Lesson 9 Biofeedback
Influencing Autonomic Tone

Lesson Revision 8.31.2007

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Lesson 9 BIOFEEDBACK

I. Scientific Principles

The human body can be thought of as a composite of twelve organ systems: the skeletal system, the articular system, the muscular system, the nervous system, the circulatory system, the integumentary system, the respiratory system, the alimentary system, the urinary system, the reproductive system, the lymphatic system, and the endocrine system. Two of the 12 systems, the nervous system and the endocrine system, are responsible for exerting control over all of the others so as to maintain the relatively stable internal environment required for normal cell functions. The endocrine system exerts control through the release of hormones and other chemical messengers that alter cell activities. The nervous system exerts control by way of nerve impulses and the release of neurotransmitters that either inhibit or excite target cells. Other cellular functions are altered by a combination of nervous and endocrine elements working together as a neuroendocrine control mechanism (Fig. 9.1).

Some functions of the human body are voluntarily controlled; that is, you can willfully initiate, modify, or stop the function. Movements of the skeleton, as in walking or lifting a weight begin by voluntarily activating motor nerves that stimulate contraction of the appropriate skeletal muscles. Once the movement begins, control over the strength and speed of contraction, alternate contraction and relaxation of opposing muscles and coordination with other muscles acting at the same joints is shifted to involuntary neural control centers in the brain and spinal cord so that the intended movement proceeds normally while the brain’s attention is directed elsewhere. In other words, you need not concentrate on contracting and relaxing flexors and extensors at the appropriate time to continue walking. Instead, you can direct your attention to where you are going. However, the movement may be voluntarily speeded up, slowed, or stopped when it becomes desirable to do so. Thus, neural control of skeletal muscle is partially voluntary and partially involuntary. The division of the nervous system that exclusively controls skeletal muscle is called the somatic motor system.

The term “autonomic” implies independent, self-controlling function. If we had to maintain vital functions such as heartbeat, breathing, blood pressure, and blood sugar through conscious effort, we would accomplish little else. Sleep, of course, would be impossible. The ANS functions independent of the will and below the level of conscious thought, helping regulate our internal environment. It is made up of two structurally and functionally distinct divisions: the sympathetic division and the parasympathetic division. Nearly all organs are supplied with both sympathetic and parasympathetic nerves.

The sympathetic nervous system is sometimes called the “fight or flight” system. It heightens awareness, dilates pupils of the eyes, increases heart rate, dilates airways, increases breathing rate and depth, increases blood flow to skeletal muscles, and causes many other internal changes that prepare the body to preserve itself in the face of a short-term or acute stress.

The parasympathetic nervous system is sometimes called the “rest and digest” system. It decreases heart rate, dilates airways, decreases breathing rate and depth, decreases blood flow to skeletal muscles, and causes many other internal changes that prepare the body to maintain its normal functions.

Both divisions of the ANS are active all of the time, displaying what is called autonomic tone. Their effects on organs generally oppose one another. As mentioned earlier, increased sympathetic stimulation increases heart rate but increased parasympathetic stimulation decreases heart rate. The heart rate at any given time of the day or night
reflects the dominance of one division over the other at that time. Each division of the ANS also directly inhibits activity in the other. A sympathetic increase in heart rate occurs in part because parasympathetic cardioinhibitory nerves are themselves inhibited by sympathetic nerve cells and vice-versa when parasympathetic dominance occurs.

For decades, many people believed that autonomic control of body functions could not intentionally or willfully be altered. A considerable amount of evidence now exists suggesting this is not true. Some of the effects of autonomic control can be altered through biofeedback training. The underlying principle of biofeedback is that we have the innate ability and potential to influence autonomic control of body functions through exertion of the will and mind.

