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II. EXPERIMENTAL OBJECTIVES

1) Introduce the concept of biofeedback training for relaxation.
2) Measure levels of arousal via heart rate and electrodermal activity (EDA).

III. MATERIALS

- BIOPAC Disposable Electrodes (EL503,) 2 electrodes per Subject
- BIOPAC Electrode Lead Set (SS2L)
- Watch with second hand or stopwatch
- Earplugs (2 per Subject) - Optional
- BIOPAC EDA setup
  - Disposable Setup: EDA Lead (SS57L) and EDA Electrodes (EL507 x 2)
  - Reusable setup: EDA Transducer (SS3LA/L) and Electrode Gel (GEL101)
- Biopac Student Lab System: BSL 4 software, MP36, MP35 or MP45 hardware
- Computer System (Windows 8, 7, Vista, XP, Mac OS X 10.5 – 10.8)

IV. EXPERIMENTAL METHODS

A. SETUP

FAST TRACK Setup

1. Turn the computer ON.
2. Turn **OFF** MP36/35 unit.
3. **Plug the equipment in** as follows:
   - EDA setup (SS3L or SS57L)—CH 1
   - Electrode Lead Set (SS2L) —CH 2
4. Turn **ON** the MP36/35 unit.
5. Select a **Subject** who ideally:
   - Has not exercised within the last hour.
   - Has not recently consumed caffeine or other stimulants.
6. Place the EDA Transducer on the index and middle finger of left hand.

Setup continues…

Detailed Explanation of Setup Steps

Fig. 14.1

Biofeedback may not work well if the **Subject's** heart rate and/or EDA are at elevated levels.

If **Subject** is cold or has just washed hands, it is advisable to thoroughly dry and warm them before recording.

EDA cannot be measured correctly unless there is good contact between the electrodes and the skin.

- **If using SS57L EDA Lead and EL507**

If electrode is dry, apply a small amount of isotonic gel (GEL101).

Attach two EL507 electrodes to **Subject's** fingertips and clip the SS57L Lead, as shown in Fig. 14.2.

Fig. 14.2 SS57L and EL507 Setup

- **SS3LA and GEL101**

→ **Clean and fill** both cavities of the EDA Transducer (SS3L/SS3LA) with isotonic gel and then **attach** to the **Subject** (Fig. 14.3).

- CLEAN: Each cavity of the EDA Transducer should be carefully cleaned after use to remove any residue from the electrode.
- FILL: Fresh isotonic gel (GEL101) must fill the cavity to create contact between the skin and the electrodes.

Position the electrodes over the pads of the fingers and wrap the Velcro® tape so the electrodes fit snugly but not so tight that blood circulation is cut off.

Fig. 14.3 SS3L/SS3LA attachment and connection

7. Set up the ECG LEAD II recording.
   a) Clean and abrade skin.
   b) Attach two electrodes on **Subject** as shown in Fig. 14.4.
   c) Connect the Electrode Lead Set (SS2L) to the electrodes following the color code (Fig. 14.4).
      - WHITE = RIGHT wrist
      - RED = LEFT ankle
      - BLACK = NO connection

If the skin is oily, clean electrode sites with soap and water or alcohol before abrading.

If electrode is dry, apply a drop of gel.

Remove any jewelry on or near the electrode sites.

Place one electrode on the medial surface of the LEFT leg, just above the ankle. Place the second electrode on the right anterior forearm at the wrist (same side of arm as the palm of hand).

DO NOT connect the BLACK lead as ground is obtained through one of the EDA leads.

IMPORTANT: Make sure the Black lead does not come in contact with any metal surface; place tape around the connector as a precaution.

For optimal electrode contact, place electrodes on skin at least 5 – 10 minutes before start of Calibration.

Fig. 14.4 Lead II electrode and lead setup

Setup continues…

8. **Start** the Biopac Student Lab Program.
9. Choose lesson **"L14 – Biofeedback"** and click **OK.**
10. Type in your filename.
11. Click OK.

Start Biopac Student Lab by double-clicking the Desktop shortcut.

No two people can have the same filename, so use a unique identifier, such as **Subject's** nickname or student ID#.

A folder will be created using the filename. This same filename can be used in other lessons to place the **Subject's** data in a common folder.

Optional: Set Preferences.

- Choose File > Lesson Preferences.
- Select an option.
- Select the desired setting and click **OK**.

