BSL PRO Lesson H08: ECG Dive Reflex Active Learning

This lesson is based on a presentation given by Dr. Jennifer Lundmark and Ms. Andrea Salmi at the HAPS Conference, Maui, HI, June 2-7, 2001

Background

Active Learning

Active Learning Lessons convert traditional physiology laboratories into inquiry-based exercises. Students perform a lab exercise designed to encourage them to make observations and develop and test multiple hypotheses during a single lab period using the BIOPAC data acquisition system. These inquiry-based exercises are designed to give students experience with the scientific method, group discussion, design of simple experimental protocols, and the responsibility of making their own decisions.

This Active Learning lesson allows students to participate in, rather than merely receive, their own education. This lesson assumes that students are familiar with the concepts of apnea, bradycardia, ECG, and heart rate variation, and provides only the basic setup and recording steps students need to create their own experiment. Students will follow an experiment to record and measure change in heart rate (ECG) from a human, and then design and test an experiment to identify the exact cause of the change.

To learn more about the benefits of Inquiry-based, Active Learning Labs, read these results from an NSF-CCLI Grant-Supported Project on Inquiry-based labs using the Biopac Student Lab System. (Page 5)

*For explanation of these terms and further experimental guidance, review the Appendix.

ECG Dive Reflex

The application of cold water to the face during breath holding (apnea) initiates the diving reflex. The diving reflex results in a decrease in heart rate (bradycardia).

This lesson investigates the temperature-dependent nature of bradycardia. Subjects voluntarily hold their breath and immerse their faces into cold water ranging from 22°C (room temperature) to 3°C (ice water) while their heart rate is monitored. Changes in heart rate are averaged over two trials.

Objectives

1. To record the change in heart rate that occurs when a Subject immerses his face in cold water.
2. To investigate the physiological reason for the observed response.
Equipment

- Windows or Macintosh computer
- BIOPAC Software: BIOPAC Student Lab PRO
- BIOPAC Data Acquisition Unit (MP36/MP35/MP46/MP45)
- BIOPAC electrode lead set (SS2L)—one or more, depending on experiment design
- BIOPAC disposable vinyl electrodes (EL503)
- Electrode gel (GEL1) and abrasive pad (ELPAD)
- Shallow tub with water and ice
- Thermometer
- Towel

Experiment Design

Follow the procedure in this PRO lesson to record and measure change in heart rate (ECG) from a human after immersing the face in cold water. Next, design an experiment to identify the exact stimulus that evokes the change in heart rate (in beats per minute or BPM). Your experiment must:

1. Test only one factor at a time.
2. Specify a hypothesis (in the form of a statement) that might provide an explanation for your observation.
3. Record heart rate data.
4. Specify what measurements will be taken and how they will be recorded (table, etc.)
5. Compare data to the predictions of the hypothesis and interpret the findings.
6. Conform to the Scientific Method.

If your data do not support the hypothesis, form a new hypothesis and test it.

Each time you test a hypothesis, you gain information, even if the hypothesis is not supported by the data. Use this information to guide your next experiment. You will likely have to test several hypotheses before you arrive at a sound conclusion. When you are confident that you have arrived at the correct cause of the heart rate change, you are done with this part of the lesson. Make sure that your data supports your conclusion!

To ensure that scientific work is acceptable, repeatable, and easy to communicate, scientists have developed a logical, stepwise progression that scientific investigation follows. This progression is known as the scientific method, summarized in the following steps.

a. **Identify a problem or objective.**
   This involves recognizing that some unknown information is needed.

b. **Form a testable hypothesis.**
   This is an educated guess answering how or why an event takes place, or providing a solution to a problem. Tools or technology must be available to test the hypothesis, otherwise it should be discarded.

c. **Test the hypothesis by observation and experimentation.**
   Determine what tests to perform, set up proper controls, and use the correct instruments. Meticulously gather data from the experiments.

d. **Interpret the data.**
   Using statistical analysis, determine if the results are statistically significant or if they occurred merely by chance. Recognize relationships between the data and previously known facts, or new observations.

e. **Draw conclusions.**
   Does the data support the hypothesis? If the hypothesis is not supported, return to Step 2.

f. **Communicate observations and conclusions.**
   Organize and present the data in such a way that others can understand what was done and observed, and could reach the same conclusion.

See Additional Study for more experiment ideas. (Page 4)
Setup

Note: This setup demonstrates basic Lead II ECG connections on a human subject. Student experiments may require variations.

Hardware

1. Plug the Electrode Lead Set into CH 1 on the MP unit.
2. Turn the MP unit on.
3. Turn the computer on.
4. Launch the BSL PRO software.
5. Open the H08 template by choosing the BSL PRO tab in the Startup Wizard and choosing “H08 – Dive Reflex” to open the graph template. (In BSL versions earlier than 3.7.7, you may open this template by browsing to it directly via File→Open).

