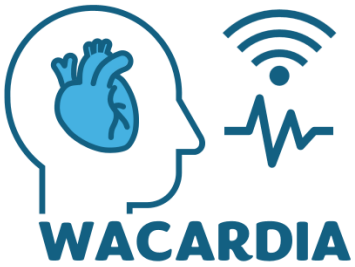
Standard Operating Procedures for WACARDIA MATLAB program to use Shimmer sensors and Heartbeat Detection tasks



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2020/01/24	First version
2024/09/20	Update with Bluetooth Lag Detection and more troubleshooting from IK and JC

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PREPARING THE SHIMMER MOBILE SENSORS

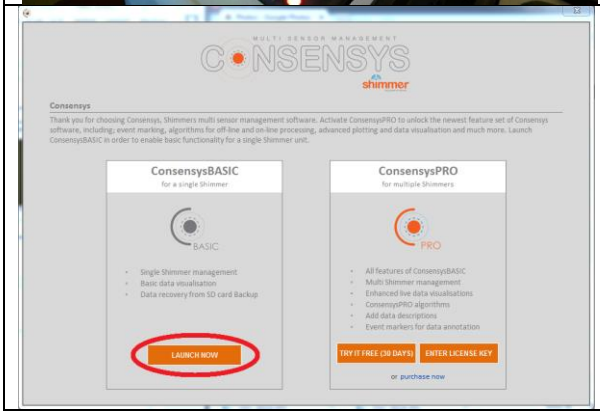
THE RED TEXT MEANS: DO THIS ONLY ONCE PER SHIMMER SENSOR, NOT EVERY TIME BEFORE THE SUBJECT COMES TO THE LAB (UNLESS THE SENSOR DOES NOT WORK PROPERLY)

To save time, keep a single set of sensors for in-lab use only so you don't have to do this often.

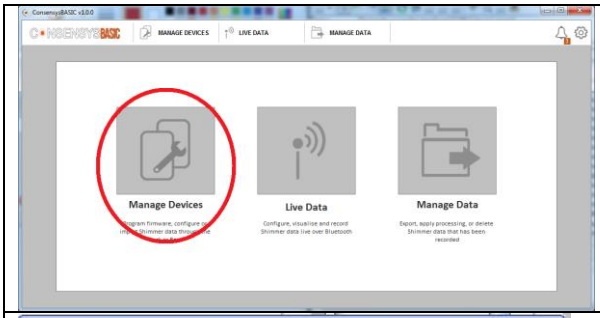
1. Plug Shimmer dock into the surge protector (if not already plugged in)
2. Plug Shimmer dock USB into the computer

3. Plug Shimmer sensors into dock (use one ECG and one EDA/GSR)

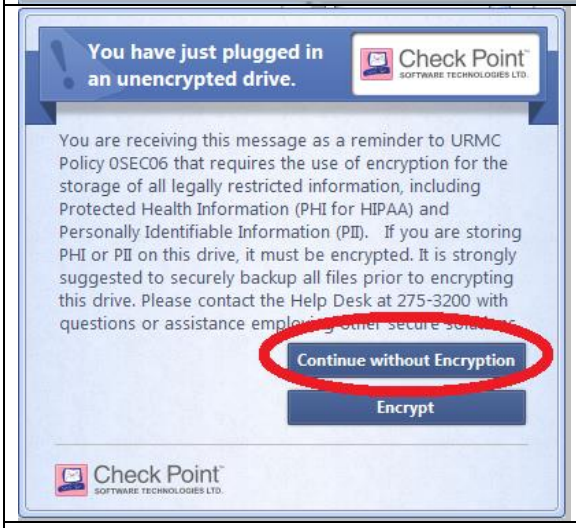
4. Turn the devices on by **flipping the orange switch up**. You'll know it is on because the lights on the front will illuminate



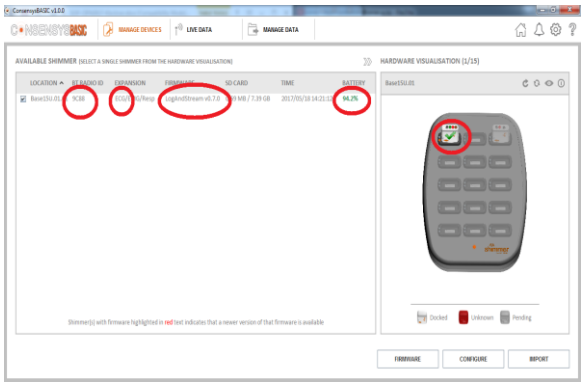
5. Open Consensys (Start menu…type Consensys, press Enter)
6. Choose ConsensysBASIC and click LAUNCH NOW at the bottom left



7. Click on “Manage Devices”



8. If you get this message requesting that the Shimmer Mobile Sensor be encrypted, choose **<u>Continue without Encryption</u>**



1. **For each of the two sensors, write down the following on the data sheet**
    a. Bluetooth (BT) radio ID, e.g., 91E0
    b. FYI the BT ID is also on the back of the sensor itself in a black rectangle
    c. Expansion (e.g., ECG or EDA/GSR+)
    d. COM port from Bluetooth settings (instructions in the next section with black text)
2. **Check that the following are valid**
    a. Firmware should be LogAndStream. If not then repeat prior instructions using the FIRMWARE button
    b. Battery should be at least 20% before the participant wears the device
3. **Close the Consensys program by clicking the X in the top right corner of the window**
    a. Click **<u>Yes</u>** to exit

On the computer, set up the FIRMWARE for the in-lab devices

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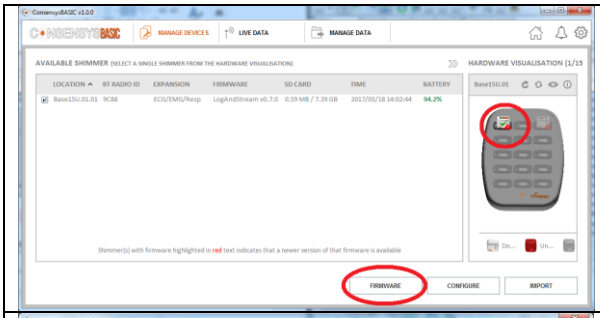
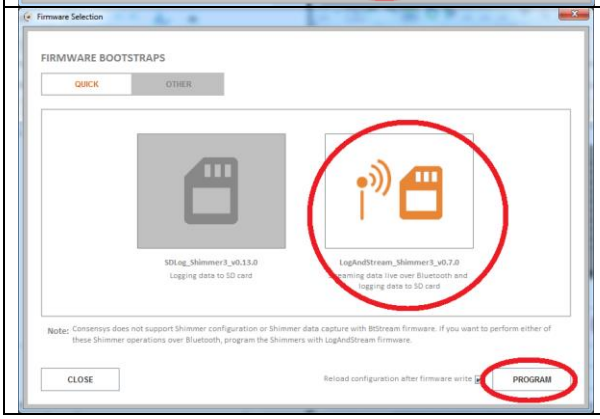
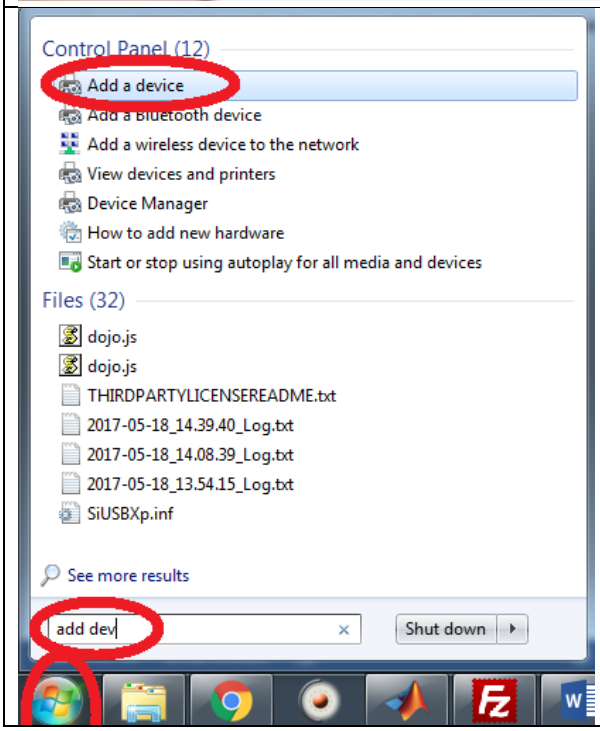
To save time, keep a single set of sensors for in-lab use only so you don't have to do this often.

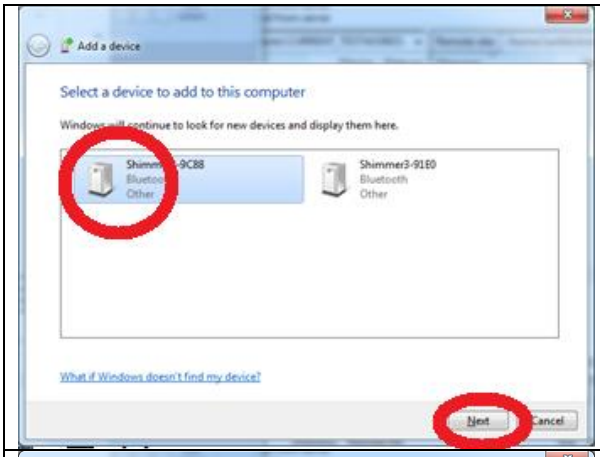
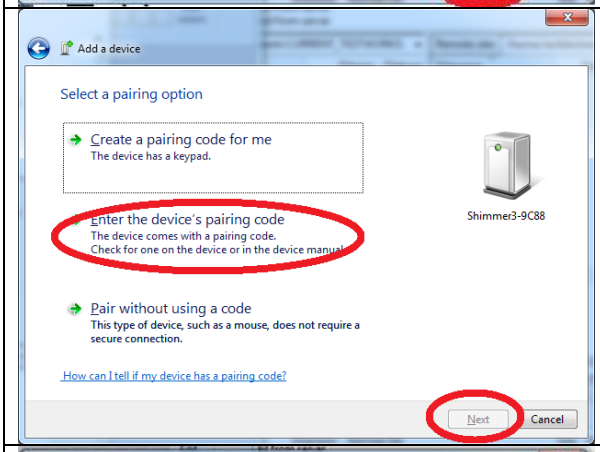
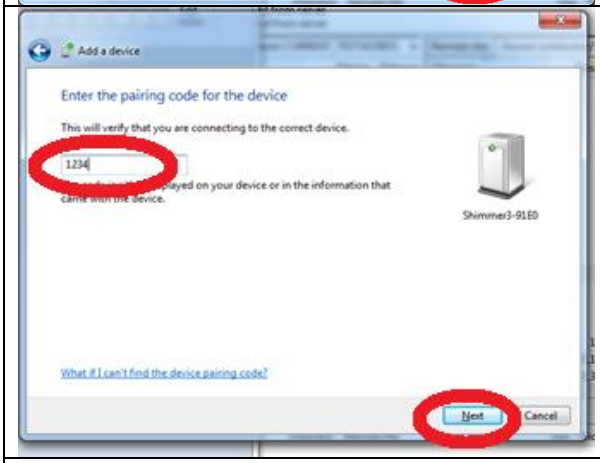
		1. Open the Consensys program (see above) if not already open 2. Click on the Shimmer device (or both if possible) and click FIRMWARE 3. FYI, at this window you can check the Firmware version and see whether it needs to be changed or not
		4. Choose LogAndStream_Shimmer to ensure that the device can stream data via Bluetooth 5. Click PROGRAM 6. Wait until process is complete 7. Click DONE 8. Do NOT encrypt the device, if asked by Windows

Windows 7 and older: Set up devices for Bluetooth connection with computer

THE RED TEXT MEANS: DO THIS ONLY ONCE PER SHIMMER SENSOR, NOT EVERY TIME BEFORE THE SUBJECT COMES TO THE LAB (UNLESS THE SENSOR DOES NOT WORK PROPERLY)

To save time, keep a single set of sensors for in-lab use only so you don't have to do this often.

