  Graphical Analysis 6

Diving Reflex

The diving reflex is an adaptation found in marine mammals for diving in cold water. The diving reflex is a reduction in heart rate, bradycardia, while diving. The majority of research on the diving reflex has been done on seals. The Weddell seal of Antarctica is a great example (Figure 1). Weddell seals can hold their breath for extended periods (20 minutes to an hour) and can dive to depths of 500 meters. During each dive, heart rate and cardiac output decrease dramatically as blood is shunted away from the extremities and directed to the vital organs.



Figure 1 Weddell seal of Antarctica. Photo by Robyn Gastineau; all rights reserved.

A much smaller version of the diving reflex occurs in all mammals and is easy to observe in humans. When cold water (<10° C) contacts the face or inside of the nose, sensory neurons are activated that increase parasympathetic activity, inhibiting breathing and decreasing heart rate. This response is not observed during normal breath holding in air or during simulated dives in warm water. The diving reflex can also be influenced by learning. Cold water swimmers or experienced skin divers may have a larger diving reflex than other subjects.

In this experiment, you will investigate the diving reflex. The test subject’s heart rate will be monitored using an EKG sensor and breath holding will be indicated by using a respiration belt.

Important: The equipment used in this experiment is for educational purposes only and should not be used to diagnose medical conditions.

Objectives

* Obtain graphical representation of heart rate and respiration effort over a period of time.
* Measure the heart-rate before and during normal breath hold.
* Measure the heart-rate before and during a simulated dive in cold water.
* Measure the heart-rate before and during a normal breath hold when a foot is placed in ice water.

MATERIALS

Chromebook, computer, or mobile device

Graphical Analysis 4 app

Go Direct Respiration Belt

Go Direct EKG

electrode tabs

ice

water

bowl or basin (large enough for a subject to submerge his or her face in the water)

paper towels (or cloth towels, as desired)

PROCEDURE

Select one person from your group to be the subject. Important: Do not volunteer to be the subject if you suffer from dizziness, nausea, or respiratory conditions such as asthma.

1. Set up the sensors and Graphical Analysis.
   1. Launch Graphical Analysis.
   2. Connect to Go Direct Respiration Belt.
   3. Connect to Go Direct EKG, and then click or tap Sensor Channels for the EKG.
   4. Deselect the EKG channel and select the Heart Rate channel.
   5. Click or tap Done.
2. Adjust the view and graphs.
   1. Click or tap View, , and select 2 Graphs.
   2. Verify that a graph of force vs. time is displayed. If not, click or tap the y-axis label of one of the graphs, and select Force. Deselect the data you do not want displayed, and click or tap the graph to dismiss the menu.
   3. The second graph should be a graph of heart rate vs. time. Click or tap the y-axis label for the second graph. Select Heart Rate and deselect all other columns. Click or tap the graph to dismiss the menu.
3. Click or tap Mode to open Data Collection Settings. Change Rate to 10 samples/s and End Collection to 120 s. Click or tap Done.
4. Place the respiration belt around the subject’s chest just below the sternum and tighten the belt until the tension indicator light, located in the bottom-left corner of the sensor label, turns green. Note: If the light is not on, tighten the strap until the light turns green. Loosen the strap if the light turns red; a red light indicates too much tension.

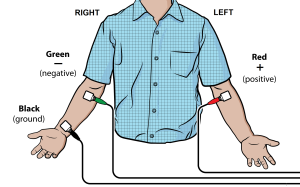


Figure 2

1. Attach three electrode tabs to the subject's arms as shown in Figure 2. Place a single patch on the inside of the right wrist, on the inside of the right upper forearm (distal to the elbow), and on the inside of the left upper forearm (distal to elbow).
2. Connect the EKG clips to the electrode tabs as shown in Figure 2. Have the subject sit in a relaxed position in a chair, with the forearms resting on the legs or on the arms of the chair. When the subject is properly positioned, proceed to the next step.

Part I  Normal Breath Hold

1. Instruct the subject to sit still in a chair and breathe normally. Check that the sensors are in the correct positions. The subject should be sitting and facing away from the device screen.
2. Click or tap Collect to start data collection. After collecting data for 40 seconds, have the subject take a large breath and hold it as long as possible. The subject should not hold his or her breath longer than 60 seconds. The test subject should breathe normally during the remainder of the data-collection period after releasing his or her breath. Data collection will stop after 120 seconds.
3. Determine the heart rate before the breath hold.
   1. Using the graph for respiratory activity as a reference for the breath hold, click or tap and drag across the corresponding area of the heart rate graph before the subject held his or her breath (from 20 to approximately 30 s). This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the pre-test heart rate in Table 1. Round to the nearest whole number.
   4. Dismiss the Statistics box.
4. Determine the heart rate at the end of the breath hold.
   1. Using the graph for respiratory activity as reference for the breath hold, select the corresponding area of the heart rate graph that corresponds with the last 10 seconds of the breath hold. This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the post-test heart rate in Table 1. Round to the nearest whole number.