This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:
Grids: Show or hide gridlines

Lesson Recordings: Specific recordings may be omitted based on instructor preferences.

END OF SETUP

B. CALIBRATION

Calibration establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimal performance. **Pay close attention to Calibration**.

FAST TRACK Calibration

1. **Subject** is seated, relaxed, breathing normally, and facing monitor (Fig. 14.5).

Detailed Explanation of Calibration Steps

The **Subject** should sit with arms relaxed at side of body and hands apart in lap, with legs flexed at knee with feet supported.

Fig. 14.5 Proper seating position.

2. Click **Calibrate.**
3. Four seconds after Calibration begins, a beep will sound. When heard, Subject will inhale once quickly and deeply, and then return to normal breathing.

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

The **Subject** should try to minimize chest movement, as this may cause excessive EMG artifact.

4. Wait for Calibration to stop.

Calibration lasts 20 seconds.

5. Verify recording resembles example data.
   - If similar, click **Continue** and proceed to Data Recording.
   - If necessary, click **Redo Calibration**.

The EDA data should increase a few seconds after the deep inhale/exhale then slowly return to baseline. The ECG waveform should have a baseline at or near 0 mV, no excessive EMG artifact, and no excessive baseline drift before or after the deep inhale/exhale. The Heart Rate (BPM) data will not be valid until after the first two cardiac (ECG) cycles after which there should not be sporadic variations that go out of the visible range.

Calibration continues…

END OF CALIBRATION

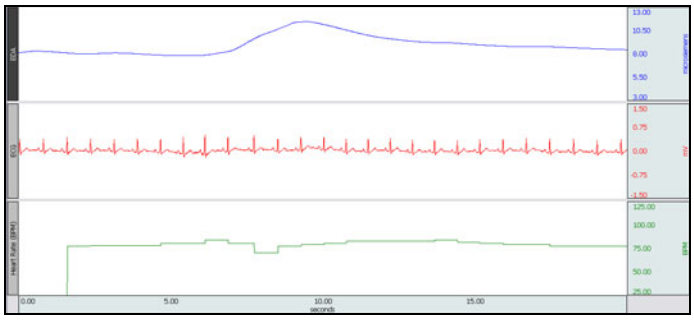

Fig. 14.6 Example Calibration data

If recording does not resemble the Example Data…

- If no beep was heard, redo Calibration and perform deep, quick, inhale/exhale after four seconds.
- If data is noisy or flatline, check all connections to MP unit.
- If EDA channel shows no variation, check that electrodes are making good contact with finger tips.
- If the ECG displays excessive baseline drift or EMG artifact, or if the Heart Rate (BPM) data shows sporadic values:
  - Verify ECG and EDA electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
  - Make sure Subject is in a relaxed position

  Note that slight baseline shifts are expected during deep inhale/exhale.

NOTE: The electrodes should be on the Subject for 5 – 10 minutes prior to Calibration. This will allow the gel to make good contact with the skin and ensure a good signal.

C. DATA RECORDING

FAST TRACK Recording

1. Prepare for the recording.
   - **Subject** is seated and relaxed, facing monitor.
   - **Review** recording steps.
2. Click **Record**.
3. **Subject** must focus on the bars and concentrate on relaxing, so both bars move down.
4. Record for 90 seconds. (Use stopwatch to keep time and then press the F9 key to insert event marker.)
5. **Subject** must focus on the bars and concentrate on arousal so both bars move up.
6. Record for 90 seconds. (Use stopwatch to keep time.)
7. Click **Suspend.**

Recording continues…

Detailed Explanation of Recording Steps

In this lesson recording, **Subject's** Heart Rate and EDA will be plotted in a thermometer style bar chart. (Fig. 14.7)

The **Subject** must concentrate on the display and try and change the readings without physical movement. Heart Rate and level of arousal (EDA) may be changed independently of each other.

The **Subject** should have minimal distractions during the recording. If the lab is excessively noisy, earplugs may be worn.

NOTE: The graph's horizontal time scale is not visible when the bar chart is onscreen. **Recorder** must use a watch or stopwatch to monitor the 90-second recording length.

Each channels visible range was set using the calibration data. Because baseline heart rate and EDA can change over time, best results are obtained by starting the recording soon after calibration.