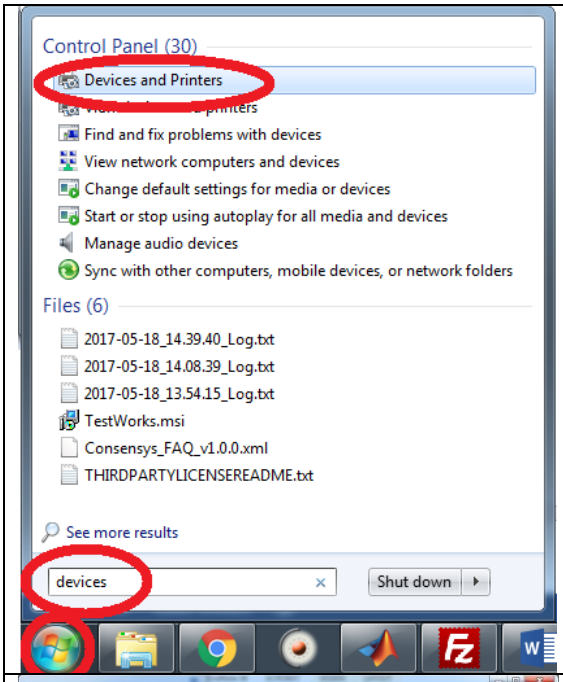
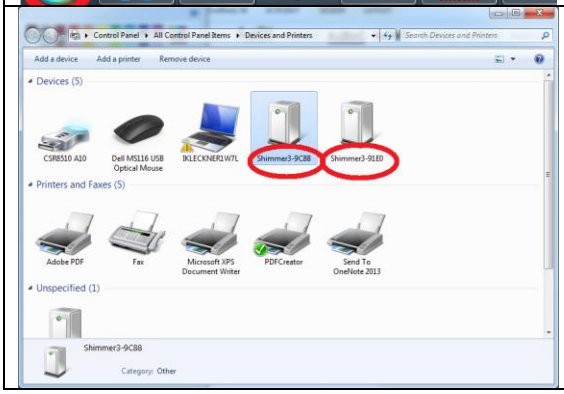
	If you are using a USB Bluetooth Dongle (probably yes) then make sure that is inserted as it will affect the COM ports that each Shimmer is assigned to
	1. Click the Start button (or press the Windows button on the keyboard) 2. Type **add device** 3. Click the **Add a device** option that appears

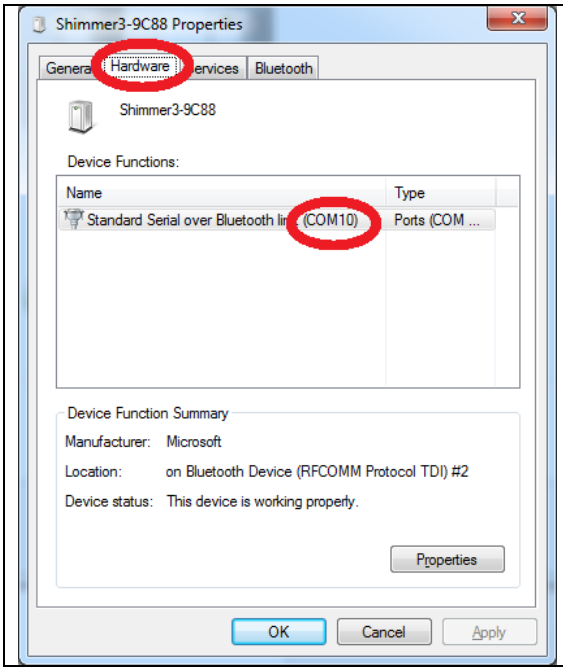
	1. The nearby Shimmer Sensors that are ON should appear here a. If they do not appear here, you must ensure your computer has Bluetooth capabilities (e.g., using a USB dongle), and perhaps you need to enable Bluetooth b. One setup in the lab uses a Bluetooth USB dongle and once it is pugged in then Bluetooth is enabled
	2. Click enter the device's pairing code 3. Click Next
	4. Enter the pairing code: 1234 5. This pairing code is the same for all Shimmer Sensors 6. Click Next
	7. Repeat this process for any other Shimmer Sensors that need to be streamed to the computer a. FYI, the sensors that are given to participants to take home do NOT need to use Bluetooth

Check COM port for Shimmer sensors

You only need to do this once per computer + Bluetooth dongle + Shimmer sensor combination

Windows 7

	Click the Start button (or press the Windows button on the keyboard) Type **devices** Click the **Devices and Printers** option that appears
	Double click on each of the Shimmer Devices that you just paired



Click the **Hardware** tab

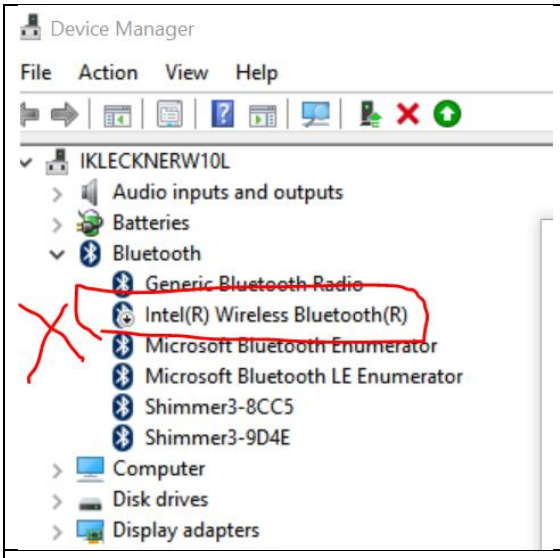
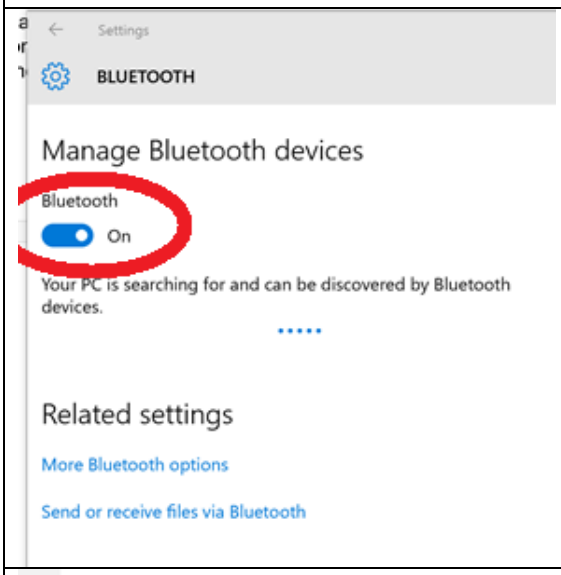
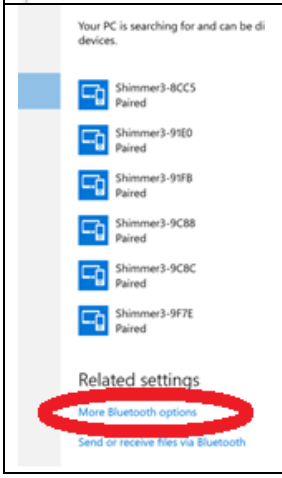
Check the COM port number (here it is 10) and write this down on the **Datasheet**

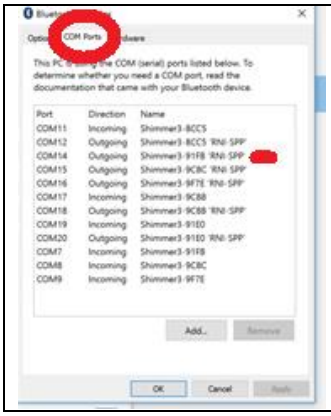
You will need to use this COM port number in a few minutes

Repeat these two steps for the other Shimmer Sensor

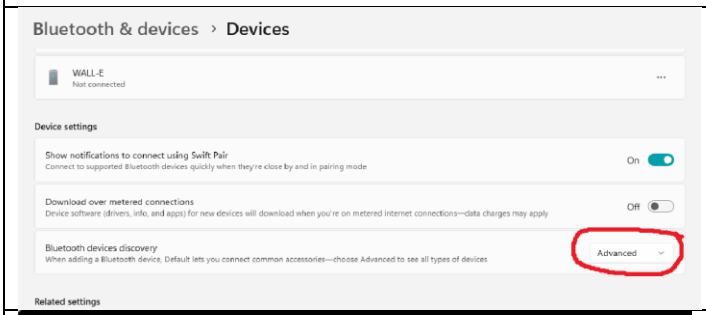
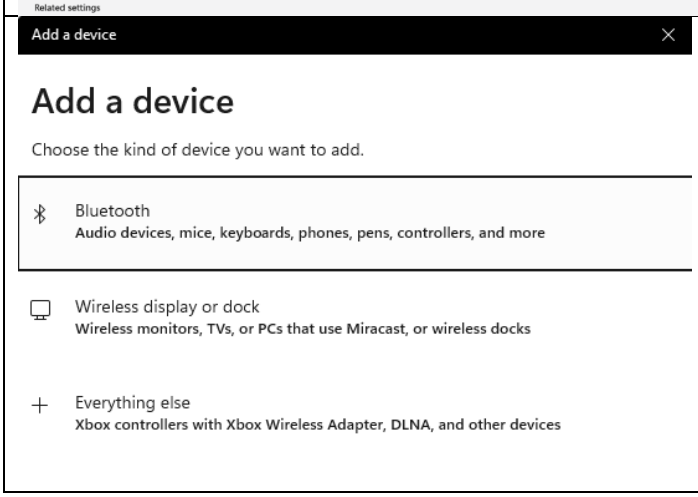
Windows 10

If you are using a USB Bluetooth Dongle (probably yes) then make sure that is inserted as it will affect the COM ports that each Shimmer is assigned to

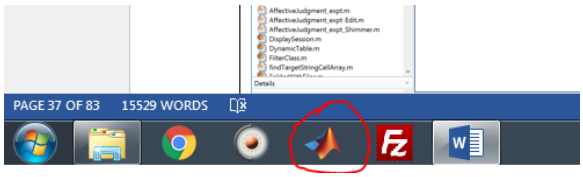
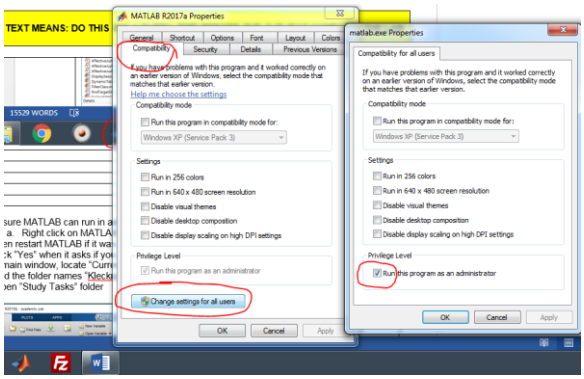
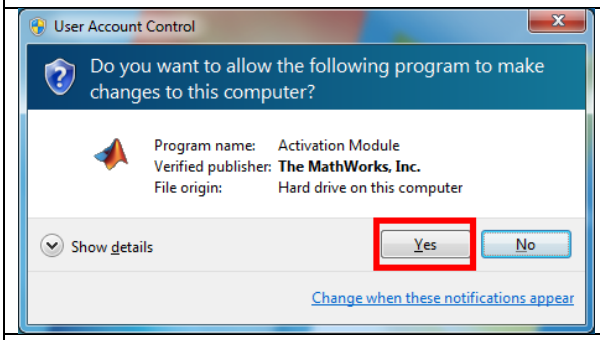
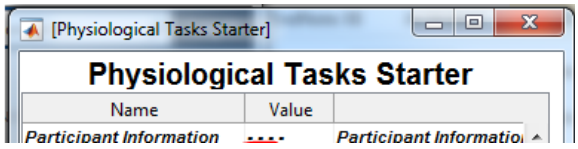
	If there is integrated AND external Bluetooth then disable the integrated Bluetooth using the device manager (**Windows button…type device manager)** Right click on the integrated Bluetooth and click Disable
	Press the **Windows** button on the keyboard or click the Windows icon in the lower left hand corner Type **Bluetooth** into search Hit **enter** to open Bluetooth settings
	Click to turn on Bluetooth
	Devices should be paired Click More Bluetooth Settings near the bottom

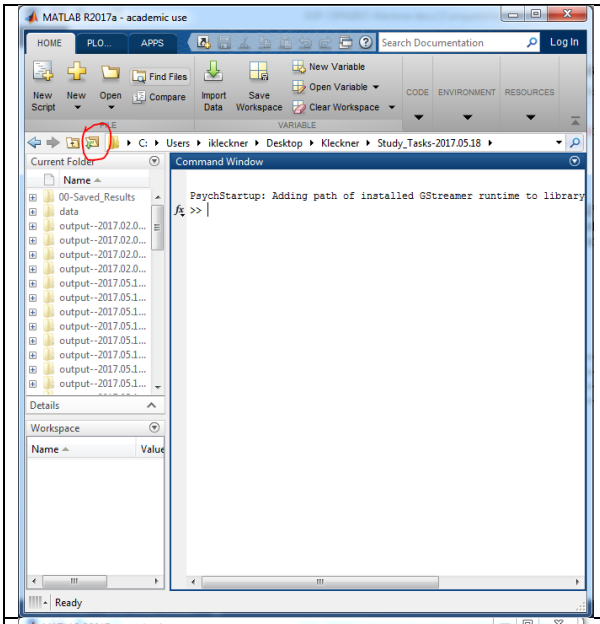
	Click on COM Ports tab to see list of devices The COM we want has RNI-SPP in the name Ex: EDA Shimmer is 91E0, COM16 Ex: ECG Shimmer is 9C88, COM18 Check the COM port number (here it is 14) and write this down on the **Datasheet** You will need to use this COM port number in a few minutes

