Experiment HH-5: The Diving Reflex

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

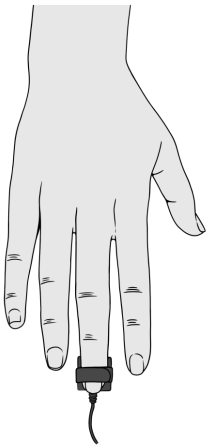
PPG-320 Pulse plethysmograph

ROAM - optional

Three pans, each with 3” of water at 5, 15, or 25^{o}C

RM-204 Respiration monitor (optional)

Pulse Transducer Setup



1. Locate the PPG-320 pulse plethysmograph.
2. Plug the connector to the PPG-320 pulse sensor into the PT port on the front of the TA.
3. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger or thumb, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
4. Instruct the subject to sit quietly.

Figure HH-5-S1: The PPG-320 connected to the IXTA.

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If you choose to use the ROAM to measure ECG, set up the electrodes as shown:

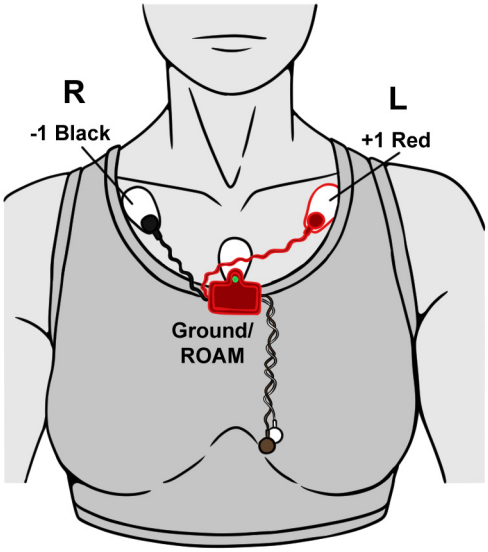

Figure HH-5-S2: The ROAM electrodes for recording ECG – optional.

Optional: Measuring Respiration Rate and Depth

Attaching a RM-204 respiration monitor to the subject permits relative changes in the subject's rate and depth of respiration to be measured during normal breathing, apnea, and testing the diving reflex. The use of a respiration monitor is optional and it is not required to complete the exercises in this experiment.

1. Locate the RM-204 respiration monitor.
2. Plug the DIN8 connector of the RM-204 into Channel A6 of the IXTA.
3. Wrap the elastic belt of the respiration monitor around the subject's chest at a level that is below the sternum. Place the sensor inside the belt so that the sensor is in the center of chest at a level that is even with the subject's elbows.
4. If the subjects are sitting during these exercises, they should sit erect so that the muscles involved in pulmonary ventilation are able to move with few restrictions.

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Figure HH-5-L5: The RM-204 respiration monitor.

Figure HH-5-L6: The RM-204 connected to the IXTA.

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Experiment HH-5: The Diving Reflex - ROAM

Exercise 1: Heart Rate at Rest

Aim: To measure the heart rate of a subject at rest.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
2. Click on the AutoScale All button. Your recording should look similar to the image below.
3. When you have a suitable trace, type **Resting** in the Mark box. Click the mark button to attach the comment to the data. Record for at least 5 minutes.
4. Click Stop to halt recording.
5. Select Save As in the File menu, type a name for the file. Click OK.