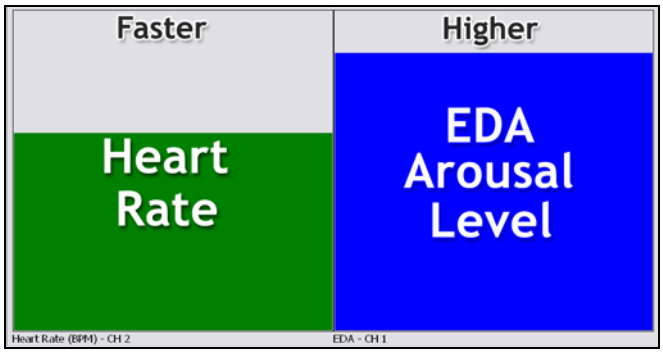

Fig. 14.7 Heart Rate and Arousal (EDA)

Hints for achieving relaxation:

- Relax your posture.
- Breathe in and out very slowly.
- Imagine yourself at warm, relaxing seashore.

Hints for achieving arousal:

- Think of a stressful situation.
- Get angry.
- Imagine yourself in a rigorous workout.

After clicking **Suspend**, the data window will change to display a standard three-channel recording with ECG, Heart Rate, and EDA. This data represents the entire recording.

8. Verify recording resembles the example data.
   - If similar, click **Continue** to proceed to optional recording section, or click **Done** if finished.

The data can vary greatly from person to person. If the **Subject** was able to manipulate his/her physiological responses to some degree, the average Heart Rate and EDA level would be lower for the first half of the recording. Note that Heart Rate (BPM) data will only be valid a few seconds after the start of the recording (after second cardiac cycle).

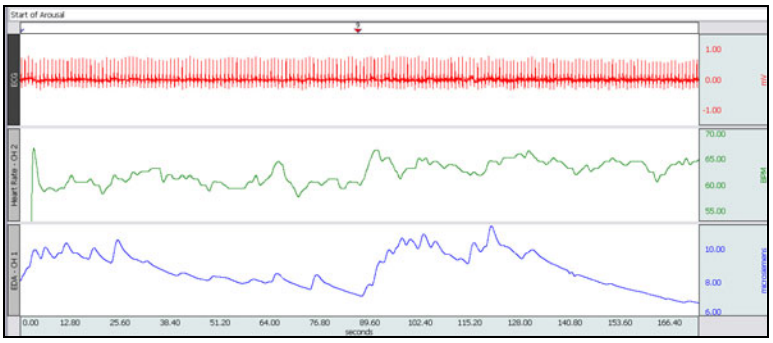

Fig. 14.8 Sample data

- If necessary:

  Click **Redo** and repeat Steps 2 – 8.

  OR

  Re-run the lesson to **Redo** Calibration.

If recording does not resemble the Example Data…

- If the event marker is missing, it can be inserted manually by right-clicking in the event region and choosing "Insert New Event" from the contextual menu. (The new event can be accurately placed at the correct location by holding down the Alt key and dragging.)
- If data is noisy or flatline, check all connections to MP unit.
- If the ECG displays excessive baseline drift or EMG artifact, or if the Heart Rate (BPM) data shows sporadic values:
  - Verify ECG and EDA electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
  - Make sure **Subject** is in a relaxed position
- If EDA channel shows no variation, make sure both electrodes are making good contact with finger tips.
- If Heart Rate or EDA data goes out of the visual range for extended periods of time, you may need to re-run the lesson and re-calibrate to adjust baseline values. To re-run the lesson:
  - Click Redo.
  - Choose "**L14 – Biofeedback"** from the Lessons menu.
  - Re-enter your name and proceed with calibration and recording.

Note that once **Redo** is clicked or the lesson is re-run, the most recent recording will be erased.

Recording continues…

OPTIONAL ACTIVE LEARNING PORTION

With this lesson you may record additional data by clicking **Continue** following the last recording. Design an experiment to test or verify a scientific principle(s) related to topics covered in this lesson. Although you are limited to this lesson's channel assignments, the electrodes or transducers may be moved to different locations on the **Subject**.

Design Your Experiment

Use a separate sheet to detail your experiment design, and be sure to address these main points:

A. ***Hypothesis***

Describe the scientific principle to be tested or verified.

B. ***Materials***

List the materials you will use to complete your investigation.

C. ***Method***

Describe the experimental procedure—be sure to number each step to make it easy to follow during recording.

