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

Overview

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, brachycardia, 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.

*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 face into cold water ranging from 37°C (room temperature) to 3°C (ice water) while their heart rate is monitored. Changes in heart rate are averaged over two trials.

The following Web links offer further information about the dive reflex:

- Immersion Effect II - SCUBA Diving & Physiology web page
- Unraveling the mammalian diving reflex - Erik Seedhouse
- Supraventricular Tachycardias - American Heart Association
- Drowning overview > Mammalian dive reflex - EMedicine
- EKG Bibliography 2003
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

- PC running Windows or Macintosh computer
- BIO PAC Software: BIO PAC Student Lab PRO
- BIO PAC Data Acquisition Unit (MP30/MP35)
- BIO PAC electrode lead set (SS2L)—one or more, depending on experiment design
- BIO PAC 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 first experiment 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 exact cause of the heart rate change, you are done with this part of the lesson. Make sure that your data support 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 tests.

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

e. Draw conclusions.
   Do the data support the hypothesis? If the hypothesis is not supported, return to step two.

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

See Additional Study for more experiment ideas.
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 MP30/MP35 acquisition unit on.
3. Turn the computer on.
4. Launch the BSL PRO software.
5. Open the Dive Reflex lab by choosing File menu > Open > choose Files of type: Graph Template (*.GTL) > File Name: DiveReflex.gtl.

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 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 electrocardiograph is 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 the muscle (EMG) signal 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 within six hours of 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.
- Allow an equilibrium period of no less than 3 minutes between immersions.
Fill a tub with water and ice until the water is 10º–15º C. Record the temperature.

Fill another tub with room temperature water. Record the temperature.

If possible, fill another tub with water and ice until the water is colder than the first tub. Record the temperature.

Record a 30 second resting ECG of the subject while he is prone, next to the ice water. Click “Start” on the data screen to begin recording data and “Stop” to end.

Prepare the subject to immerse his face in the cold water.

Click “Start” then press “esc” as soon as the subject immerses his face a few seconds later.

The subject should remain immersed for 20-30 seconds (the longer the better). Click “Stop” after the subject removes his face from the water to end recording.

Give the subject a towel to dry his face.

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:

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

GRAPH TEMPLATE SETTINGS

Click here to open a PDF of the graph template file settings. The BSL PRO Graph Template file automatically establishes the settings shown in the table.

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