Windows 11

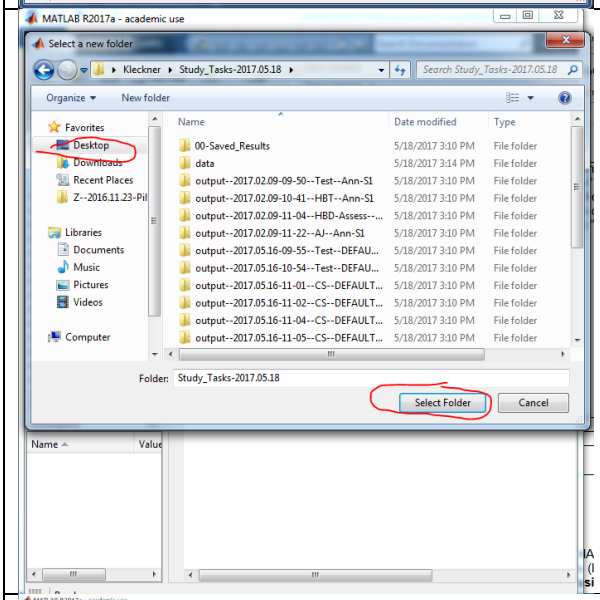
	If you are using a USB Bluetooth Dongle (probably yes, then **follow the steps above** for Windows 10 to disable integrated Bluetooth.
	1. Open Settings > Bluetooth and devices 2. Press “View more devices” 3. Scroll down until “Bluetooth devices discovery” under Device settings 4. Switch it from Default to Advanced
	5. Return to “Bluetooth and devices” and select “Add device” 6. Choose Bluetooth, the top option 7. Select your Shimmer sensor when it appears and connect! **(The PIN default is 1234)** After this, **follow the steps above** to determine the COM port number for the Shimmer

Test connection with Shimmer Sensors

	If you are using a USB Bluetooth Dongle (probably yes) then make sure that is inserted as it will affect the COM ports that each Shimmer is assigned to
	Open MATLAB • Use the shortcut on the computer desktop or taskbar • Or click Start…type ***matlab*** then hit **Enter**
	**Only do this once per computer** Ensure MATLAB can run in administrator mode (only needs to be done once per computer) Right click on MATLAB shortcut…Properties…Compatibility…Run as administrator Then restart MATLAB if it was already running
	Click “Yes” when it asks if you want MATLAB to make changes to the computer
	MATLAB may be set up with the proper directory and to automatically open the **Task_Starter** program If a window like this does NOT open, then complete the following 3 steps in red to open it.



In main window, click **Current Folder** on left side of screen

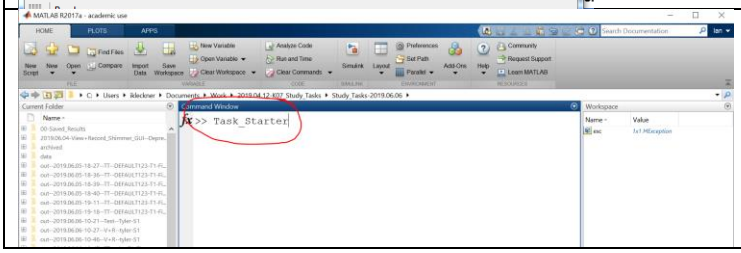


Go to Desktop

Kleckner

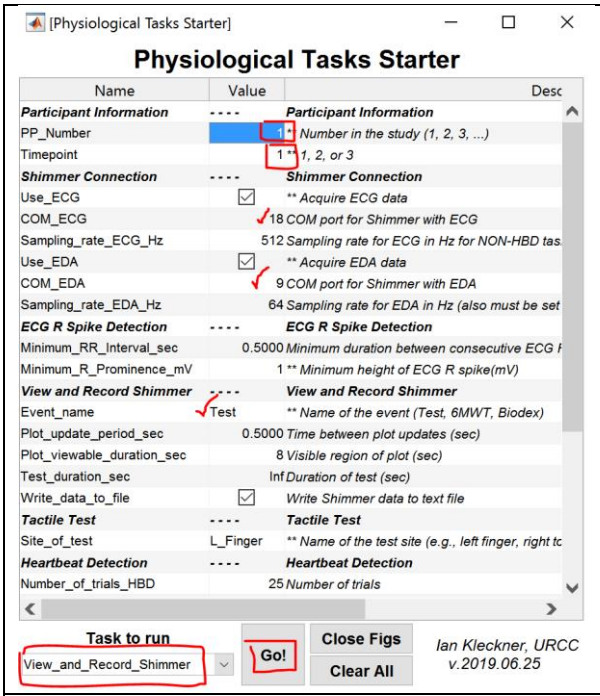
Study_Tasks-2019.06.12 (or most recent folder of a similar name)

Click **Select Folder**



In the command window, type ***Task*** and hit **tab**, it will complete the command for you to **Task_Starter**

Hit **Enter**



Type in subject number (1, 2, …)

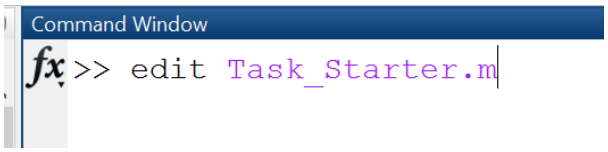
Type in timepoint (1, 2, or 3)

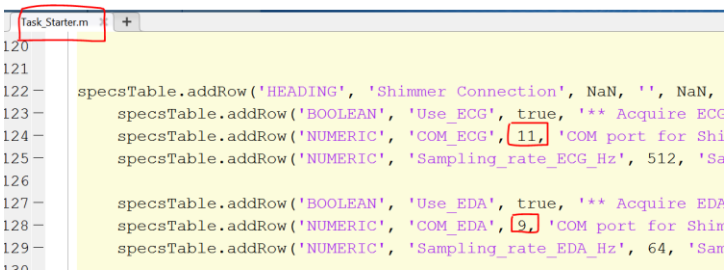
Type in COM port for Shimmer ECG (e.g., 10) obtained from Windows Bluetooth settings (steps above)

Type in COM port for Shimmer EDA (e.g., 8) obtained from Windows Bluetooth settings (steps above)

At bottom left, set **Task to run** to **Test_Shimmer_Sensors**

Click **Go!** at bottom right





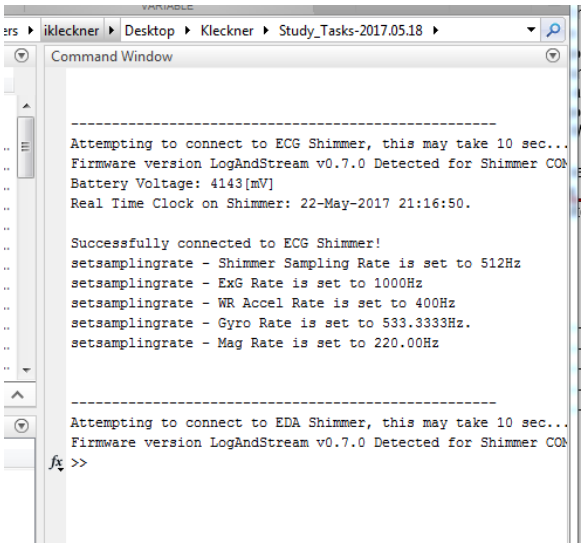
If you want to edit the DEFAULT values in the Task Starter, edit the file Task_Starter.m

In the command window, type **edit Task_Starter.m**

In the window that opens, edit the values shown in the picture to the left. E.g., to change the default COM port for the Shimmer ECG, you would edit this code around line 123 (might differ by code version). You would change 11 to a different value.

```
specsTable.addRow('NUMERIC',
'COM_ECG', 11, 'COM port for
Shimmer with ECG', 0, Inf);
```

Then Save the file (**Ctrl+s**), exit the Task_Starter (click the **x** in the top right), and start it again by typing **Task_Starter** then hitting **Enter** in the MATLAB command window.

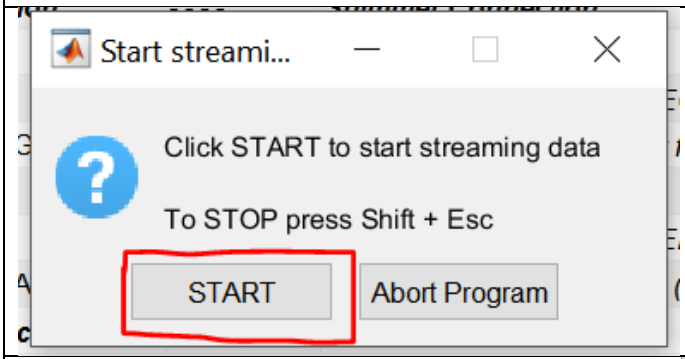


Watch the MATLAB command window for progress for how the computer is connecting to the Shimmer devices

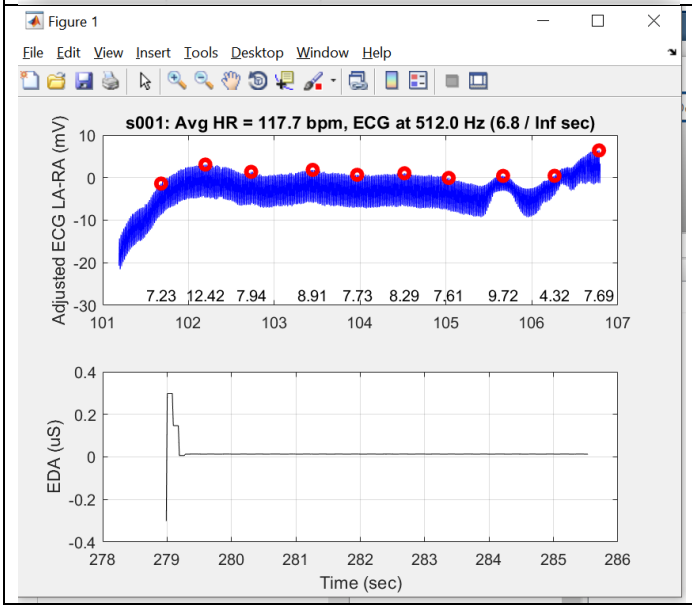
This takes approximately 20 sec

If there are any issues here (red text in MATLAB window) then check the following

- Computer's Bluetooth is on (press the Windows button, type Bluetooth, hit enter, and turn it on)
- MATLAB has administrator access
- Shimmer devices are on
- RealTerm software installed on computer
- Shimmer source code is in MATLAB directory where Kleckner/Study_Tasks files are
- Try turning the Shimmer devices OFF…waiting 5 sec…then turning them ON again
- Try restarting MATLAB (type **exit** at the command window then hit **enter**)
- Call Ian or email him

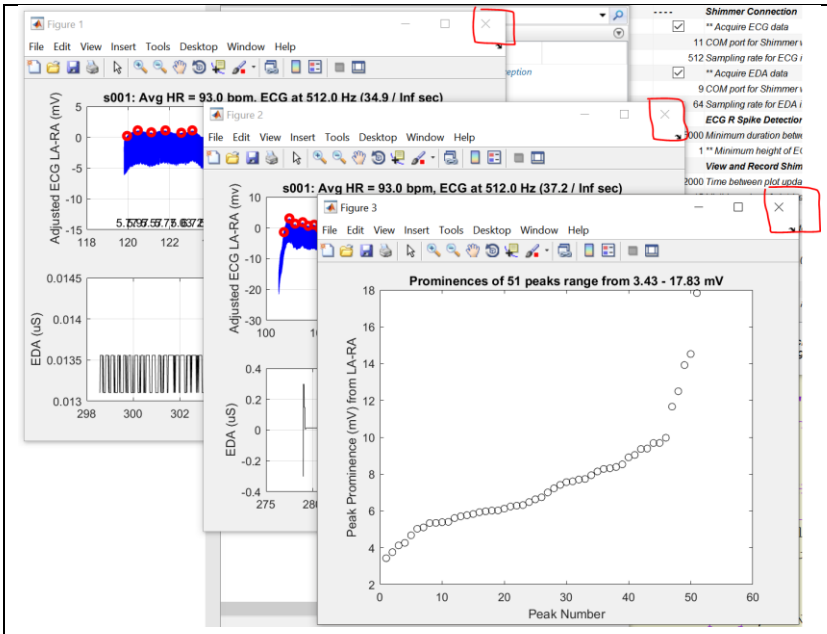


Click **START**



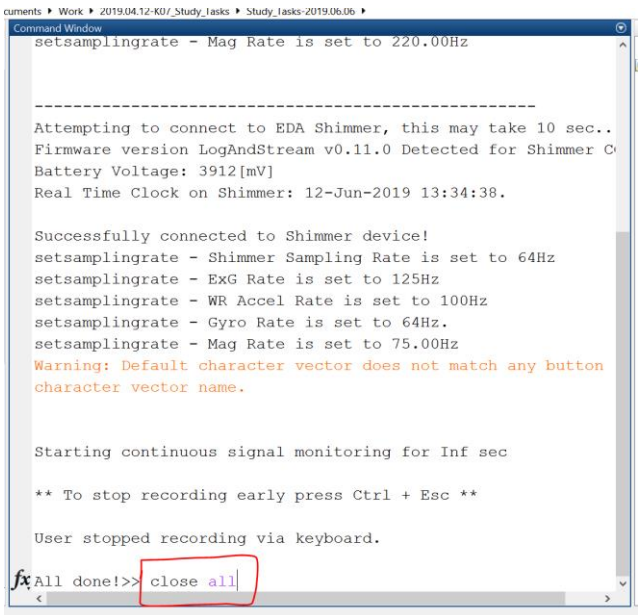
A new windows opens up and shows data from the sensors. If anything appears, that is a success

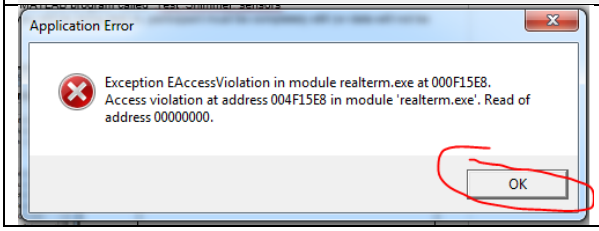
You can watch the number of seconds in the recording until it reaches the goal or you can **hold Shift+Esc for a couple seconds to exit**



Now you know that MATLAB can successfully connect to both Shimmer ECG and Shimmer EDA devices! Of course, these data are just noise because the electrodes are not connected to anything.