NOTE: In BSL 4.1.2 and higher, this Lesson Procedure PDF is also embedded in the graph template’s Journal but is best viewed with the Journal set to “Floating display.” See Appendix 2 for details.

Calibration

No Calibration is required.

Subject — Electrode Connections

IMPORTANT! Selected Subject must not have any known heart conditions.

The electrode connections for setting up a Dive Reflex test consist of an electrode lead set attached to skin electrodes and plugged into an MP unit.

1. Abrade the anterior surface of the right wrist and the medial aspect of both ankles, then cleanse with alcohol.
2. Permit the areas to dry then apply gel-filled vinyl electrodes to each area.
3. Attach the electrode lead set as follows:

<table>
<thead>
<tr>
<th>Lead II Setup</th>
<th>Lead Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Wrist:</td>
<td>White</td>
</tr>
<tr>
<td>Right Ankle:</td>
<td>Black</td>
</tr>
<tr>
<td>Left Ankle:</td>
<td>Red</td>
</tr>
</tbody>
</table>

Running the Experiment

Hints for minimizing data error

- The Subject should not talk or laugh during any of the recording segments.
- The Subject should be relaxed in the position noted for each recording segment.
- The Subject should be as still as possible during the recording segment. The skin electrodes very sensitive to small changes in voltage caused by contraction of skeletal muscles, and the Subject's arms and legs need to be relaxed so that muscle (EMG) signals does not corrupt the ECG signal.
- Start recording a few seconds before the Subject gets wet to give the computer time to display the data.
- Subject should remain immersed for 20-30 seconds — the longer the better!
- Screen Subjects for smoking and drugs, which alter cardiac activity.
- Prohibit caffeine intake six hours prior to the experiment.
- Place Subjects in a prone position on a pad until their ECG-monitored heart rate stabilizes. The prone position is the best Subject orientation because it has been shown to minimize movement for facial immersion. (Marsh, N., D. Askew, K. Beer, M. Gerke, D. Muller, and C. Reichman, 1995. “Relative contributions of voluntary apnea, exposure to cold and face immersion in water to diving bradycardia in humans”. Clinical and Exp. Pharmacol. and Physiol. 22:886-887.)
- Conduct immersions in random order and do not advise the Subject of the water temperature before immersion.
1. Fill a tub with water and ice and stir until the water temperature is 10°–15°C. Record the temperature.
2. Fill another tub with room-temperature water. Record the temperature.
3. If possible, fill another tub with water and ice and stir until the water is colder than the first tub. Record the temperature.
4. Record a 30-second resting ECG of the subject while he is prone, next to the ice water. Click "Start" in the graph window to begin recording data and "Stop" to end.
5. Prepare the Subject to immerse his face in the cold water.
6. Click "Start", and then press F9 key (Esc in Mac) as soon as the Subject immerses his face a few seconds later.
7. The Subject should remain immersed for 20-30 seconds (the longer the better). Click "Stop" after the Subject removes face from the water to end recording.
8. Give the Subject a towel to dry face.
9. Repeat the experiment at least once.

**Analysis**

Average changes in heart rate over a minimum of two trials. Define the baseline heart rate as the mean heart rate over a 10 second interval, 5 seconds before the Subject was asked to immerse his face in water. Define the final heart rate as an average of the last 5 seconds of immersion.

**Additional Study**

1. Record the requested data on the following worksheet and answer the questions to test your knowledge.

   [WORKSHEET]

2. Design and complete another experiment using the given equipment. For example, might you see a similar change in heart rate by immersing the Subject's hand in cold water? Might postural changes or thought processes affect heart rate?

3. In addition to heart rate, monitor Lung Volume via pneumotrace to determine the effect of different breath-hold lung volumes on bradycardia.

**Recording Variations**

This laboratory procedure provides a visual depiction and an online analysis of heart rate changes encountered during immersion in cold water. The procedure can also be used as a platform to demonstrate physiological responses to other conditions. Examples include:

- change in heart rate while sitting up vs. standing
- change in heart rate while breathing deeply vs. normally
- change in heart rate while resting vs. after exercise
Appendix
Inquiry-based Labs / Active Learning

INQUIRY-BASED LABS USING THE BIOPAC STUDENT LAB SYSTEM: RESULTS FROM AN NSF-CCLI GRANT-SUPPORTED PROJECT.
Dr. Jennifer A. Lundmark, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819-0778, lundmark@cscu.edu; and Andrea K. Solmi, Cosumnes River College, 4601 Center Parkway, Sacramento, CA 95823-5799, salmiasr@crr.cccd.cc.ca.us

The objective of this NSF-funded project is to incorporate modern computerized data acquisition equipment into introductory Human Anatomy and Physiology courses, thus allowing the investigators to revise the laboratory curriculum to improve critical thinking skills and understanding of physiological principles. It is also believed that using this new equipment will give students technical experience that will improve their workplace skills. This is a collaborative project between Dr. Jennifer Lundmark, a faculty member at California State University, Sacramento, and Andrea Solmi, a faculty member at Cosumnes River College, a community college. Students at both institutions participate in the experimental laboratory exercises.

