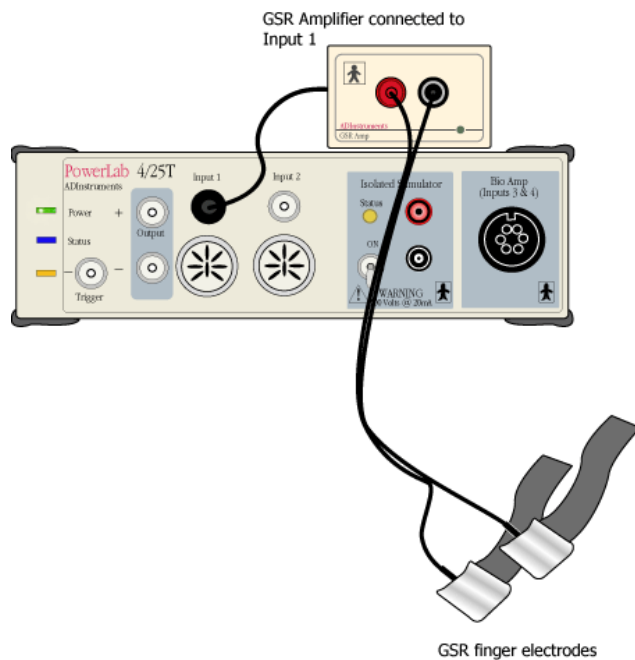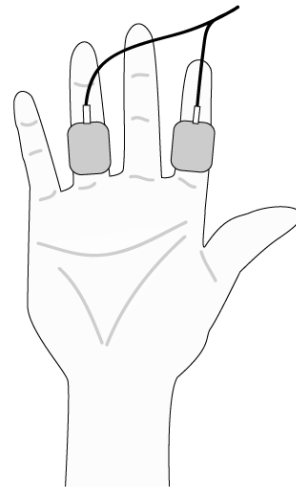Figure 3.Placement of the GSR electrodes on the hand. The hands should be clean and dry, and all jewelry should be removed prior to recording.

Figure 2.PowerLab and GSR Amplifier set up for Exercise 1.

Examining the startle response

1. Click **Start** to begin recording.

2. Add a **comment** with the volunteer's name into the Chart window.

3. The volunteer should be sitting relaxed, with their hands in their lap, facing away from the computer monitor.

4. Prepare a **comment** with "breathing." Do not enter the comment.

5. Ask the volunteer to take several deep breaths. When they do so, enter the comment by pressing the Return/Enter key on the computer keyboard.

6. Next, ask the volunteer to close their eyes and relax. Prepare a **comment** with "startle," but do not enter it into the Chart window.

7. Allow the volunteer to relax for two or three minutes. Without warning the volunteer, make a loud sound by clapping your hands together behind their head (or any other scenario you think may help to cause startle).

8. Immediately press the Return/Enter key on the computer keyboard to enter the comment into the Chart window.

9. Continue recording for one minute.

10. Click **Stop** to end the recording.

11. Remove the GSR finger electrodes from the volunteer.

12. If there is enough time, repeat this exercise for each member of the lab group.

Exercise 2: Skin conductance and skin temperature during mild stress

In this exercise, skin conductance and skin temperature during mild stressful activities will be examined. Work in groups of three or more students for this exercise.

1. Attach the Skin Temperature Probe to the back of the Thermistor Pod.

2. Connect the 8-pin DIN cable from the rear of the Thermistor Pod to the Input 2 Pod Port on the front panel of the PowerLab.
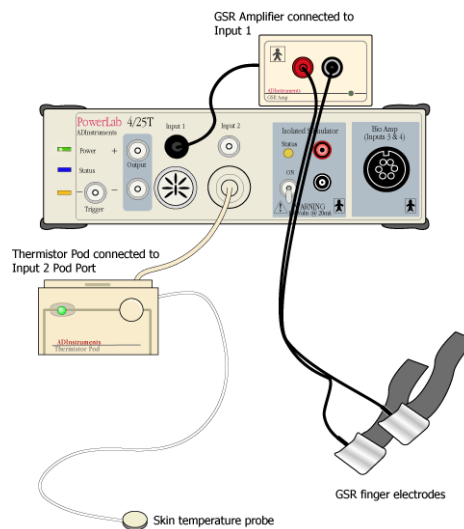

Figure 4.The PowerLab set-up for measuring skin conductance and temperature.