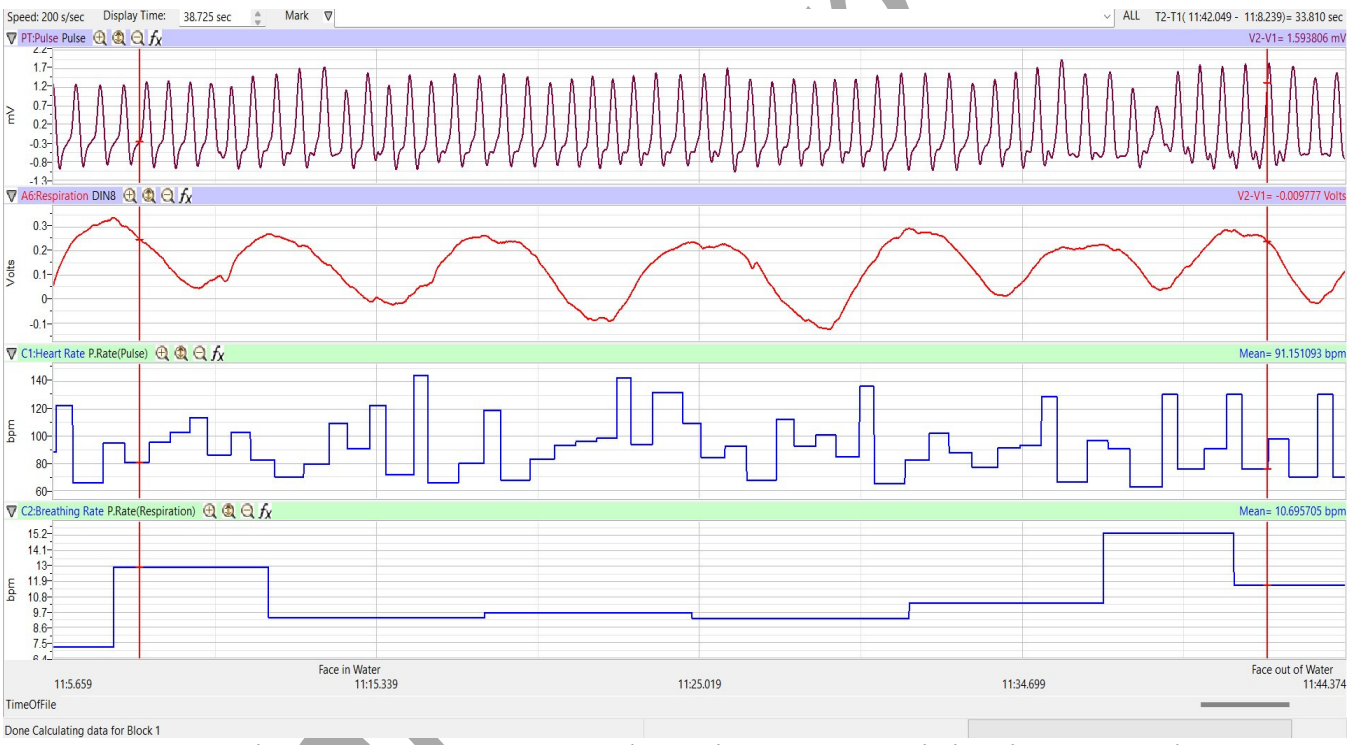

Figure HH-5-L1:The ECG, Respiration, HR and Breathing Rate recorded in the main window using the wireless ROAM.

NOTE: Hide channel A6 and C2 if not using the Respiration Belt.

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Data Analysis

1. Scroll through the recording and find a twenty second section of data with exemplary pulse waves. Since the subject is breathing normally, the trace on the Heart Rate channel may cycle, which demonstrates normal respiratory sinus arrhythmia.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete heart rate cycles on the Main window.
3. Click on the Analysis window icon to transfer the data to the Analysis window.

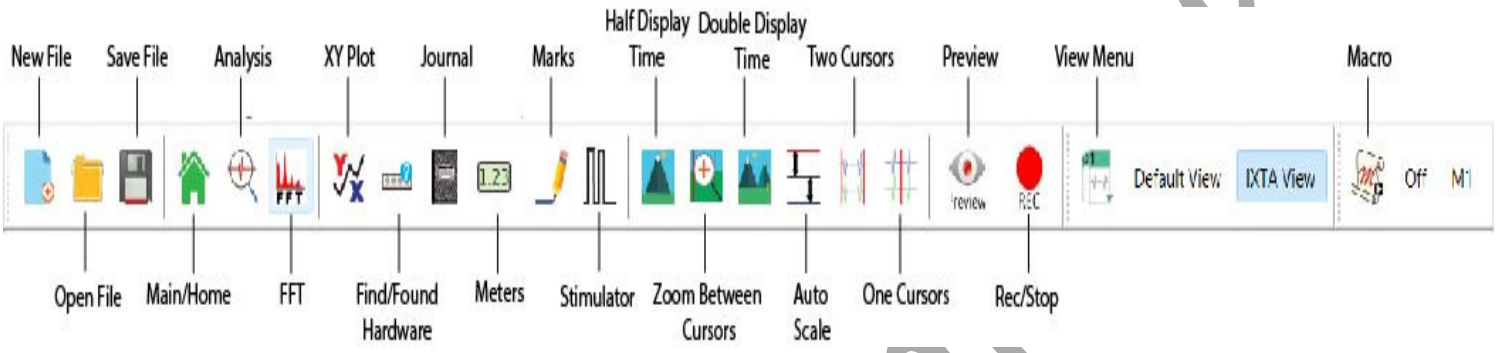

Figure HH-5-L2:The LabScribe Toolbar.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The names of the mathematical functions used in the analysis: V1, V2, V2-V1, T2-T1, Max, Min, Mean, and T2-T1 appear in this table. The values for these three parameters on each channel are seen in the table across the top margin of each channel.