When the program is complete, **close all three figures** showing data, or click **Close Figs** in the Task Starter





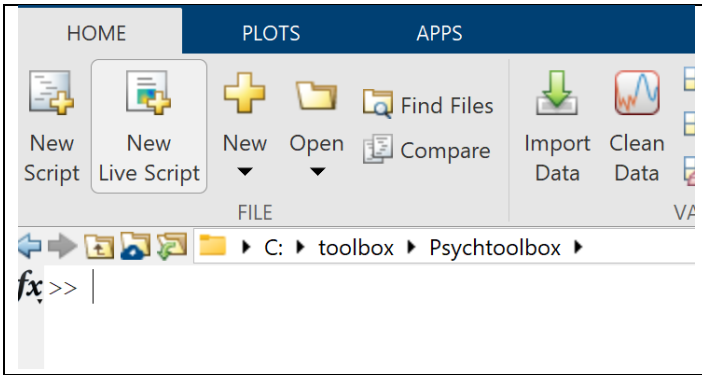
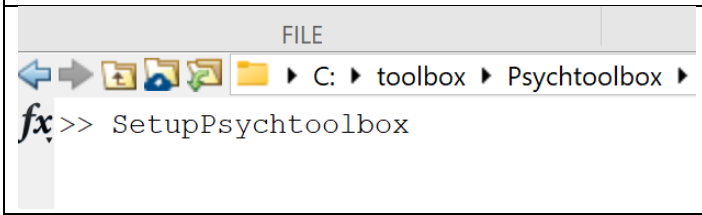
If you ever see this message, just click **OK**

It is **no big deal**, and you don't need to document it. It's just a side-effect of exiting the MATLAB programs early, so it's bound to happen sometimes.

TROUBLESHOOTING

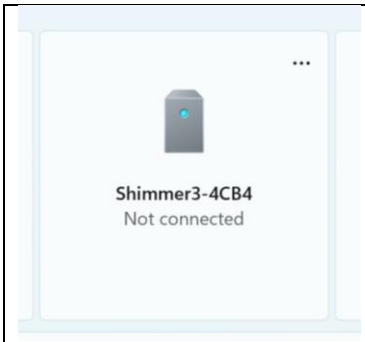
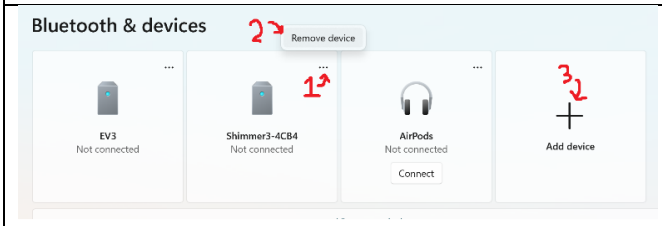
Error: Invalid MEX-file
'C:\toolbox\Psychtoolbox\PsychBasic\MatlabWindowsFilesR2007a\Screen.mexw64':
The specified module could not be found.

If you receive this error message in the MATLAB command window, please reinstall Psychtoolbox by following these steps:

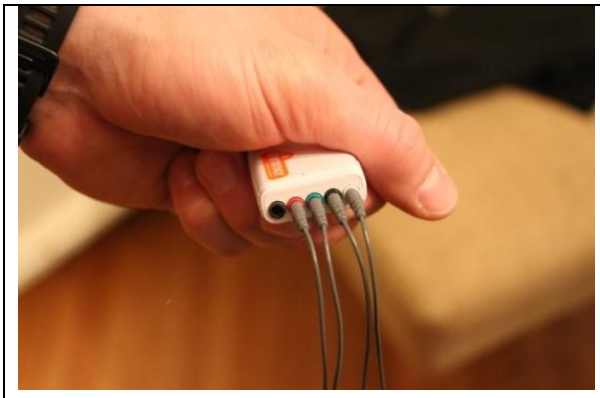
	Open MATLAB using 'Run as administrator' In the MATLAB command window, navigate to Psychtoolbox (**probably inside C:/toolbox**)
	Run the command 'SetupPsychtoolbox'

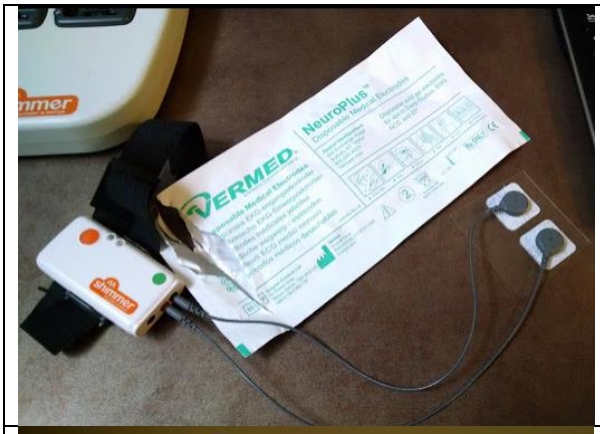
Psychtoolbox will automatically re-install, and the program should work from there.

Error: Shimmer device will not connect to the computer via Bluetooth

	There is a bug in Windows 11 where Settings might show that the Shimmer is not connected when it actually is. If your screen looks like this even after following the steps to connect to the device, do this to check whether or not the Shimmer is actually connected.
	1. Click the 3-dot menu on the Shimmer 2. Select 'Remove device' 3. Press the box labeled 'Add device' 4. Add a Bluetooth device (the first option) 5. Select the Shimmer when it pops up (PIN: 1234)
	The display will probably show the Shimmer Connected for a few seconds, but then revert back to Not connected. If so, start MATLAB (as administrator) and run the View and Record Shimmer program. The program will hopefully run successfully, and you can move on to running trials.

PREPARE SHIMMER SENSORS, ELECTRODES, AND STRAPS

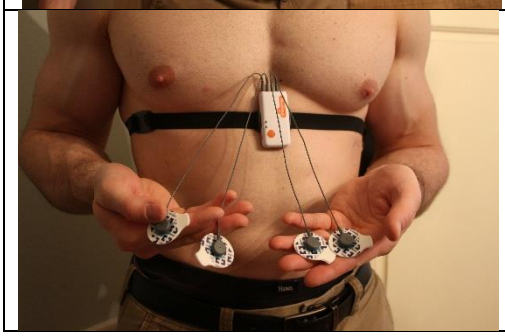
	The Shimmer ECG has four wires: **red, green, black, and white** The brown lead receptacle (on the left) is not used here
	Plug the Shimmer ECG leads into each of four round **Medline ECG electrodes** Attach a **long chest strap** to the Shimmer ECG

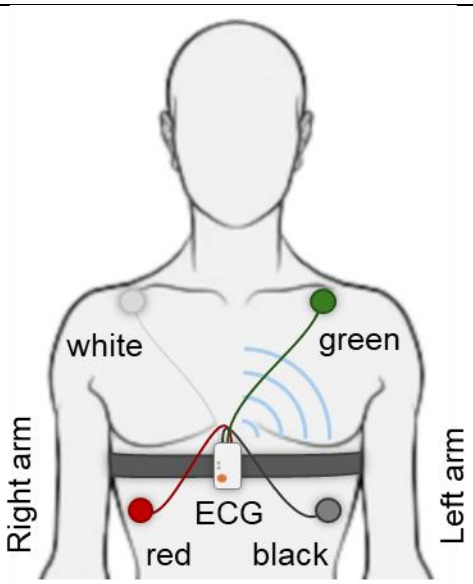
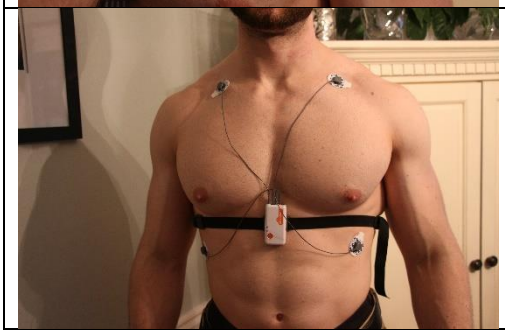
	Plug the Shimmer EDA leads into each of two square **Vermed ECG electrodes**(here, used for EDA) Attach a **short arm strap** to the Shimmer EDA
	Plug the Shimmer sensors back into the dock so their battery will remain charged

SUBJECT ARRIVES

- Offer them a drink of water (also helps improve signal quality)
- Offer them a bathroom break
- Ask them to wash their hands lightly with little / no soap

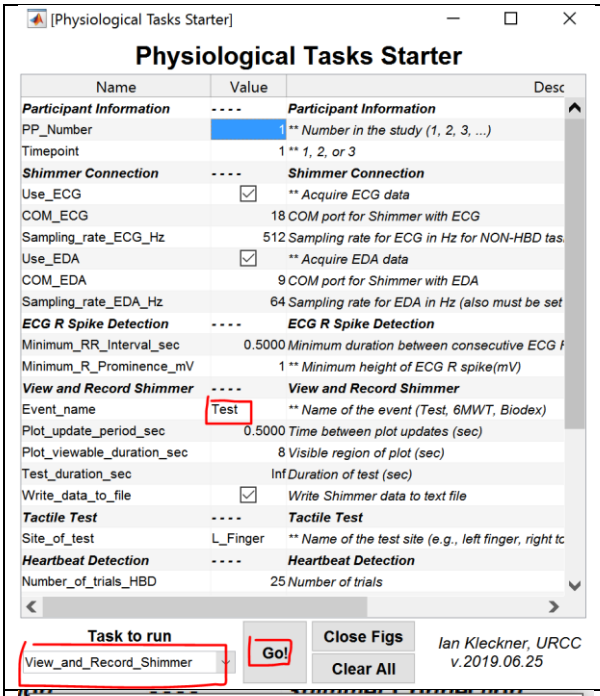
Place Shmmer ECG (chest)

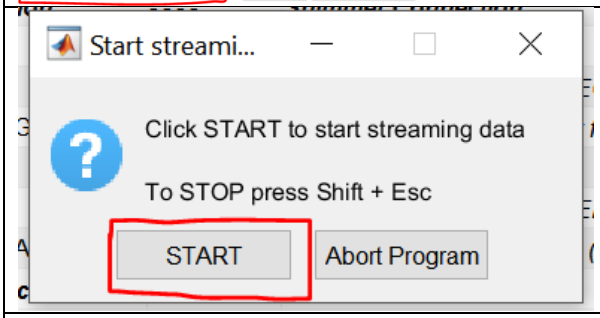
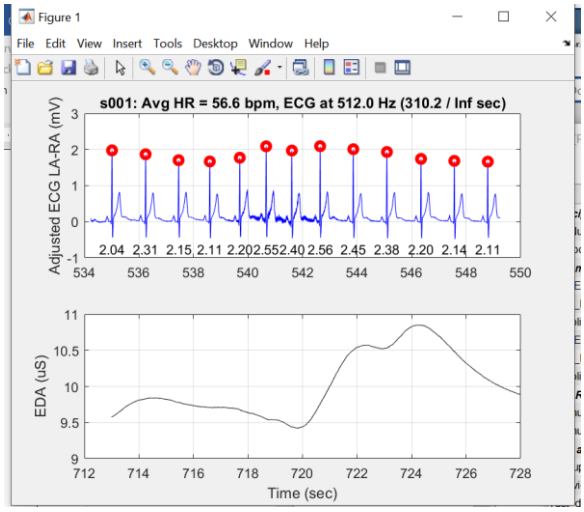
	Thread belt through clasp
	Secure belt around waist
	Move belt up to below the chest (above the chest is fine too, just make sure the ECG leads aren't under tension
	Snap the heart rate monitor into plastic harness
	Snap each of four sensors into the head of the wires

	The locations of the four sensors should follow the colors**: red, green, black, and white.** The locations may be moved slightly to fit the body and clothing • White on right collarbone • Green on left collarbone • Red on right rib • Black on left rib
	Ensure your skin is clean by rubbing with an alcohol pad and gauze pad (if needed) and letting the skin dry
	All four sensors in place, you may add medical tape on the wires to keep them in place Make sure the wires are not under tension because that will introduce noise

TEST SHIMMER ECG AND EDA DATA QUALITY

1. Signal quality is best when the participant is still (either standing, seated, or lying down)
2. If the task involves movement (e.g., walking), this step should involve the participant standing still
3. High quality data can still be obtained during ambulatory tasks such as walking as long as appropriate measures are taken (e.g., taping ECG leads to the skin so they do not tug on the electrodes or Shimmer device while moving).