Run Your Experiment

D. ***Set Up***

Set up the equipment and prepare the subject for your experiment.

E. ***Record***

Use the **Continue**, **Record** and **Suspend** buttons to record as much data as necessary for your experiment.

Click **Done** when you have completed all of the recordings required for your experiment.

Analyze Your Experiment

F. Set measurements relevant to your experiment and record the results in a Data Report.

9. After clicking **Done**, choose an option and click **OK**.

If choosing the **Record from another Subject** option:

- Repeat Setup Steps 5 – 7 and then proceed to Calibration.

10. Carefully remove all electrodes.

If using the SS57L EDA Lead, remove the electrode pinch connectors and peel off all electrodes. Discard the electrodes. (BIOPAC electrodes are not reusable.)

If using the SS3LA EDA Transducer, clean the electrode gel from each cavity.

Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours which is quite normal.

END OF RECORDING

V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode.

   - Note Channel Number (CH) designation:

Channel	*Displays*
CH 2	**ECG**
CH 41	**Heart Rate**
CH 42	**EDA**

   - Note measurement box settings:

Channel	*Measurement*
CH 41	**Value**
CH 42	**Value**
CH 41	**Mean**
CH 42	**Mean**

2. Set up your display window for optimal viewing of all Heart Rate and EDA data.

Data Analysis continues…

Detailed Explanation of Data Analysis Steps

If entering **Review Saved Data** mode from the Startup dialog or lessons menu, make sure to choose the correct file.

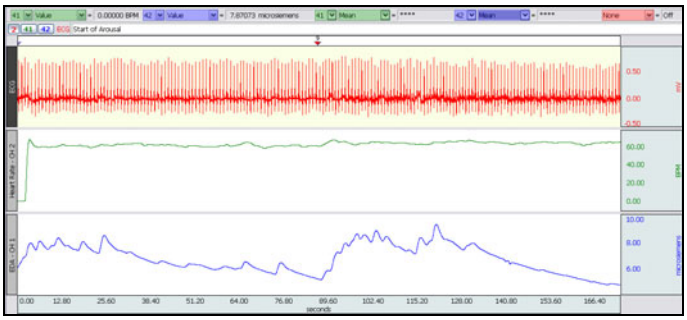

Fig. 14.9 Example data window

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click them.

Brief definition of measurements:

Value: Displays the amplitude value at the point selected by the I-beam cursor.

- If an area is selected, displays the value of the endpoint based on the direction the cursor was dragged.
- Single point Values will be shown when placing the Arrow cursor over the data while holding down the left mouse button.

Mean: Displays the average value in the selected area.

The "selected area" is the area selected by the **I-beam** tool (including endpoints).

The ECG (CH 2) data can be hidden***** since it is not used in the measurements.

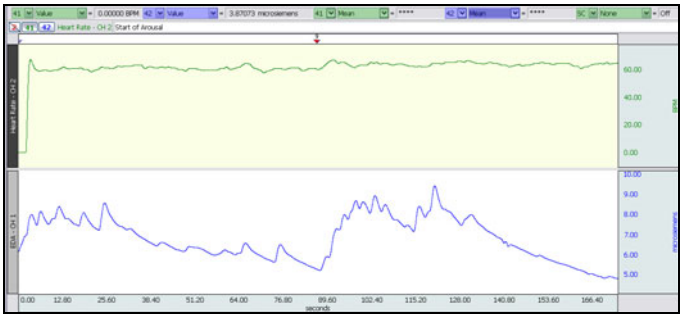

Fig. 14.10 ECG (CH 2) hidden

Useful tools for changing view:

Display menu: Autoscale Horizontal, Autoscale Waveforms, Zoom Back, Zoom Forward

Scroll Bars: Time (Horizontal); Amplitude (Vertical)

Cursor Tools: Zoom Tool

Buttons: Overlap, Split, Show Grid, Hide Grid, -, +

Hide/Show Channel: "Alt + click" (Windows) or "Option + click" (Mac) the channel number box to toggle channel display.

To optimize the Heart Rate (BPM) vertical scale, zoom in on the valid portion of the Heart Rate (BPM) data, then select Display > Autoscale Waveforms.