The revision of our lab curriculum involved the translation of pre-existing laboratory exercises into inquiry-based lab exercises. The new exercises include Scientific Inquiry, Electromyography, Electrocardiogram, Pulmonary Ventilation, and Respiratory Volumes. It is our goal that in providing inquiry-based exercises, students will improve their critical thinking skills, achieve a greater understanding of the physiological processes explored in the laboratory, and experience less frustration in gathering data. We closely observed the students during the labs, and evaluated the effectiveness and problems associated with each lab exercise. The input provided by the students and by all instructors using the lab exercises is continually incorporated into revisions of the lab exercises. One of our most profound findings was the sense of understanding we now have of the amount of freedom vs. the amount of guidance that the students required during the labs. We believe this understanding is one of the more important aspects that we can share with other faculty. Therefore, our workshop at the 2001 HAPS conference focuses on how to make the transition from instructor-driven to student-driven laboratories. Participants in our workshop perform the same EMG exercise as our students and experience this guided inquiry firsthand.

In addition to increasing student understanding of physiological processes, this project has also attempted to increase student appreciation of the scientific process. Several of the lab exercises have been specifically written to reach this goal. For example, the Scientific Inquiry exercise has students observe a drop in heart rate as a subject holds their breath and takes that as evidence of a similarity to the diving reflex. The students are challenged to develop and test their own hypotheses to isolate the variable responsible for the drop in heart rate. It gives the students experience in scientific thinking, stimulates their curiosity, gives them more control over their own learning, allows them to test and retest and to more fully understand the steps involved in scientific inquiry. We have gathered anonymous feedback from students, and the data indicate their substantial enthusiasm for this approach to learning.

Another goal of this project was to improve student skill with and confidence in using current technology. Since the new equipment allows for relatively easy collection of real time data (for example ECG, EMG, respiratory volumes), students can efficiently collect the data, evaluate it and design additional experiments during the same lab period. They also have the frequency and opportunity to critically evaluate the data, correct mistakes, or expand their inquiry. Specifically, we have observed students evaluate EMG data from a muscle, realize that it didn’t match their expectations, evaluate their subject preparation, correct an error and redo the experiment. We have seen them analyze respiratory volumes data, note that it didn’t appear to be valid, study their equipment calibration procedures and redo the exercise. It is important that students learn to evaluate their experimental procedures and see the impact on their results. The new equipment has given students the freedom to make mistakes and learn from them in a nonthreatening manner. They learn that very sophisticated equipment can be easy to use without fear.

We have also created an environment for students to ask “What would happen if...” questions, then set up an experiment and answer their own questions. The equipment provides immediate feedback, which increases their enjoyment of learning and their overall enthusiasm for science. The lab exercises have been written to give students freedom to explore questions of their own design, and to expand on the physiological principle being investigated.

This project has been very successful in many respects. Students have shown increased enthusiasm during labs, their responses to exam questions and homework problems show their understanding of the principles investigated, and they are very comfortable using the equipment. The lab exercises are more inquiry-based and less “cookbook” than in the past, engaging students as more active participants in their learning. This is of great benefit to students as learners in general. The use of modern, computerized technologies also benefits students widely, and will increase their confidence as they encounter related equipment in other aspects of their college education and in their workplaces.

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Appendix 2:
Enabling the “Floating window” Journal Display

BSL 4.1.2 and higher: In addition to the Help menu, lesson-specific PRO Lesson PDFs are also available in the lesson’s Journal and viewable by clicking the Journal’s “lesson procedure” tab. To enhance viewing of lesson PDFs from within the Journal, BIOPAC recommends changing the Journal display preference from the default “Docked at bottom of graph window” setting to “Floating window.” This option allows for easy resizing and repositioning of the onscreen lesson Journal while allowing full access to the graph. “Floating window” also provides a higher resolution PDF display and positions any Output Control panels directly below the graph for easier viewing.

To change the Journal display to “Floating window”:

1. In BSL PRO, choose “Display > Preferences” (or click the Preferences toolbar button).
2. Highlight the “Journal” option in the Preferences window.
3. Under “Display Style,” select “Floating window” and click OK.
4. The Journal will now appear in a separate window from the BSL graph. (It may appear behind the graph display. Drag the graph sideways and click the Journal window to bring it to the front.
5. Click the “lesson procedure” tab to view the PDF. Reposition and resize the Journal window as necessary. Toggle between Journal text (notes you’ve entered) and the lesson procedure PDF by clicking the “Journal” and “lesson procedure” tabs.