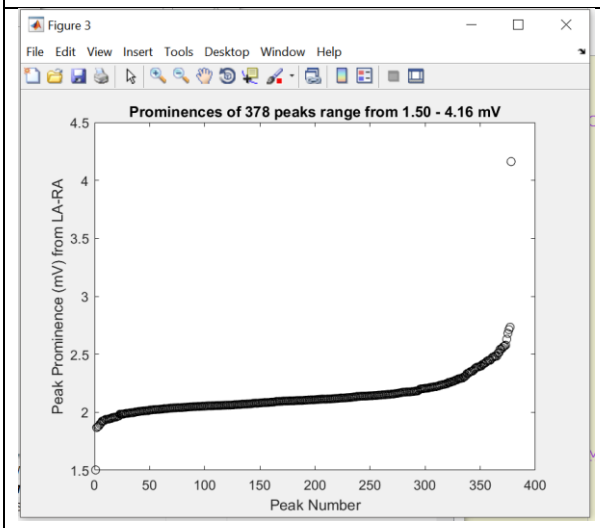
<table>
<tr>
<td> 
</td>
<td>Make sure the Event Name is still Test

Click <u>Go!</u> in the MATLAB Physiological Tasks Starter to run the View_and_Record_Shimmer program</td>
</tr>
<tr>
<td> 
</td>
<td>Click <u>Start</u></td>
</tr>
<tr>
<td> 
</td>
<td>Watch the signals from the ECG at the top
• There should be one red circle per R spike (heartbeat)
• Read the prominence values under each R spike to get a sense of its minimum value
• You can also see the T wave after each R spike
• This signal here looks good in terms of signal to noise ratio
• If there is excessive noise or artifacts, then try the following:
  • Ask the subject to sit still and upright with feet on the floor
  • Consider replacing or repositioning the electrodes after another rougher alcohol and gauze wipe
  • If the electrodes are on a region with a lot of subcutaneous fat then move them</td>
</tr>
</table>

closer to a near-superficial bone (ribs or clavicle)
    - Re-initialize the Shimmer sensor (new firmware, new settings. See above instructions in red text)

Watch the EDA signal at the bottom

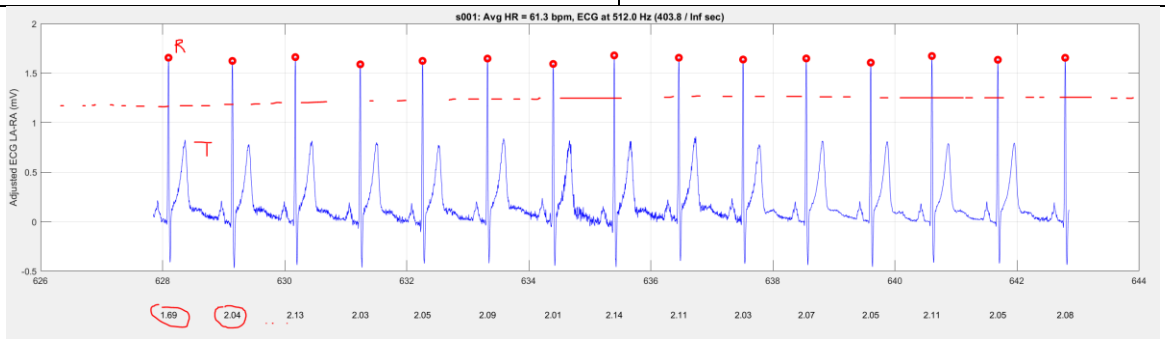
- Should look smooth and decreasing over time
- There will be some transient “responses” that increase the signal substantially over the course of a few seconds
- Ask the participant to take a big breath and hold it for a couple seconds, you should see a rise in EDA over the next few seconds after the breath hold
- If the signal does not look something like this
    - Reposition the electrodes
    - Re-initialize the Shimmer sensor (new firmware, new settings. See above instructions in red text)



<u>Find the best prominence value</u> that would have captured nearly all of these R spikes and go slightly smaller

- From this plot it would be 1.5
- But this is only if the subject is sitting in this position

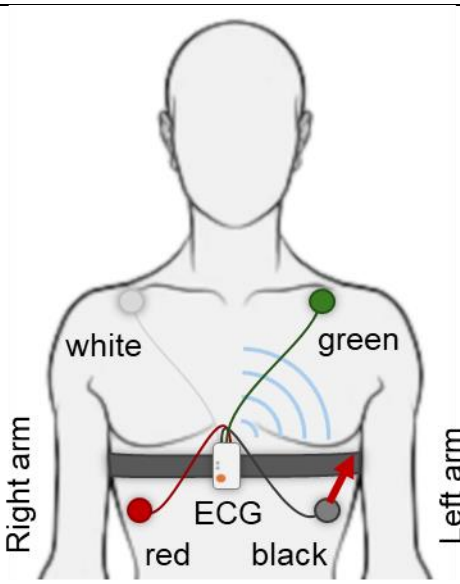
This should be small enough to catch EVERY ECG R spike, but large enough to NOT catch noise spikes



To determine the best prominence value you should **think of drawing a horizontal line through the ECG data that is between the tops of the R spikes and tops of the T waves**. Specifically, so that spikes ABOVE the line are R spikes and T waves never cross the line

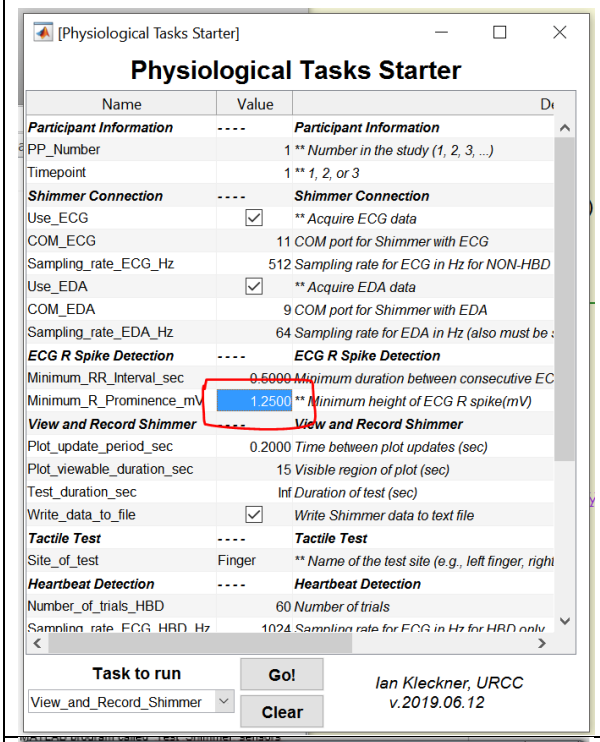
These data are high quality in that the horizontal line at approximately 1.25 mV is much lower than every R spike and much higher than every T wave

The prominence values are shown at the bottom of this plot (first two are circled)



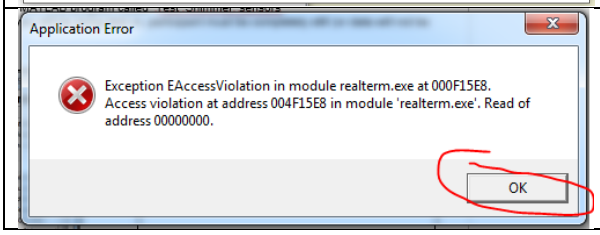
If the T-wave is very large then it might interfere with detection of R spikes.

If needed: to reduce the T-wave, try moving the lower left (black) electrode up



If needed, update the Prominence value in the Task Starter

The default value is 1 mV and this **default value can be changed** by editing Task_Starter.m, if desired (see instructions above in red)

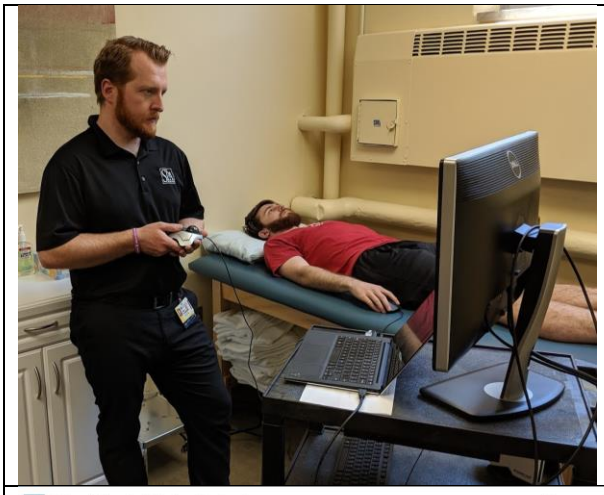
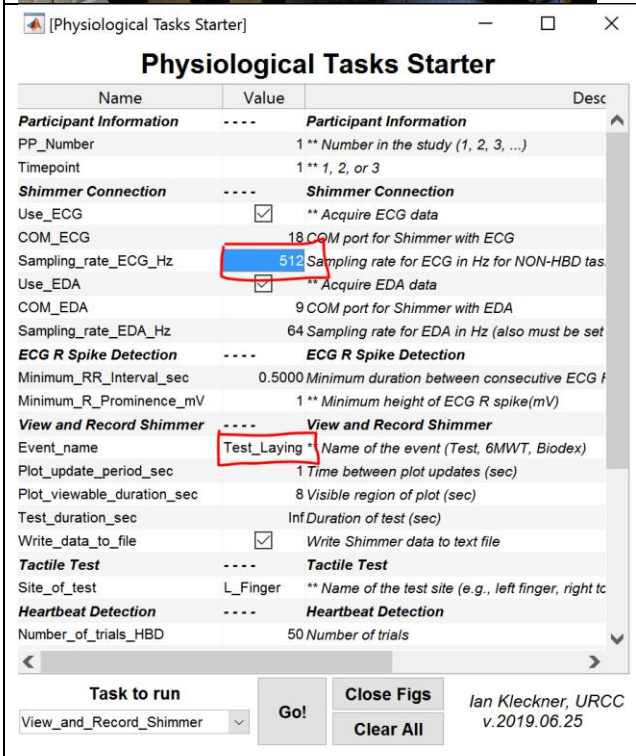


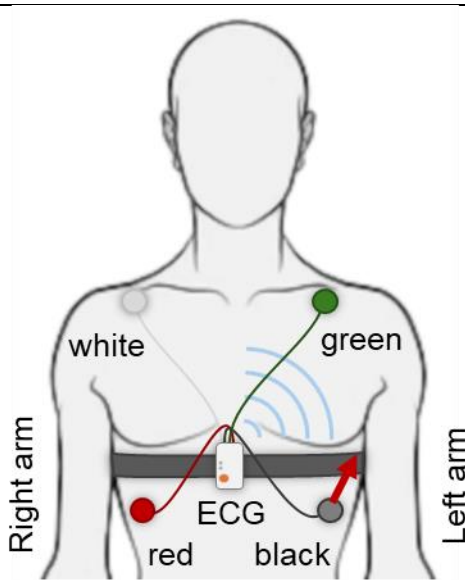
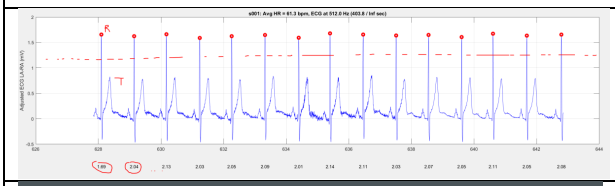
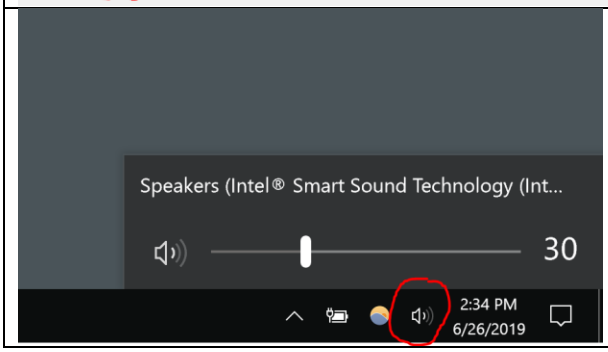
If you ever see this message, just click **OK**

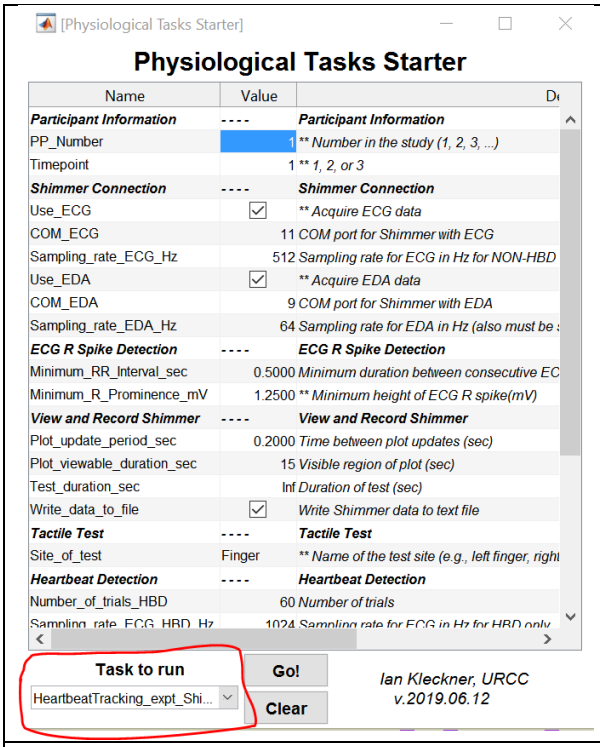
It is **no big deal**, and you don't need to document it. It's just a side-effect of exiting the MATLAB programs early, so it's bound to happen.