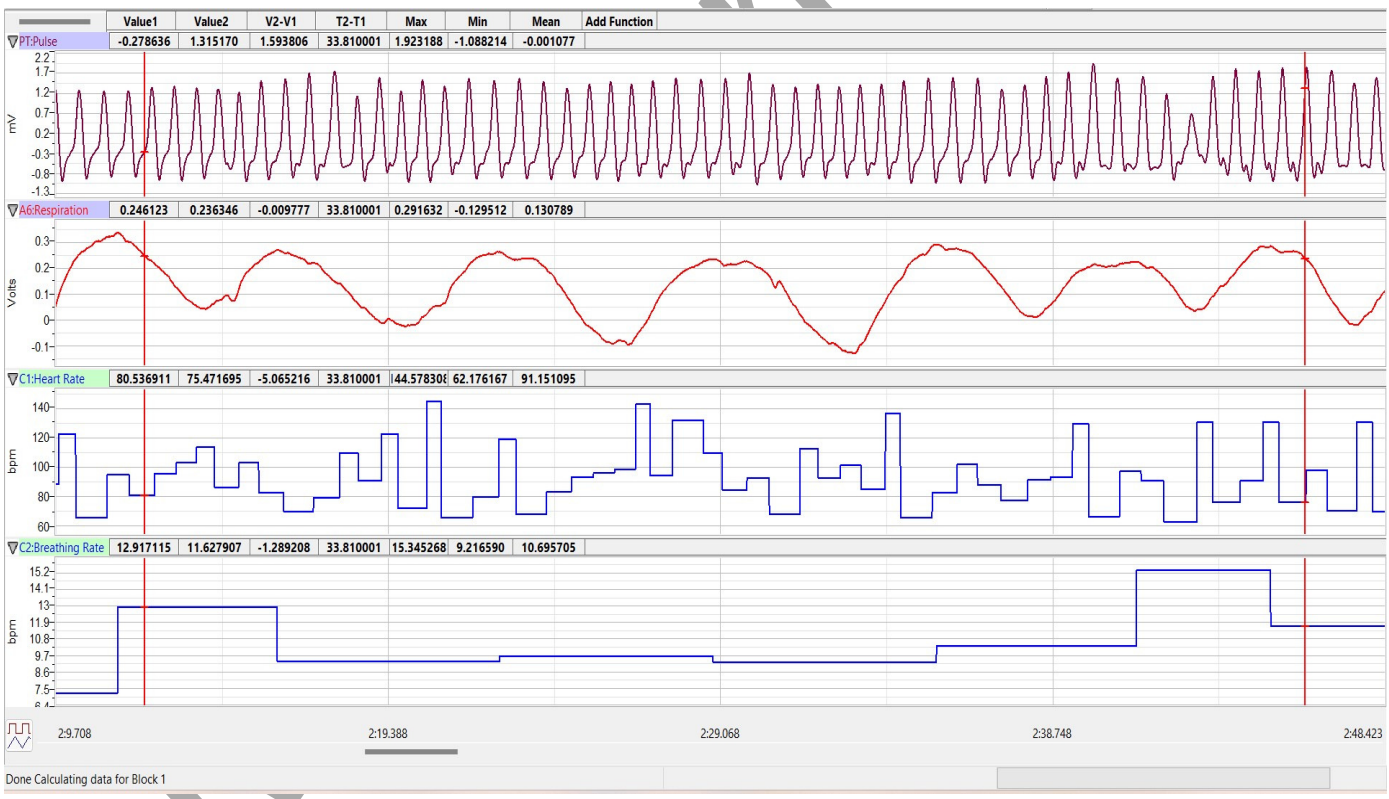

Figure HH-5-L3:The HR and Breathing Rate as shown in the Analysis window.

5. Once the cursors are placed in the correct positions for determining the maximum, minimum, and mean heart rates in the section of data displayed in the Analysis window, the values of these parameters can be recorded in the Journal by typing their names and values directly into the Journal, or on a separate data table.
6. Enter the subject's resting heart rate and breathing rate values into Table 1.

Exercise 2: Heart Rate and Apnea

Aim: To measure the heart rate of a subject while they are holding their breath.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
2. Remind the same subject to sit quietly with their hands in their lap. Instruct the subject to hold their breath as long as possible in this exercise.
3. Click on the AutoScale all button. Use the same techniques used in Exercise 1 to display the signals properly.
4. When the recording is suitable, type **Holding Breath** in the Mark box. Click the mark button to attach the comment to the data as the subject begins to hold their breath (Apnea).
5. Quickly type **Breathing Again** in the Mark box. Click the mark button to attach the comment to the data **only when** the subject resumes breathing. Continue recording for at least one minute after the subject begins breathing.
6. Click Stop. Click Save.