Biofeedback training is a learning process whereby people exert conscious control over physiological processes controlled by the autonomic nervous system. During the training periods, a biologic signal that changes with altered autonomic tone, such as the heart rate or skin temperature of the subject, is monitored and “fed back” to the subject in real time as a visual or auditory signal that the person can use to enhance a desired response. The use of a heart rate monitor during biofeedback training in stress management is a good example.

Mental or psychological stress increases sympathetic activity and decreases parasympathetic activity, resulting in an increase in heart rate, an increase in blood pressure, reduced gastrointestinal functions, and so forth. Over the short term, these changes may be beneficial, but when they are prolonged or become chronic, they become detrimental and can cause disease. Using heart rate biofeedback techniques, an affected person can be taught to relax and to increase parasympathetic tone and thus reduce sympathetic activity, evidenced by a decrease in heart rate. Initially, a machine monitors heart rate and provides the feedback signals that help the subject develop voluntary control. Eventually, the subject is able to recognize and control reactions to stress on his own by recalling and eliciting the same relaxed state of mind used in the biofeedback laboratory when he is at home or at work. Relaxation training using biofeedback has been successfully applied to the management of asthma, cerebral palsy, hypertension, migraine headache, irritable bowel syndrome, and numerous other maladies.

In this lesson, to explore the concept of biofeedback training and its effect on autonomic control of heart rate, heart rate will be plotted on the screen as a thermometer style bar chart that will rise and fall with changes in heart rate, allowing the Subject to become conscious of his/her heart rate. The Subject will try to influence the reading without physical movements.

II. EXPERIMENTAL OBJECTIVES

1) Introduce the concept of biofeedback as a technique to alter autonomic tone.
2) Measure changes in autonomic tone via heart rate.

III. MATERIALS

- Computer system (running Windows XP or Mac OS X)
- Biopac Science Lab system (MP40 and software)
- Electrode lead set (40EL lead set)
- Disposable vinyl electrodes (EL503), three electrodes per subject
- Suggested: PowerPoint Viewer 2003 or later (free download at www.microsoft.com/downloads)

PowerPoint Viewer 2003 lets you view full-featured presentations created in PowerPoint 97 and later versions, which can greatly enhance the feedback segments of this lesson.

- Presentation 1 – images or sound
- Presentation 2 – modified Presentation 1 with startling sound or image inserted
IV. EXPERIMENTAL METHODS

A. Set Up

**Fig. 9.2**

**EQUIPMENT**

**SUBJECT**

right forearm WHITE lead

right leg BLACK lead (ground)

left leg RED lead

**Fig. 9.3 Lead II connections**

**FAST TRACK**

1. Turn the computer **ON**.
2. Set the MP40 dial to **OFF**.
3. **Plug the equipment in** as follows:
   Electrode leads (40EL) → MP40
4. Attach three electrodes to the **Subject** as shown in Fig. 9.3.
5. Connect the electrode **leads** (40EL) to the electrodes, matching lead color to electrode position as shown above.

**IMPORTANT**
Clip each electrode lead color to its specified electrode position.

6. **Start** the Biopac Science Lab software.
7. Choose lesson **L09-Biofeedback-1** and click **OK**.
8. Type in a unique **file name**.
9. Click **OK**.

**Details**

Attach three electrodes to the Subject in a Lead II configuration, as shown in Fig. 9.3:

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

No two people can have the same file name, so use a unique identifier, such as the subject’s nickname or student ID#.

This ends the Set Up procedure.
Lesson 9: Biofeedback

B. Check

**FAST TRACK**

**MP40 Check**

1. Set the MP40 dial to ECG/EOG.

2. Press and hold the Check pad on the MP40.

3. Click when the light is flashing.

4. Wait for the MP40 Check to stop.

5. Let go of the Check pad.

6. Click Continue.

**Signal Check**

7. Click Check Signal.

8. Read the prompt and click Yes.

9. Click OK.

10. After the beep, inhale and exhale deeply once, and then wait for the Signal Check to stop.

11. Review the data.
   - If correct, go to the Record section.
   - If incorrect, click Redo Signal Check.

Continue to hold the pad down until prompted to let go.