HEARTBEAT TRACKING TASK

	WARNING: If you are completing BOTH HBD and HBT tasks, complete HBT first to prevent participants from obtaining knowledge of heart rate by hearing the beeping from HBD

	Have the participant lay down on the table and make them comfortable with pillows or towels (e.g., under their neck, knees, etc.) The participant can start the trial when they are ready by clicking the mouse button They do not have to view the monitor during the test, but they may like to view the monitor during instructions
	Because the ECG signal can change when they are lying down, check the signal again Set sampling rate back to 512 Hz Set the Event Name to **Test_Laying**

	Adjust electrode position if needed to reduce T wave, etc.
	Adjust the prominence if needed
	Make sure the computer volume is on and audible to the participant (try Volume=30 to start)

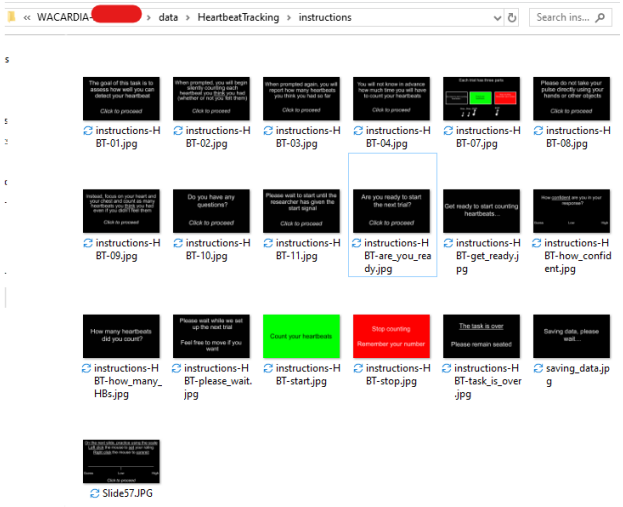


In the task starter program, choose the **Heartbeat_Tracking_Shimmer** task

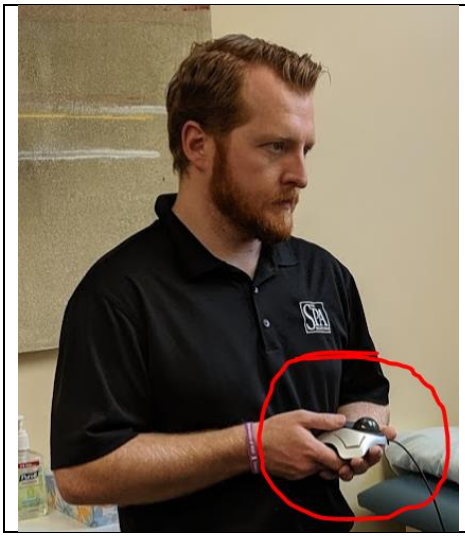
Then click **Go!**

Follow on-screen instructions (see full instructions below)

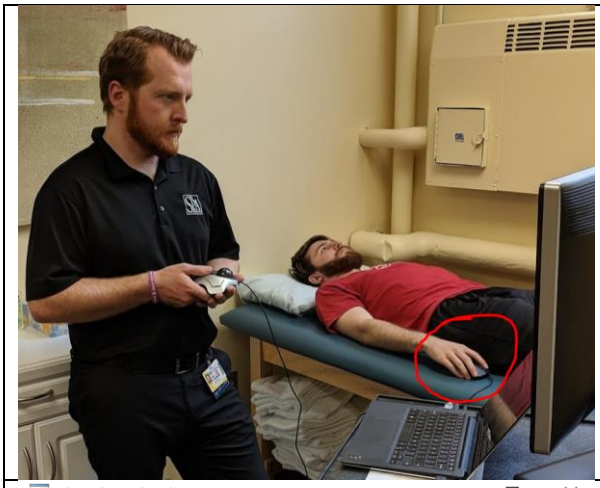
Full instruction images in data/HeartbeatTracking



- The goal of this task is to assess how well you can detect your heartbeat
- When prompted, you will begin silently counting each heartbeat you <u>think</u> you had (whether or not you felt them)
- When prompted again, you will report how many heartbeats you think you had so far
- You will not know in advance how much time you will have to count your heartbeats
- Each trial has three parts: (1) Get ready to start counting heartbeats, (2) Count your heartbeats, and (3) Stop counting. Remember your number
- You will also be asked how <u>confident</u> you are in your response
- (Opportunity to practice confidence rating)
- Please do not take your pulse directly using your hands or other objects
- Instead, focus on your heart and your chest and count as many heartbeats you <u>think</u> you had even if you didn't feel them
- Do you have any questions?

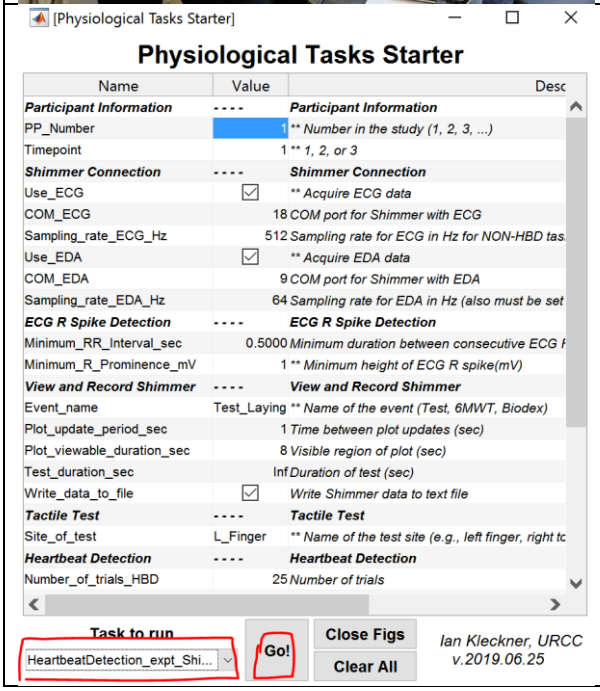
	The researcher should explain the task instructions by reading from the screen **The researcher will make all responses for the subject**

HEARTBEAT DETECTION TASK



Have the participant lie down on the table and make them comfortable with pillows or towels (e.g., under their neck, knees, etc.)

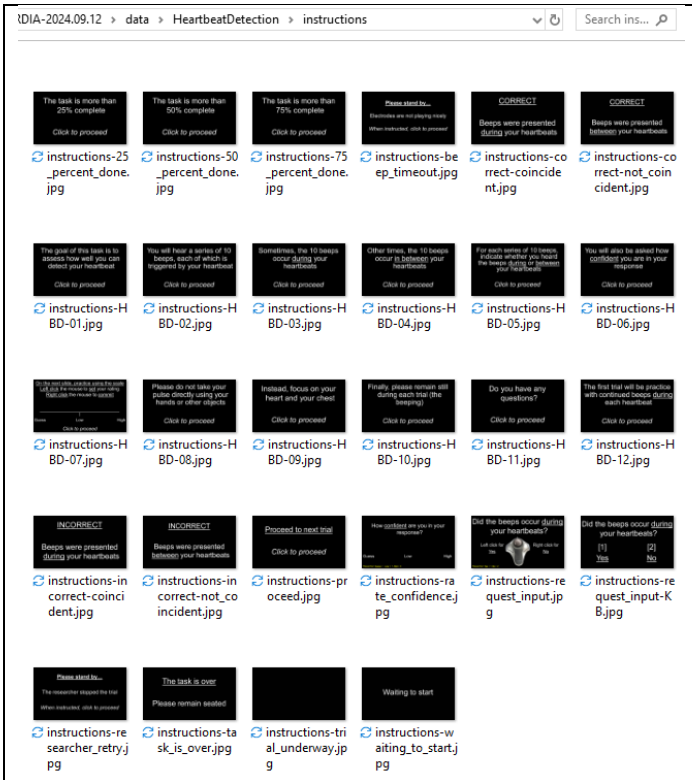
The participant can start the trial when they are ready by clicking the mouse button



In the task starter program, choose the **Heartbeat_Detection_Shimmer** task

Then click **Go!**

Follow on-screen instructions



- The goal of this task is to assess how well you can detect your heartbeat.
- You will hear a series of 10 beeps, each of which is triggered by your heartbeat.
- Sometimes, the 10 beeps occur <u>during</u> your heartbeats.
- Other times, the 10 beeps occur <u>in between</u> your heartbeats.
- For each series of 10 beeps, indicate whether you heard the beeps <u>during</u> or <u>between</u> your heartbeats.
- You will also be asked to rate how <u>confident</u> you are in your response.
- Please do not take your pulse directly using your hands or other objects. Instead, focus on your heart and chest.
- Finally, please remain still during each trial (the beeping).
- Do you have any questions?

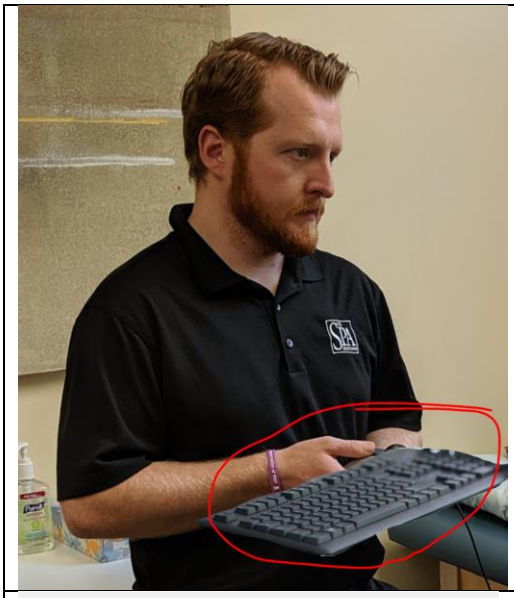
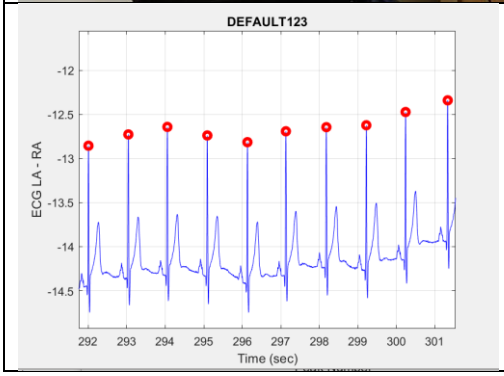
<u>Perform a practice trial with beeps DURING heartbeats (this starts automatically before the first trial of the task)</u>

Participants **may take their pulse** to hear beeps and feel heartbeats

Proivde guidance that they can **breathe deeply, hold their breath, and exhale slowly** to increase pressure in the chest and feel their beating heart

Have them try this for a minute or two

After the practice, they may not touch their bodies during the beeping

	The participant will only make verbal responses for this task to make it easier and faster for them The researcher will have their own **keyboard** to enter responses for the participant **You can exit the practice by holding Shift + Esc**
	**If there is a beeping mistake** during the trial (too fast, too slow, missed beat), the **researcher should hold Shift + Esc** to restart the trial

This task can also be done without the participant having to view anything. The researcher can enter responses for the participant while verbally asking the participant after each trial.