3. Choose a volunteer from the group to participate in this exercise.

4. Attach the Skin Temperature Probe to the palmar surface of one of the volunteer's fingers using medical tape.

5. Follow the "Zeroing the GSR Amplifier" procedure from Exercise 1. Make sure that the GSR electrodes and Skin Temperature Probe are not on the same finger.

6. Ask the volunteer to relax, and place their hands in their lap.

7. Click **Start** to begin recording.

8. Add a **comment** with the volunteer's name into the Chart window.

9. Record baseline skin temperature and skin conductance for one minute.

10. Ask a member of your group (not the volunteer) to pick a number between 500 and 800.

11. Ask another member of the group to choose an odd number between seven and thirteen.

12. Instruct the volunteer that when you say "go," to start with the first chosen number and subtract the second chosen number from it, aloud. Have the volunteer continue to subtract the second chosen number from the resulting value until you say, "stop."

13. When you say, "go," add a **comment** with "stress" to the Chart window.

14. Each time the volunteer calls out a number, add a **comment** to the data trace by pressing the Return/Enter key on the computer keyboard.

15. Allow the volunteer to perform the mental arithmetic exercise for one minute. At the end of one minute, instruct the volunteer to stop and allow them to relax.

16. Enter a **comment** with "end arithmetic" to the Chart window.

17. Continue to record for one minute, then, click **Stop**.

18. If there is enough time, repeat this exercise for the other members of your group.

Note: Perform the "Subject Zero" function for the GSR Amp with each new volunteer.

Exercise 3: A simple lie detector experiment

In this exercise, skin conductance, skin temperature and heart rate measurements will be used to determine if a subject is being truthful.
Work in groups of four for this exercise. One person will act as the *monitor*, and will operate the PowerLab and Chart. A second person will volunteer to be the *subject*, and the other two people will act as *witnesses* (witness #1 and #2).

Equipment set-up

1. Obtain the following cards from a standard deck of playing cards:

Suit	Cards
Spades	5 & 9
Clubs	2 & 10
Hearts	4 & 7
Diamonds	8 & 3

2. Attach the Bio Amp subject cable to the socket on the front panel of the Bio Amp.

3. Connect the black, green and white shielded lead wires to the Bio Amp subject cable (Figure 5).
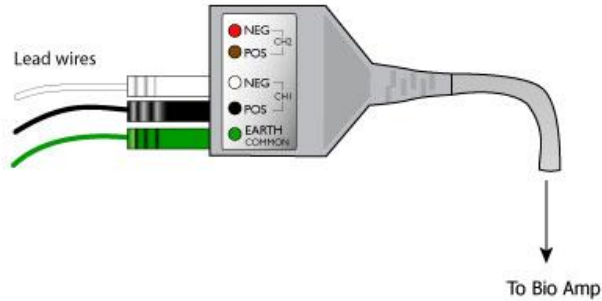
Figure 5. Connect the three lead wires to the Bio Amp subject cable as shown.

4. Lightly abrade the volunteer's skin on both wrists and right ankle with an abrasive pad/gel.

5. Attach disposable ECG electrodes to the subject's wrists and right ankle.

6. Connect the snap lead wires to the electrodes as follows:

    Green (earth): Right ankle
    Black (CH1 positive): Left wrist
    White (CH1 negative): Right wrist

7. You will need three channels to see and then save the data you are collecting.

Establishing a baseline

1. Before performing the "lie detector" test, the subject will need to answer ten "yes or no" questions that the volunteer must answer truthfully.

2. Choose ten questions from the list below to use as baseline questions.

3. Click **Start** to begin recording.

4. Add a **comment** with the volunteer's name.

5. Add a **comment** with "baseline."

6. Have the monitor ask the volunteer each of the ten pre-selected questions.

7. Each time the volunteer answers a question, add a comment on the trace with either a "+" for a "yes" answer or a "−" for a "no" answer.

8. Wait ten seconds before asking the next question in the list.

9. After the volunteer answers the ten baseline questions, continue recording and proceed to the next part of the exercise.