The MP40 check procedure will last five seconds.

The light should stop flashing when you let go of the Check pad.

When the light stops flashing, click Continue.

A beep should occur four seconds into the Signal Check. The Subject should take one deep inhale and exhale, and then return to normal breathing. The program needs to see some variation in the BPM data. If you do not hear a beep, make sure your computer volume is turned up and click Redo Signal Check.

The eight-second Signal Check recording should resemble Fig. 9.4. The important aspect to check for is a clear ECG signal with recognizable R-waves.

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C. Record

**FAST TRACK**

1. Prepare for the recording and have the **Subject** sit and relax.

**Details**

Watch the Help menu videos to prepare for the recording. This lesson requires that the Subject concentrate on the monitor display of Heart Rate and try to influence the reading without physical movement.

Subject should sit with arms relaxed, preferably in a chair with armrests. When the recording starts, Heart Rate will be plotted in a thermometer style bar chart (Fig. 9.5). The bar chart display only works while data is being recorded. The display will change to a standard data plot when recording is complete.

![Fig. 9.5 Heart rate bar display](image)

The Heart Rate display will increase (rise) as the heart rate increases. The upper and lower range of each reading was set after the Signal Check, based on the Subject's data. The reading should begin with values in approximately the center of the display; if the bar begins beyond the mid-range, consider redoing the Signal Check.

Note that you will have to click **Suspend** to halt a segment: the first click will make it the active window (instead of the Heart Rate bar display), and the second click will execute the command.

**SEGMENT 1 — Baseline**

2. Position **Subject** facing away from monitor.

3. Click **Record**

4. **Subject** sits and breathes normally to establish a baseline.

5. Record for 20 seconds and then click **Suspend**.

6. Review the data.
   - If correct, go to Step 7.

Subject should not look at the monitor during the baseline recording. Subject should be alert and seated with eyes open, but not looking at the monitor.

When you click **Record**, the recording will begin and an append marker labeled “Baseline” will automatically be inserted.

When you click **Suspend**, the recording will halt, giving you time to review the data and prepare for the next recording segment.

Your data should resemble Fig. 9.6.

![Fig. 9.6 Baseline](image)
If incorrect, click **Redo**.

The data is incorrect if:
- a) The **Suspend** button was pressed prematurely.
- b) An electrode peeled up causing a large baseline drift, spike, or loss of signal.
- c) The Subject has too much muscle (EMG) artifact.

If the data is incorrect, click **Redo** and repeating Steps 3-6; the last data segment you recorded will be erased.

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**SEGMENT 2 — Increasing Parasympathetic Tone**

7. Position **Subject** facing the monitor so the heart rate display is clearly visible.

8. Click **Resume**.

9. **Subject** watches monitor and mentally tries to voluntarily increase parasympathetic tone (lower heart rate display).

10. After 120 seconds, click **Suspend**.

11. Review the data.
   - If correct, go to **Step 12**.

12. If incorrect, click **Redo**.

When you click **Resume**, the recording will begin and an append marker labeled **Increasing Parasympathetic Tone** will automatically be inserted.

**Tips for Increasing Parasympathetic Tone:**
- a) Imagine yourself at a warm, relaxing seashore.
- b) Close your eyes.
- c) Smile.
- d) Breathe in and out very slowly.
- e) Relax your posture.

Record for 120 seconds and then click **Suspend**. When you click **Suspend**, the recording will halt, giving you time to review the data and prepare for the next recording segment.

Your data should resemble Fig. 9.7.

![Fig. 9.7 Increasing Parasympathetic Tone](image-url)

The data is incorrect if:
- d) The **Suspend** button was pressed prematurely.
- e) An electrode peeled up causing a large baseline drift, spike, or loss of signal.
- f) The Subject has too much muscle (EMG) artifact.