REMOVE THE PHYSIOLOGICAL SENSORS

General care and removal of sensors

- Please be careful, as these devices are very sophisticated and sensitive, as well as fragile and expensive

 Never pull the wires, they might break	 To remove the wires use one finger to push down on the electrode and the other fingernail to pry the sensor head off the electrode	 Gently prying the sensor head away should make it pop off

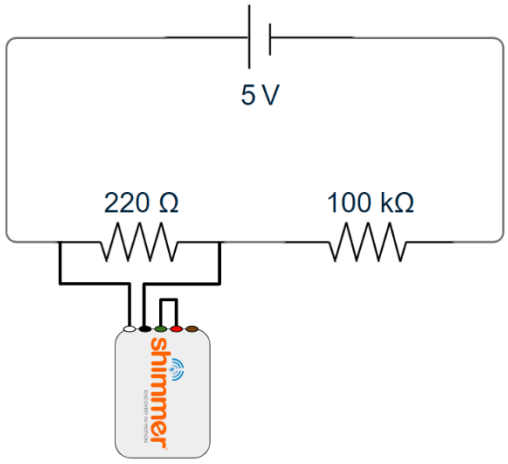
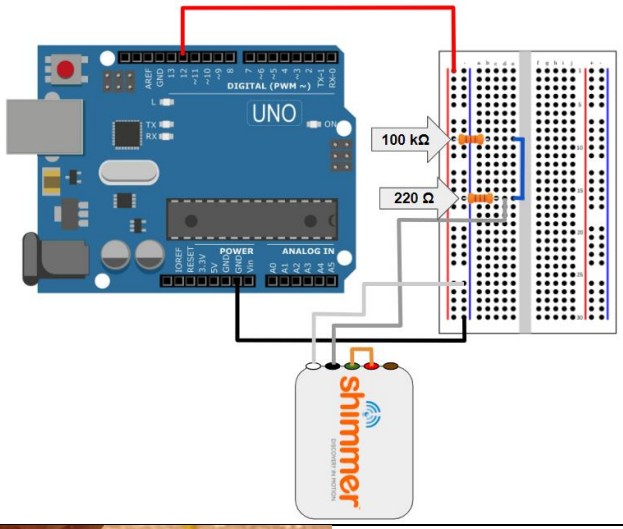
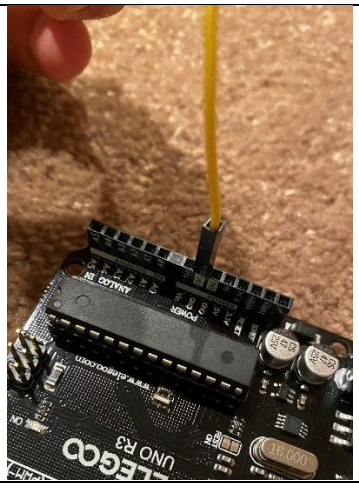
BLUETOOTH LAG DETECTION: SHOPPING LIST

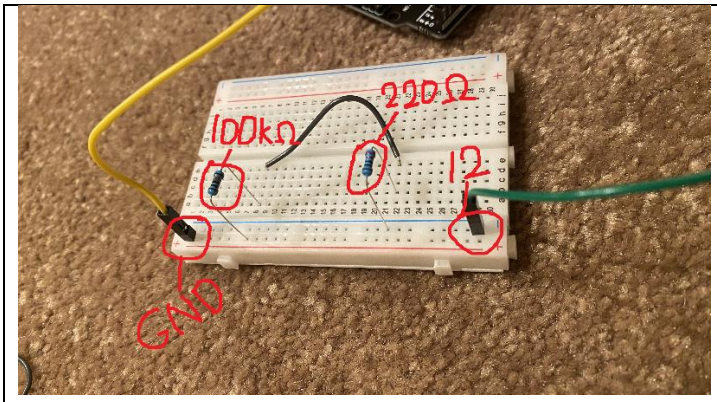
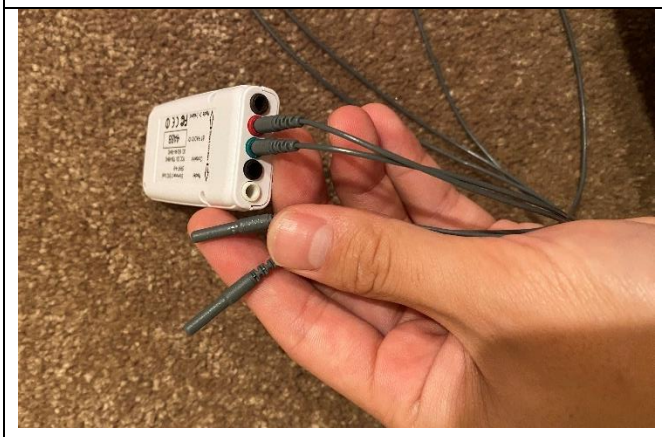
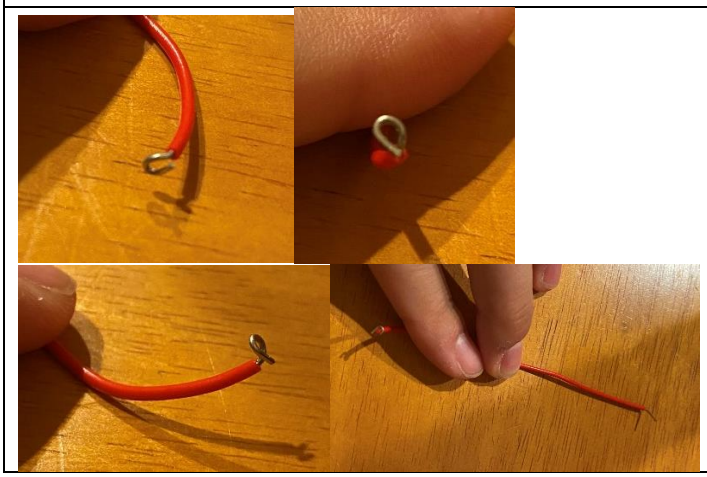
Item	Price	Picture	Example Vendor Link
Arduino UNO (and USB cable):	$15		https://a.co/d/hVkQWBm
Resistor kit	$6		https://a.co/d/2HRYN8K
Breadboard	$7		https://a.co/d/hliAigO
OPTIONAL Short Wires	$8		https://a.co/d/0VzUSP3
Wires with pins	$8		https://a.co/d/fS564xB
Electrical tape	$2		https://a.co/d/gunv23S

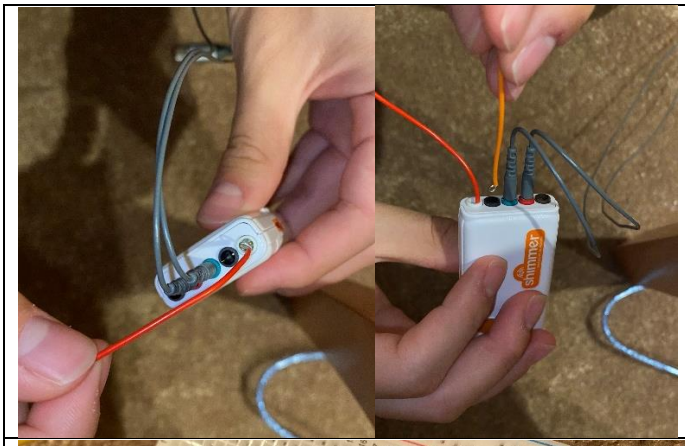
OPTIONAL More Shimmer Leads	$52		https://shimmersensing.com/product/9in-biophysical-lead-pack/

BLUETOOTH LAG DETECTION: ARDUINO-SHIMMER CIRCUIT SETUP

These instructions assume access to the contents of the WACARDIA Shopping List (see above)

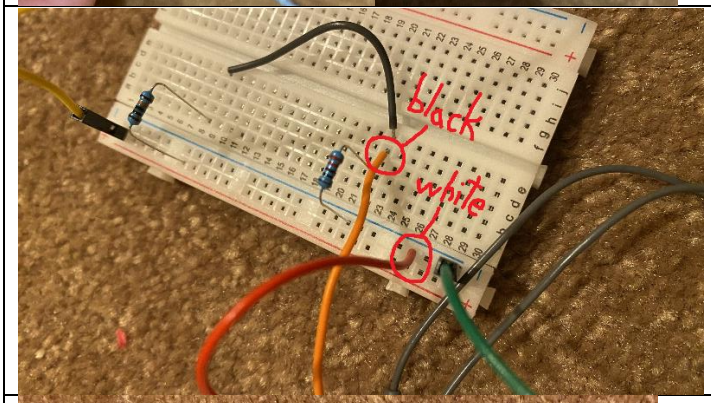
	**Note:** The goal of these setup instructions is to create the circuit shown on the left with the **Arduino as the power source**. Feel free to build this circuit in another way, as long as the **resistors have the correct strengths**, and the **Shimmer electrodes are configured correctly**.
	**Note:** These instructions are meant to construct the circuit shown in more detail on the left. **We now provide step-by-step instructions to get to this point.**
 	First, insert two wires into the Arduino: one (pictured as yellow) in a **pin labeled "GND**", and the other (pictured as green) in the **pin labeled "12."**

	Insert wires and resistors onto the breadboard as shown in the picture. **You should also refer to the diagram above**. The yellow and green wires correspond to the yellow and green wires connected to the Arduino.
	Remove the electrode leads from the white and black ports on the Shimmer sensor. **Notice that inside the ports, there is a thin metal piece which connects to the electrode lead.**
	Use the electrical tape to tape the ends of the red and green electrode leads together, so that the two metal parts are securely touching.
	This step requires finesse: Twist the end of one of the wires into a small loop, just wide enough to fit around the electrode leads. **This might take multiple tries to perfect.** Create two of these looped wires.



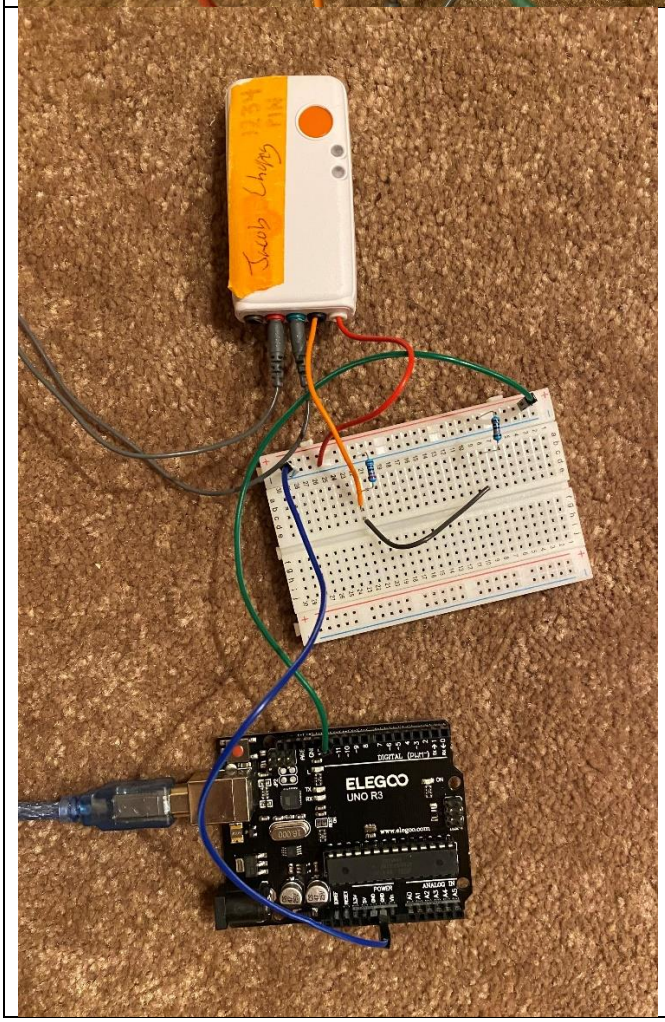
Carefully, insert the loop of a wire into the white and black ports. If your loop is the right size, you should be able to feel when the wire is securely fastened.

Be gentle when dealing with these wires, since they can easily become dislodged.



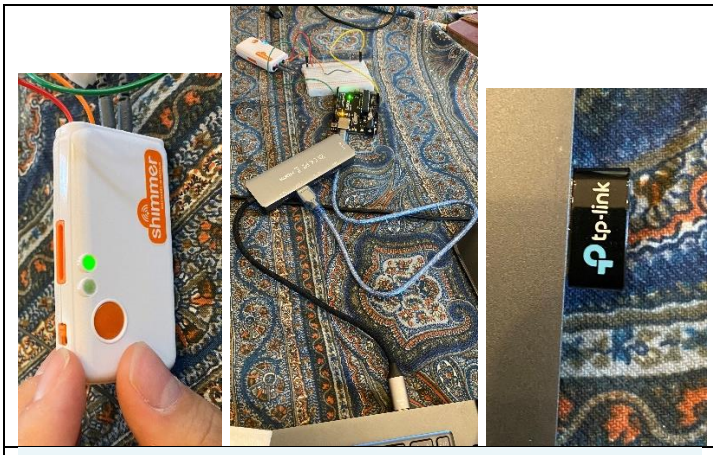
Insert the ends of the wires connected to the Shimmer ports into the breadboard, as shown in the picture.