Part II  Diving Reflex

1. Prepare an ice water bath and place it on the table so it is in front of the subject.
2. Instruct the subject to sit still in a chair and breathe normally. Check that the sensors are in the correct positions. The subject should be sitting and facing away from the device screen.
3. In this step, you will collect data using the following procedure. Make sure everyone understands the procedure, and then collect data.
   1. Click or tap Collect to start data collection.
   2. After data have been collected for 40 seconds, the subject should take a deep breath, hold it, and submerge his or her face in the ice water bath.
   3. The face should be submerged for as long as possible, or for a total of 60 seconds, whichever comes first.
   4. After removing his or her face from the ice water, the subject should continue to breathe normally.
   5. Data collection will stop automatically after a total of 120 seconds have elapsed.

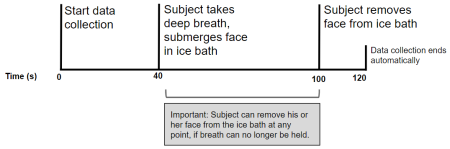


Figure 3

1. Determine the heart rate before the dive.
   1. Using the graph for respiratory activity as reference for the breath hold, select the corresponding area of the heart rate graph before the subject held his or her breath (from 20 s to approximately 30 s). This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the pre-test heart rate in Table 1. Round to the nearest whole number.
   4. Dismiss the Statistics box.
2. Determine the heart rate at the end of the dive.
   1. Using the graph for respiratory activity as reference for the breath hold, select the corresponding area of the heart rate graph that corresponds with the last 10 seconds of the dive. This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the post-test heart rate in Table 1. Round to the nearest whole number.

Part III  Breath Hold with Foot in Cold Water

1. Have the subject remove his or her shoes and socks. Place the bowl of ice water next to the foot that will be placed in the ice bath.
2. Instruct the subject to sit still in a chair and breathe normally. Check that the sensors are in the correct positions. The subject should be sitting and facing away from the device screen.
3. In this step, you will collect data using the following procedure. Make sure everyone understands the procedure, and then collect data.
   1. Click or tap Collect to start data collection.
   2. After data have been collected for 40 seconds, the subject should hold his or her breath and place the foot into the basin of ice water.
   3. The foot should stay in the ice water for as long as the subject can hold his or her breath, or for a total of 60 seconds, whichever comes first.
   4. Once the subject has released the breath, he or she should remove the foot carefully from the ice water bath and continue breathing normally.
   5. Data collection will stop after 120 seconds.
4. Determine the heart rate before the foot was placed in the ice bath.
   1. Using the graph for respiratory activity as reference for the breath hold, select the corresponding area of the heart rate graph before the subject held his or her breath (from 20 to approximately 30 s). This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the pre-test heart rate in Table 1. Round to the nearest whole number.
   4. Dismiss the Statistics box.
5. Determine the heart rate at the end of the breath hold.
   1. Using the graph for respiratory activity as reference for the breath hold, select the corresponding area of the heart rate graph that corresponds with the last 10 seconds of the dive. This will highlight the region of interest.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. Record the mean heart rate as the post-test heart rate in Table 1. Round to the nearest whole number.

DATA

|  |  |  |
| --- | --- | --- |
| Table 1  Heart Rate | | |
| Condition | Pre-test heart rate  (bpm) | Post-test heart rate  (bpm) |
| Breath hold (air) |  |  |
| Diving reflex (face in cold water) |  |  |
| Breath hold (foot in cold water) |  |  |

Data analysis

1. Did the heart rate of the test subject change after holding his or her breath? If so, describe how it changed.
2. Did the heart rate of the subject change during the simulated dive in cold water? If so, describe how it changed. Did you observe a diving reflex?
3. Did the heart rate of the subject change during the breath hold when they placed the foot in the cold water? If so, describe how it changed. Did you observe a diving reflex?
4. Which experiment tested the hypothesis that the diving reflex is elicited by cold water contacting the face? Explain?

Extensions

1. Have the subject perform a simulated dive using a bowl of warm water. Is a diving reflex observed?
2. Have the subject perform a breath hold while a cold pack or bag of ice and water is applied to the face. Is a diving reflex observed?
3. Calculate the percent change in heart rate for the conditions you have tested. The percent change in heart rate can be calculated using the following equation:



1. If any members of the class are cold water swimmers or free divers, use the class data to determine if they have a larger diving reflex than other subjects.