If the data is incorrect, click **Redo** and repeat Steps 8-11. Note that once you press **Redo**, the last data segment you recorded will be erased.
SEGMENT 3 — Increasing Sympathetic Tone

12. Click Resume.

13. Subject watches monitor and mentally tries to voluntarily increase sympathetic tone (increase heart rate display).

14. After 120 seconds, click Suspend.

15. Review the data.
   - If correct, go to Step 16.
   - If incorrect, click Redo.

16. Click Resume.

17. Start Presentation 1.

18. Subject tries to remain relaxed during the presentation.

19. Click Suspend.

20. Review the data.
   - If correct, go to Step 21.
   - If incorrect, click Redo.

SEGMENT 4 — Presentation 1

Subject should remain seated and facing the monitor.

When you click Resume, the recording will continue and an append marker labeled Increasing Sympathetic Tone will be automatically inserted.

**Tips for Increasing Sympathetic Tone:**
- Think of a stressful or unpleasant situation.
- Scowl.
- Hold your breath.

Record for 120 seconds and then click Suspend. When you click Suspend, the recording will halt, giving you time to review the data and prepare for the next recording segment.

Your data should resemble Fig. 9.8.

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**Note**  The recording will vary greatly from person to person, and it is hard to generalize about the results. You should be able to manipulate your physiological responses to some degree, although it may take some practice.

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When you click Resume, the recording will continue and an append marker labeled Presentation 1 will be automatically inserted.

Subject should sit with arms relaxed, preferably in a chair with armrests.

**Suggested stimulus:** PowerPoint slide show

When you click Suspend, the recording will halt, giving you time to review the data and prepare for the next segment.

Your data should resemble Fig. 9.9.

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**Fig. 9.8 Increasing Sympathetic Tone**

**Fig. 9.9 Sample data for response to Presentation 1**
### SEGMENT 5 — Presentation 2

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.</td>
<td>Click Resume.</td>
</tr>
<tr>
<td>22.</td>
<td>Start Presentation 2.</td>
</tr>
<tr>
<td>23.</td>
<td><strong>Subject</strong> tries to remain relaxed during the presentation.</td>
</tr>
<tr>
<td>24.</td>
<td>Click Suspend.</td>
</tr>
<tr>
<td>25.</td>
<td>Review the data.</td>
</tr>
<tr>
<td></td>
<td>- If <strong>correct</strong>, go to Step 26.</td>
</tr>
<tr>
<td></td>
<td>- If <strong>incorrect</strong>, click Redo.</td>
</tr>
<tr>
<td>26.</td>
<td><strong>Optional</strong>: Click Resume to record additional segments.</td>
</tr>
<tr>
<td>27.</td>
<td>Click Done.</td>
</tr>
<tr>
<td>28.</td>
<td>Click Yes.</td>
</tr>
<tr>
<td>29.</td>
<td>Choose an option and click OK.</td>
</tr>
<tr>
<td>30.</td>
<td>Remove the electrodes.</td>
</tr>
</tbody>
</table>

When you click **Resume**, the recording will continue and an append marker labeled **Presentation 2** will be automatically inserted.

Subject should sit with arms relaxed, preferably in a chair with armrests.

*Suggested stimulus*: PowerPoint slide show

When you click **Suspend**, the recording will halt, giving you time to review the data and prepare for the next recording segment.

Your data should resemble Fig. 9.10.

![Fig. 9.10 Sample data for response to Presentation 2](image)

**Optional**: You can record additional segments by clicking **Resume** instead of **Done**. A time marker will be inserted at the start of each added segment.

When you click **Done**, the data window will change to display two channels: ECG (recorded) and Heart Rate (calculated). This data represents the entire recording. A pop-up window with options will appear. Click **Yes** (or **No** if you want to redo the last segment).

When you click **Yes**, a dialog with options will be generated. Make your choice, and click **OK**.

- If you choose **Analyze current data file**, go to the Analyze section for directions.