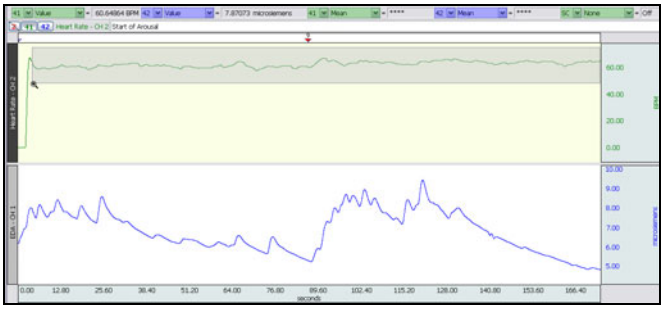

Fig. 14.11 Zoom In on valid Heart Rate data

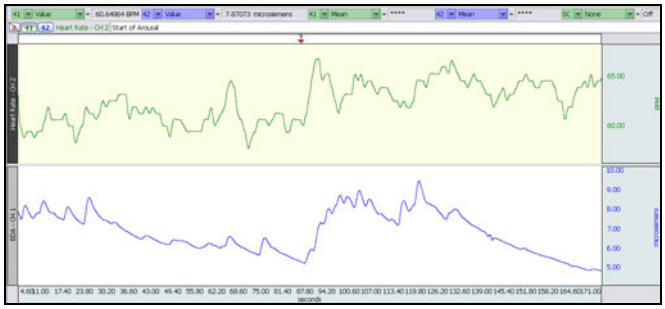

Fig. 14.12 After Display > Autoscale Waveforms

3. Measure the maximum and minimum values for Heart Rate (BPM) during the Relaxation portion (first 90 seconds).

A

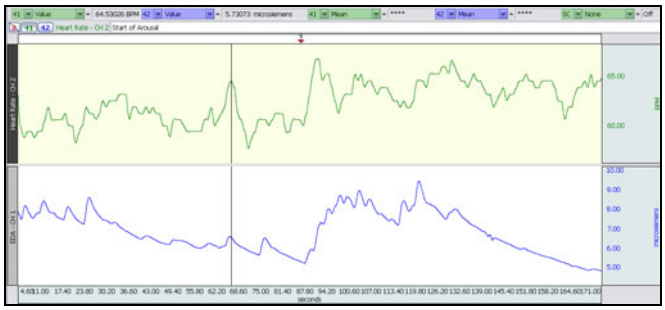

Fig. 14.13 Cursor placed at Maximum Heart Rate during Relaxation

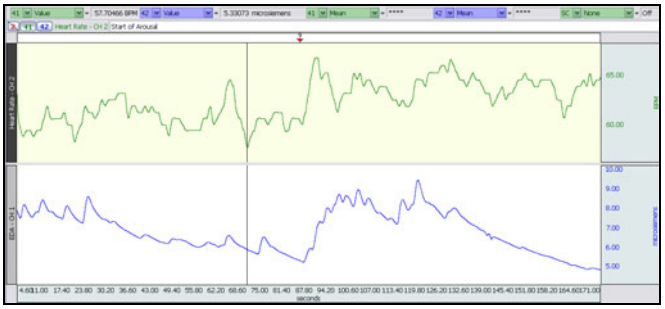

Fig. 14.14 Cursor placed at Minimal Heart Rate during Relaxation

4. Measure the maximum and minimum values for EDA during the Relaxation portion.

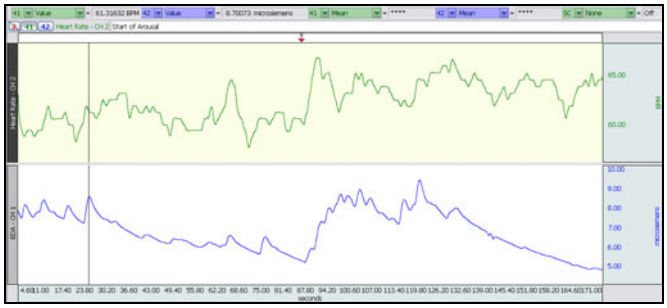

Fig. 14.15 Cursor placed at Maximum EDA during Relaxation

Data Analysis continues…

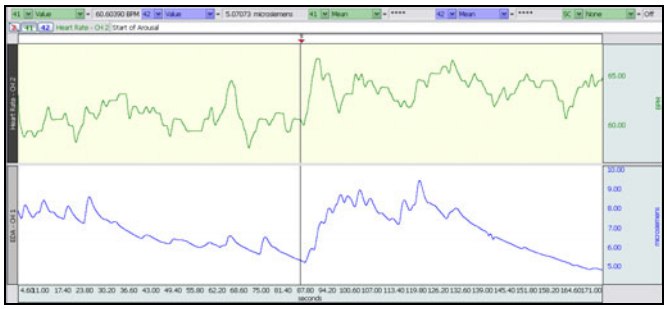

Fig. 14.16 Cursor placed at Minimal EDA during Relaxation

5. Measure the maximum and minimum values for Heart Rate and EDA during the Arousal portion.

   A

The "Start of Arousal" is indicated by the event marker, approximately 90 seconds into the recording.

6. Select all Relaxation data, excluding the first few seconds and then record the Mean measurement for Heart Rate (BPM) and EDA.

   A

Exclude the first few seconds as the Heart Rate was not valid.

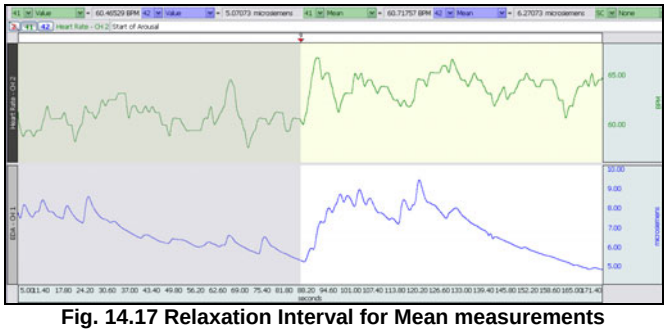

Fig. 14.17 Relaxation Interval for Mean measurements

7. Select all Arousal data, and then record the Mean measurement for Heart Rate (BPM) and EDA.

   A

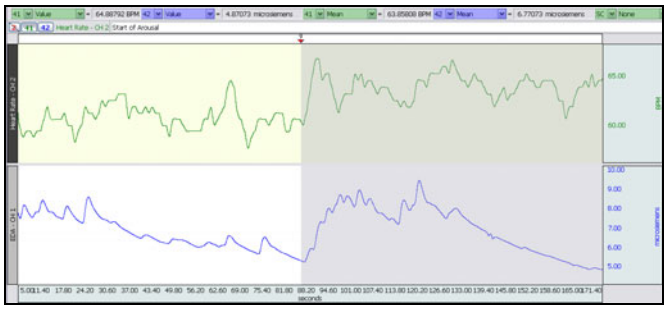

Fig. 14.18 Arousal Interval for Mean measurements

8. Answer the questions at the end of the Data Report.
9. **Save** or **Print** the data file.
10. **Quit** the program**.**