Data Analysis

1. Scroll through the recording and find the section of data that was collected while the subject was holding their breath.
2. Use the Display Time icons, or the cursors and the Zoom between Cursors button, to adjust the Display Time of the Main window to show the data from ten seconds before the subject held their breath to at least twenty seconds after breathing resumed.
3. Click on the Analysis window icon.
4. Place one cursor at the point when the subject held their breath and the other cursor at the point breathing resumed.
5. Look at the Function Table in the Analysis window and make sure the mathematical functions used in the analysis, Max, Min, and Mean, appear.
6. Use one of the techniques explained in Exercise 1 to record the values for these parameters in the Journal, or on a separate data table.
7. Enter the subject's heart rate during apnea into Table 1. Breathing rate will be "0" at this time

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because the subject is holding their breath.

8. Move the cursors so they bracket 20 seconds of data immediately after the subject started breathing again – enter the values for heart rate and breathing rate into the Journal or on the data table.

Questions

1. How does the subject's average heart rate while resting compare to the heart rate while holding breath?
2. How do the subject's maximum and minimum heart rates while resting compare to the same heart rates while holding breath?
3. How do the subject's max, min and mean breathing rates compare while at rest and after holding breath?

Exercise 3: Heart Rate While Testing the Diving Reflex

Aim: To measure the effects of "diving" into cold water on heart rate.

Approximate Time: 30-45 minutes

Procedure

1. Have the subject sit in front of a pan of room temperature water (25^{o}C). If the subject wears glasses, the glasses should be removed. If the subject has long hair, the hair should be pulled back away from the face.
2. Click the Record button. The signal should begin scrolling across the screen.
3. Click on the AutoScale All button. Use the same techniques used in Exercise 1 to display the signals properly.
4. When the recording looks good, type **25^{o}C Water** in the Mark box.
5. Instruct the subject to hold their breath and submerge their face (up to the hairline and in front of the ears) in water for **20 seconds**. Click the mark button as the subject's face enters the water.
6. Quickly type **Face Out of Water** in the Mark box. As the subject pulls their face out of the water, click the mark button. Record for at least 1 minute while their face is out of the water and they are recovering.
7. Click Stop to halt recording after this trial.
8. Select Save in the File menu.
9. Repeat the diving exercise into the pan of 25^{o}C water two additional times. Allow enough time between trials for the subject's heart rate to return to normal.

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Note: *If a preliminary examination of the data indicates the subject's heart rate did not change, the subject may not have a good diving reflex. Select another subject to perform this exercise before continuing. Repeat the first part of Exercise 3 before moving to #10.*

10. Repeat this exercise with the same subject submerging their face in pans of water at 15°C and 5°C.

Data Analysis

1. Scroll through the recording and find the first trial when the subject submerged their face in 25°C water. Click the down arrow next to the Mark button and choose the 25°C water mark.
2. Use the Display Time icons, or the cursors and the Zoom between Cursors button, to adjust the Display Time of the Main window to show the data from ten seconds before the subject submerged their face to twenty seconds after removing their face from the water.
3. Click on the Analysis window icon.
4. Place one cursor at the point when the subject submerged their face in the water and the other cursor at a point five seconds later.
5. Look at the Function Table in the Analysis window and make sure the mathematical functions used in the analysis: V1, V2, V2-V1, T2-T1, Max, Min, and Mean, appear.
6. Use one of the techniques explained in Exercise 1 to record the values for these parameters in the Journal, or on a separate data table.
7. Move one cursor to the point that is five seconds before the subject removed their face from the water and the second cursor to the point just as the subject's face was removed from the water. Record the maximum, minimum, and mean heart rates for this time period.
8. Move the cursors so they bracket 20 seconds of data immediately after the subject started breathing again – enter the Mean values for heart rate and breathing rate info the data table.
9. Repeat these measurements for each of the three trials at 25°C, 15°C, and 5°C.
10. Determine the averages of the maximum, minimum, and mean heart rates in the first five seconds and the last five seconds of submersion at each temperature. Enter these values in the Journal or in Table 1.
11. Determine the subject's max, min and mean breathing rate immediately after removal from the water.

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Table HH-5-L1:Heart Rate at Rest, during Apnea and Facial Exposure to Different Temperatures.

		Heart Rate (BPM)			Breathing Rate (BPM)		
Experiment		**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
Resting							
Holding Breath (Apnea)							
Face in 25°C Water	First 5 sec						
	Last 5 sec						
	20 sec after						
Face in 15°C Water	First 5 sec						
	Last 5 sec						
	20 sec after						
Face in 5°C Water	First 5 sec						
	Last 5 sec						
	20 sec after						

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Questions

1. What happens to the subject's heart rate as their face is submerged in water at 25°C?
2. What happens to the subject's heart rate as their face is submerged in water at 15°C? In water at 5°C?

3. What causes the subject's heart rate to change when their face is submerged in cold water?
4. How does the mammalian diving reflex help a person who falls into cold water? Think in terms of the organs that need oxygen.
5. How does breathing rate compare after each of the different temperature water submersions? Is there a difference is what happens depending on the temperature of the water? Why or why not?

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