You should also refer to the diagram above. The orange wire connects to the black Shimmer port, and the red wire connects to the white Shimmer.



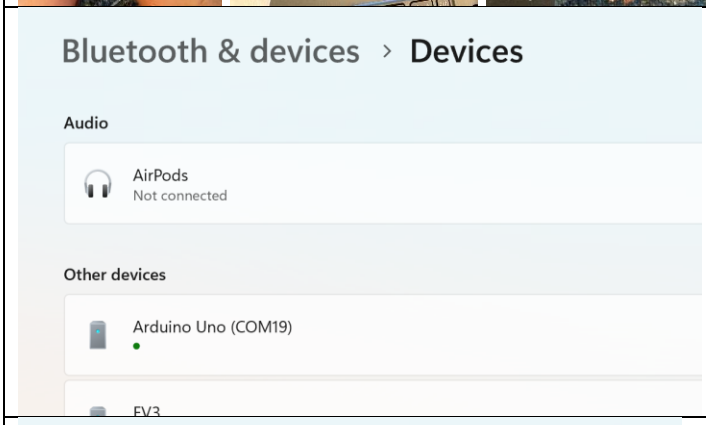
In the end, your setup should look like this.

BLUETOOTH LAG DETECTION: RUNNING THE PROGRAM



Setup hardware

- Follow the steps above to set up the Arduino-Shimmer circuit
- Turn on the Shimmer device and connect to it via Bluetooth (follow previous instructions)
- Connect the Arduino to the computer via USB port
- Ensure that the Bluetooth dongle is inserted if it is being used (probably yes)

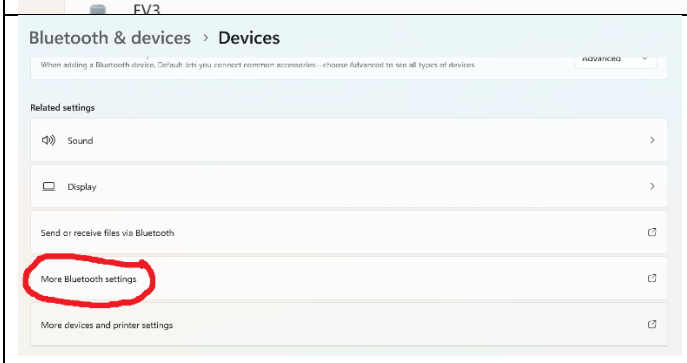


Check Arduino COM port

Navigate to Settings > Bluetooth & devices > View more devices

Scroll down to the ‘Other devices’ section until you see the ‘Arduino Uno’ device

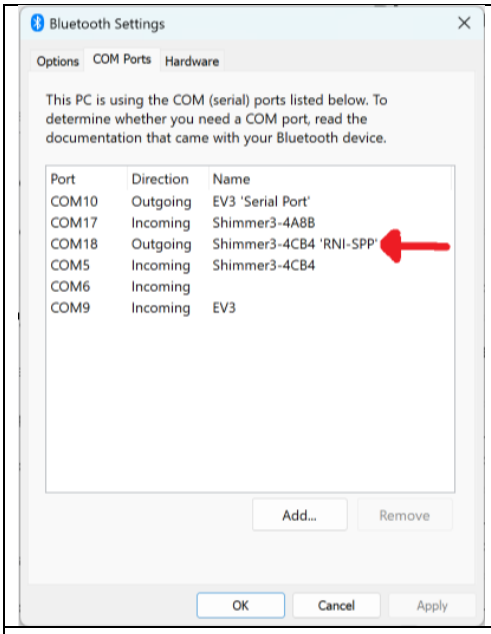
Record the number of the COM port



Check Shimmer COM port

If you’re still in ‘View more devices,’ scroll down further to the ‘Related settings’ section

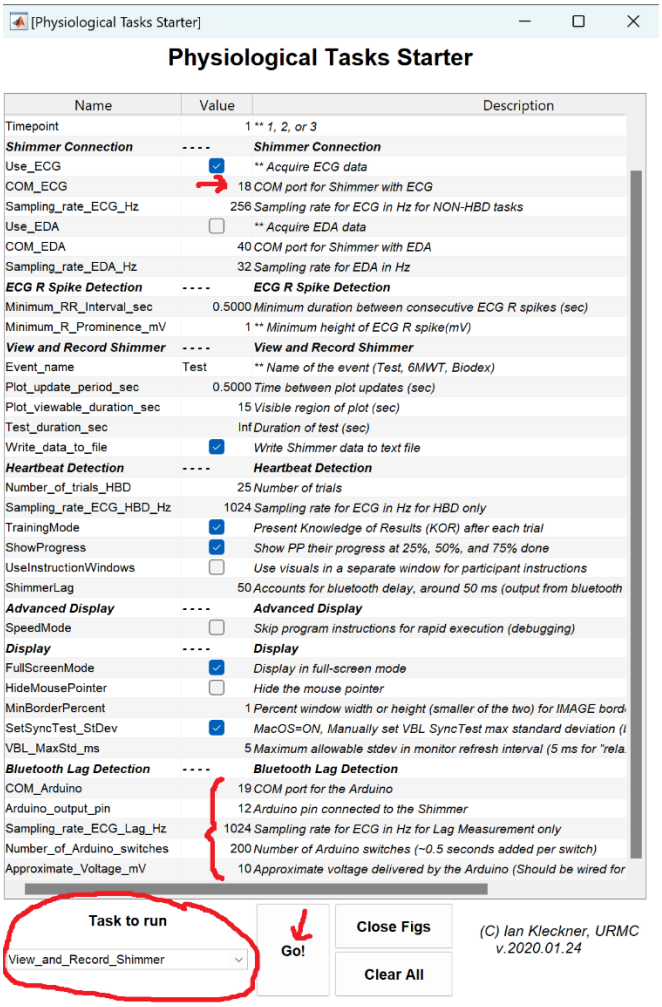
Select ‘More Bluetooth settings’



Check Shimmer COM port (cont.)

In the window that pops up, go to the 'COM Ports' tab. Record the COM port number of the Shimmer sensor that is 'Outgoing' and labeled '**RNI-SPP**'

Follow the instructions on the first two pages of the **Test connection with Shimmer sensors** section (pages 11 and 12 of this document) to open the Task Starter program.



Adjust relevant variables in Task Starter

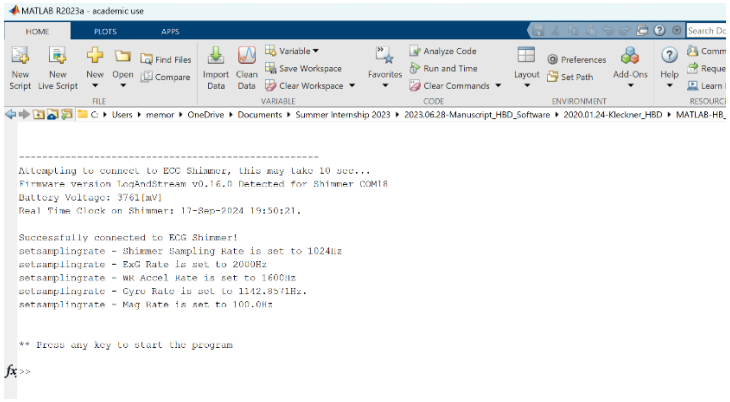
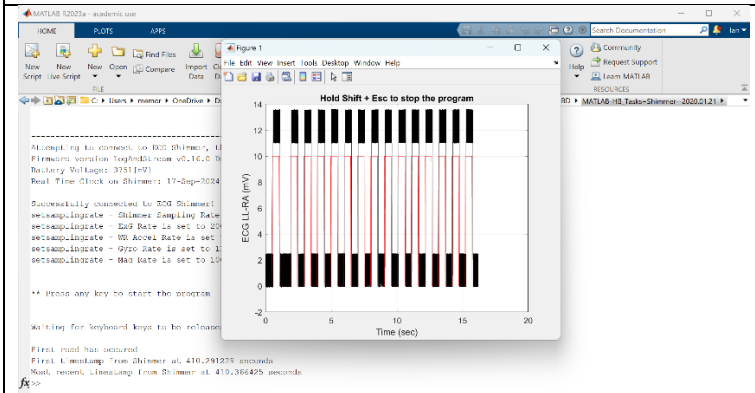
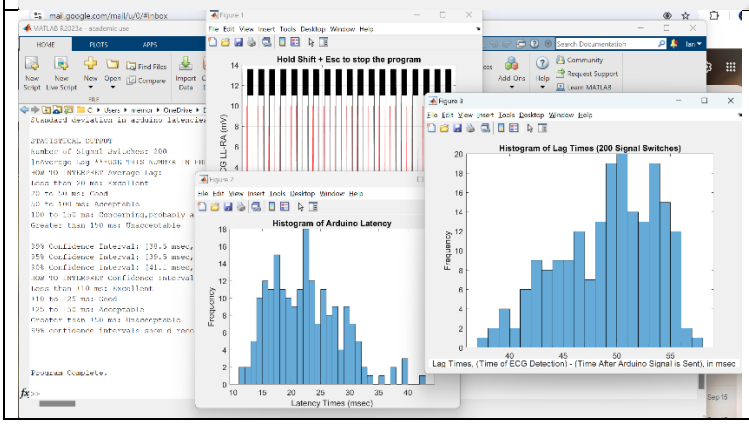
After changing a value, press Enter to confirm the change.

Under Shimmer Connection:

- Change **COM_ECG** to match the COM port for the Shimmer found above

Under Bluetooth Lag Detection:

- Change **COM_Arduino** to match the COM port for the Arduino found above
- Change **Arduino_output_pin** to the number of the digital pin that your circuit is wired to (probably 12)
- **Sampling_rate_ECG_lag_Hz** should stay at 1024
- Change **Number_of_Arduino_Switches** to the desired number of data points (i.e., number of times the Arduino signal turns on or off). We recommend 200 for a standard trial
- **Approximate_Voltage_mV** should stay at 10 mV with the resistors we recommend in this SOP. If different resistors are used, change this value to approximately 5000 * R2 / (R1 + R2), where R1 and R2 are the resistances of the resistors used in the circuit (right now R1 = 100,000 and R2 = 220)

	At the bottom, change the 'Task to run' from **View and Record Shimmer** to **Bluetooth Lag Detection**. When everything is ready, press **Go!**
	Shimmer information will be output. **IF there is an error stating that the Shimmer cannot be found…** • Delete any Realterm tabs you have open • Wait a short period and run the program again • Check again to ensure that you have the correct COM port • Disconnect and reconnect to the Shimmer in Bluetooth settings Press a key to start the program when prompted
	The live graph of Arduino signals and ECG data should appear (**press Ctrl + F if it doesn't appear immediately**) While the program is running, monitor the graph to watch for abnormalities, like unusually high levels of noise or signal magnitudes significantly higher than 10-15 mV.
	After the program terminates, the statistical output and two histograms will appear. The **Histogram of Lag Times** displays all the lag time data points measured by the program. These should all be clustered roughly around 50 ms. If there is significant deviation or major outliers, you should run the program again. The **Histogram of Arduino Latency** displays the average amount of time it takes for the computer to send an Arduino command (for debugging)

STATISTICAL OUTPUT Number of Signal Switches: 200]nAverage Lag ***USE THIS NUMBER IN HBD PROGRAM***: 49.2 msec HOW TO INTERPRET Average Lag: Less than 20 ms: Excellent 20 to 50 ms: Good 50 to 100 ms: Acceptable 100 to 150 ms: Concerning,probably acceptable Greater than 150 ms: Unacceptable 99% Confidence Interval: [38.5 msec, 56.5 msec], Range: ±9.0 95% Confidence Interval: [39.5 msec, 55.7 msec], Range: ±8.1 90% Confidence Interval: [41.1 msec, 55.3 msec], Range: ±7.1 HOW TO INTERPRET Confidence Interval: Less than ±10 ms: Excellent ±10 to ±25 ms: Good ±25 to ±50 ms: Acceptable Greater than ±50 ms: Unacceptable 99% confidence intervals should recorded in publications Program Complete. fx >>	The command window will display statistics from the trial. The **Average Lag** is clearly marked. This value should be input into Tasks Starter as **ShimmerLag** under the Heartbeat Detection section. We also provide 90%, 95%, and 99% confidence intervals, along with ranges. **Information about how to interpret these values is included in the output.** If any of these statistics are absurdly outside of reasonable ranges, check the ECG graph and Lag Times histogram for possible errors.