An electronically editable **Data Report** is located in the journal (following the lesson summary,) or immediately following this Data Analysis section. Your instructor will recommend the preferred format for your lab.

END OF DATA ANALYSIS

END OF LESSON 14

Complete the Lesson 14 Data Report that follows.

BIOFEEDBACK

- *Relaxation and Arousal*

DATA REPORT

Student's Name: _____

Lab Section: _____

Date: _____

Subject Profile

Name:_____ Height:_____

Age:_____ Gender: Male / Female Weight:_____

I. Data and Calculations

A.

Table 14.1

Calculation	CH/Measurement	Relaxation Data	Arousal Data	Units
Min. Heart Rate	41 Value			BPM
Max. Heart Rate	41 Value			BPM
Min. EDA	42 Value			microsiemens
Max. EDA	42 Value			microsiemens
Mean Heart Rate	41 Mean			BPM
Mean EDA	42 Mean			microsiemens

II. Questions

B. Based on the data from Table 14.1, did the effects of the parasympathetic nervous system change with biofeedback? Explain the physiological mechanisms causing the results.

C. Describe a biofeedback program for "stress management." Include details such as the physiological variable(s) you would measure, the transducers needed, and your criterion for a successful training program.

D. Name the branches of the autonomic nervous system and explain their function.

E. Define Biofeedback and explain in general terms how it works.

F. What change, if any, did your EDA recording show when you were aroused? Relaxed?

G. Why is EDA a useful measure for biofeedback training?

III. OPTIONAL Active Learning Portion

A. ***Hypothesis***

B. ***Materials***

C. ***Method***

D. ***Set Up***

E. ***Experimental Results***

End of Lesson 14 Data Report