List of sample questions
(**Note:** words in italics can be changed to match the volunteer).

    1. Is your full name *John Smith*?
    2. Did you have *eggs* for *breakfast* this morning?

3. Do you drive a car to school?
4. Is your car a *Ford*?
5. Do you smoke?
6. Your real name is *Abraham Lincoln*, isn't it?
7. Today is *Wednesday*, isn't it?
8. Didn't you take an exam yesterday?
9. You're wearing a *hat*, aren't you?
10. Is *psychology* your favorite subject in school?
11. You don't know how to ride a bicycle, do you?
12. Did you work out at the gym yesterday?
13. Isn't your favorite dessert *chocolate ice cream*?
14. Do your friends call you "*Superman*?"
15. It's the year *1959*, right?
16. You don't have any classes tomorrow, do you?
17. Aren't you always late for work?
18. Do you like to *ski*?

Deception exercise

1. Gather the pre-selected playing cards.

2. Have witness #1 shuffle the cards, and place them face down and fanned out on the table.

3. Have witness #2 choose a card, and show it to the volunteer and witness #1. Do *not* show the card to the monitor.

4. The monitor should enter a comment into the Chart trace with "negative response."

5. Instruct the subject to respond, "no" to each question asked.

6. Witness #1 will now replace the card into the stack, face down, and re-shuffle the cards.

7. Witness #2 will turn the first card up, and show it to the monitor.

8. The monitor will prepare, but not enter, a comment describing the card, e.g., 9S for the nine of spades.

9. Have witness #2 show the card to the entire group.

10. The monitor will now ask the subject "Was your card the _____?" **Note:** the monitor should identify the card by number and suit, e.g., "three of diamonds."

11. The monitor should add the **comment** with the card suit and number into the Chart trace when the subject answers.

12. Repeat steps 7-11 for each of the remaining cards. Allow twenty seconds between each card.

13. Have witness #1 gather the cards and re-shuffle them.

14. Enter a comment into the Chart trace with "positive response."

15. Repeat the procedure in steps 5-11 above, only this time the subject should be instructed to answer "yes" every time they are asked about the card.

16. At the end of the trial, have witness #1 gather and re-shuffle the cards.

17. Enter a **comment** in Chart with "no response."

18. Repeat the exercise in steps 5-11 as before, but this time instruct the subject to remain silent as each card is turned over and the question is asked.

19. After the last card has been turned over, wait twenty seconds and then click **Stop**.

20. The monitor should now attempt to tell the subject what card was picked, based on the data for skin temperature, skin conductance and heart rate.

21. Disconnect the electrodes from the volunteer and repeat this exercise with other members of the group if time permits.

Analysis

Exercise 1: The startle response

1. Examine the data in the Chart View window.

2. Place the marker on the data trace where the comment was added, signifying a stimulus.

3. Place the waveform cursor on the peak in the skin conductance tracing.

4. Record the change in amplitude and the latency (time from stimulus onset to peak response) in Table 1 of the Data Notebook.

5. Repeat steps 2-4 for the other stimulus events in the recording.

6. Calculate the mean skin conductance change and mean latency and record the values in Table 1 of the Data Notebook.

7. If this exercise was performed on other people in the group, record their average response and latency separately from other people's data.

Exercise 2: Skin conductance and skin temperature during mild stress

1. Examine the data in the Chart View window.

2. Select data in both channels from the first minute of the trace, before the subject was asked to perform mental arithmetic.

3. Click the Data Pad button from the Chart Toolbar.

4. The Data Pad will appear, and display the average values for skin conductance and skin temperature in columns one and two.

5. Record these values in Table 2 of the Data Notebook under the heading "Baseline Values".

6. Return to the Chart View window, and examine the data in the section of the trace during which the volunteer was performing mental arithmetic.

7. Each blank comment represents when the subject announced a number. Select several seconds of data around the first blank comment. Return to the Data Pad by clicking the Data Pad button from the Chart Toolbar. Record the average skin conductance and skin temperature in Table 2 of the Data Notebook under the heading "Stress".

8. Repeat steps 6-7 for each of the blank comments in the mental arithmetic section of the data trace.

9. Select the last thirty seconds of the recording (the relaxation period), and determine the mean skin temperature and skin conductance values. Record them in Table 2 of the Data Notebook under the heading "Recovery."