Disconnect the lead clips and peel off the electrodes.

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V. **ANALYZE**

**FAST TRACK**

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

   Note Channel Number (CH) designation:
   
   **Channel**   **Displays**
   CH46          Heart Rate

   **Details**
   
   To review saved data, choose **Analyze current data file** from the Done dialog after recording data, or choose **Review Saved Data** from the Lessons menu and browse to the required file.

   The data window should come up the same as Fig. 9.11.

   **Fig. 9.11 Heart Rate**

   **Fig. 9.12 ECG and Heart Rate**

   **Note**
   The ECG data channel is hidden since results will be measured from the heart rate channel.

   To show/hide a channel:
   
   **Windows**: Ctrl-click channel box
   **Mac**: Option-click channel box

2. Set up the measurement boxes as follows:

   **Channel**   **Measurement**
   CH46          Value
   CH46          Delta T
   CH46          Mean
   CH46          P-P

   **Details**
   
   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 specific measurements:

   **Value**: displays the amplitude value for the channel at the point selected by the I-beam cursor. If a single point is selected, the value is for that point, if an area is selected, the value is the endpoint of the selected area.

   **Delta T**: displays the amount of time in the selected segment (the difference in time between the endpoints of the selected area).

   **Mean**: displays the average value in the selected area.

   **P-P**: Peak-to-Peak measurement shows the difference between the maximum amplitude value in the selected range and the minimum amplitude value in the selected range.

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

   This is the data that represents Subject’s baseline heart rate.

3. Set up your display window for optimal viewing of the baseline segment.
4. Measure the heart rate value about 10 seconds into each segment.

5. Save or print the data file.

6. Exit the program.

7. Set the dial to **Off**.

**END OF DATA ANALYSIS**

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**END OF LESSON 9**
Complete the Lesson 9 Data Report that follows.
The Data Report starts on the next page.
These are sample questions. You should amend, add, or delete questions to support your curriculum objectives.

Lesson 9 BIOFEEDBACK
Influencing Autonomic Tone

DATA REPORT

Student's Name: ________________________________
Lab Section: ________________________________
Date: ________________________________

I. Data and Calculations

Subject Profile

Name: __________________________ Age: __________
Gender: Male / Female Height: _______ Weight: _______

Experimental Data & Calculations

A. Complete the following table.

<table>
<thead>
<tr>
<th>Measurement (CH46)</th>
<th>Baseline</th>
<th>Parasympathetic Tone</th>
<th>Sympathetic Tone</th>
<th>Autonomic Tone Pres. A</th>
<th>Autonomic Tone Pres. B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seg. 1</td>
<td>Seg. 2</td>
<td>Seg. 3</td>
<td>Seg. 4</td>
<td>Seg. 5</td>
</tr>
<tr>
<td>Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta T</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Mean</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>P-P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. Data Summary and Questions

B. Based on the data from Table 9.1, was the Subject able to voluntarily increase parasympathetic tone or sympathetic tone? Support your answer with the appropriate experimental data.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

C. How would you characterize the presentations (i.e., scary or calming)? How would you expect the Subject to respond to the stimulus?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________
D. Name the divisions of the autonomic nervous system and explain their general functions.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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

________________________________________________________________________

________________________________________________________________________

F. What is meant by the term autonomic tone? Use heart rate as an example.

________________________________________________________________________

________________________________________________________________________
VI. ACTIVE LEARNING LAB

Design a new experiment to test or verify the scientific principle(s) you learned in the Biopac Science Lab recording and analysis segments.

- For this lesson, you might examine how repeating segments or changing the presentations influence the results.

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.

- See the Set Up section or Help > About Electrodes for electrode placement guidelines.

Run Your Experiment

D. Set Up

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

E. Record

Use the Record, Resume, and Suspend buttons in the Biopac Science Lab program to record as many segments as necessary for your experiment.

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

Analyze Your Experiment

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