10. If this exercise was performed on multiple group members, each person in the group should record their own results and then share them with the other members of the group or class.

Exercise 3: A simple lie detector experiment

Baseline data

1. Examine the data from the baseline question segment of the recording.

2. Using the waveform cursor, determine and record the skin conductance, skin temperature and heart rate ten seconds before and ten seconds after each question was answered. Record these values in Table 3 of the Data Notebook.

3. Determine the change in skin conductance, skin temperature, and heart rate for each of the baseline questions, and enter the values in Table 3 of the Data Notebook.

4. Calculate the average change in skin conductance, skin temperature and heart rate for the volunteer subject and record the values in Table 3 of the Data Notebook.

Deception exercise

1. Examine the section of the recording that contains the subject's negative responses during the deception exercise.

2. Determine the skin temperature, skin conductance and heart rate ten seconds before and ten seconds after each card was shown, as indicated by the comment.

3. Record these values for each card in Table 4a.

4. Repeat this procedure for the positive responses and the "no response" sections of the recording. Record the data for positive responses in Table 4b, and the "no response" values in Table 4c.

5. Calculate the change in skin temperature, skin conductance, and heart rate after the card was shown and the question asked.

6. Attempt to determine which card was chosen, based on the results.

7. Record the actual card chosen in the Data Notebook.

Data Notebook

Table 1.Skin conductance and the startle response.

Stimulus Event	Change in skin conductance after stimulus (µS)	Latency (s)
1		
2		
3		
4		
	Average skin conductance response (µS)	Average latency (s)

Table 2.Skin conductance and skin temperature in response to mild stress.

Baseline Values		Stress		Recovery	
Skin conductance (µS)	Skin Temperature (°C)	Skin conductance (µS)	Skin temperature (°C)	Skin conductance (µS)	Skin temperature (°C)

Table 3. Baseline data for the lie detector experiment

Question#	Response (+/-)	Skin Conductance (µS)			Skin Temperature (°C)			Heart Rate (BPM)		
		Before Question	After Question	Difference	Before Question	After Question	Difference	Before Question	After Question	Difference
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Table 4a. Results from the lie detector experiment when the volunteer gave only negative responses

Card	Skin Conductance (µS)			Skin Temperature (°C)			Heart Rate (BPM)		
	Before Question	After Question	Difference	Before Question	After Question	Difference	Before Question	After Question	Difference
5 of Spades									
9 of Spades									
2 of Clubs									
10 of Clubs									
4 of Hearts									
7 of Hearts									
3 of Diamonds									
8 of Diamonds									

Table 4b. Results from the lie detector experiment when the volunteer gave only positive responses

Card	Skin Conductance (µS)			Skin Temperature (°C)			Heart Rate (BPM)		
	Before Question	After Question	Difference	Before Question	After Question	Difference	Before Question	After Question	Difference
5 of Spades									
9 of Spades									
2 of Clubs									
10 of Clubs									
4 of Hearts									
7 of Hearts									
3 of Diamonds									
8 of Diamonds									

Table 4c. Results from the lie detector experiment when the volunteer gave no response.

Card	Skin Conductance (µS)			Skin Temperature (°C)			Heart Rate (BPM)		
	Before Question	After Question	Difference	Before Question	After Question	Difference	Before Question	After Question	Difference
5 of Spades									
9 of Spades									
2 of Clubs									
10 of Clubs									
4 of Hearts									
7 of Hearts									
3 of Diamonds									
8 of Diamonds									

Table 5. Predictions from the deception exercise.

Predicted Card	Actual Card

Study Questions

1. Define latency.

    ## What do you think:

2. Does the subjects' skin conductance increase or decrease in response to being startled? Why?

3. Will there be a noticeable change in the volunteer's skin temperature during mild stress? Does skin temperature increase or decrease during stress? What branch of the autonomic nervous system is active during stress? Please explain.

4. How are you able to determine from the data which card was chosen? Which variable or variables are most informative for your decision? Please explain.

5. In many countries, polygraph (lie detector) results are not admissible as evidence in a court of law. Why do you suppose this is?

6. Design a circuit to measure galvanic skin conductance.

7. What are other applications of skin conductance response analysis?