Experiment HN-8: Human To Human Interface

Introduction to Neuroprosthetics and Human-to-Human Muscle Control

Take control…of your partner that is!

An exciting, new technological development has to deal with the science and research into neuroprosthetics. A neuroprosthetic is a device that replaces the function of a damaged body part and interfaces with the nervous system – think of the body suit that Iron Man wears and the new prosthetic devices that are being 3-D printed for use for kids with malformed limbs. These devices can be controlled by the person using them just by thinking about what they want to do, like writing or holding onto something. These devices are controlled in such a way so there is an interface with the nervous system to make the prosthetic work.

There are many reasons why this research is so exciting. One has to do with how to help people with spinal cord injuries. Currently, if someone damages their spinal cord above a certain point, they are confined to a wheelchair and could be on supportive mechanisms to help them breathe; this is what happened to Christopher Reeves after his accident from falling off a horse. The interesting thing is that even though the spinal cord is damaged, the muscles in the person's limbs are still "alive" and can function, but they need to receive information from somewhere to be able to move. With a damaged spinal cord, the information being sent from the brain does not reach the limbs. This is where neuroprosthetics comes into play. Imagine if you could send a signal from the brain directly to a prosthesis, and have it work!! There is currently research out there where this is actually happening. Another method of controlling artificial limbs is by using the electrical activity generated by pectoral or quadriceps muscles to control the sensors and motors right in the robotic arm or leg.

So, where does this Human-to-human interface come in? In lab, since we do not have the capability to get Iron Man's suit or 3-D print a prosthetic, we can use one person as the "brain" and one person as the "prosthesis". This means that one person will have the ability to actually control the movements of the other!

This will be done by using the stimulator on the IX-TA unit and having Person A (the "controller") squeeze a ball that will in turn signal the interface (the IX-TA) to fire a signal off to Person B. Person B's hand will be holding the hand dynamometer and when "A" squeezes the ball…Person B will squeeze the hand dynamometer…totally without their own control. The stimulator works like a TENS unit (Transcutaneous Electrical Nerve Stimulation) that is used by physical therapists for interrupting nerve and muscle spasms to promote healing. When Person A squeezes the ball, it will signal the stimulator to send a current to Person B, when that current is received by the muscles in the hand, the hand will twitch.

This lab opens up many opportunities for hypothesis testing. Can you hold a pencil, balance a ball, or make a Lego car move?

Take a look at Iron Man, Robert Downey, Jr. giving a boy a bionic Iron Man Arm -
https://www.youtube.com/watch?v=z7wSx6LovG0

Equipment Required

PC or Mac Computer

IXTA, USB cable, Power supply for IXTA

iWire-B3G cable and three EMG lead wires

Disposable snap electrodes (7)

HV stimulator lead wires

FT-220 hand dynamometer

Tennis ball

Start the Software

1. Click on LabScribe
2. Click Settings → Human Nerve → HumanToHumanInterface
3. Once the settings file has been loaded, click the **Experiment** button on the toolbar to open any of the following documents:
    - Appendix
    - Background
    - Labs
    - Setup (opens automatically)
    -

The Equipment Setup

Note – You must connect the iWire-B3G cable to the IXTA prior to turning it on.

1. Attach the connector on the end of the iWire-B3G cable to the iWire 1 input of the front of the IXTA (HN-8-S1).
2. Connect the FT-220 to the black tygon extension tubing, connect this to the A2 port on the front of the IXTA.
3. Connect the stimulator leads to the HVS stimulator on the front of the IXTA as stated in the directions below.
4. Prepare your subjects.

Figure HN-8-S1: IXTA with the FT-220, iWire-B3G and stimulator lead wires for performing the Human to Human Interface lab.

Person A

1. The subject should remove all jewelry from his/her right arm.
2. Clean the areas where the electrodes will be attached with an alcohol swab (Figure HN-8-S1). Abrade the skin in those areas.
3. Obtain three disposable electrodes.
4. Locate areas on the forearm; place electrodes over these locations and attach the colored recording leads (Figure HN-8-S2).
    - Place the black (-1) electrode just below the crease of the elbow, slightly lateral of midline.
    - Place the red (+1) electrode on the mid-forearm, also slightly lateral
    - Place the ground (green) electrode between the red and black electrodes as shown.
5. Person A should also hold a tennis ball or other squeezable object.

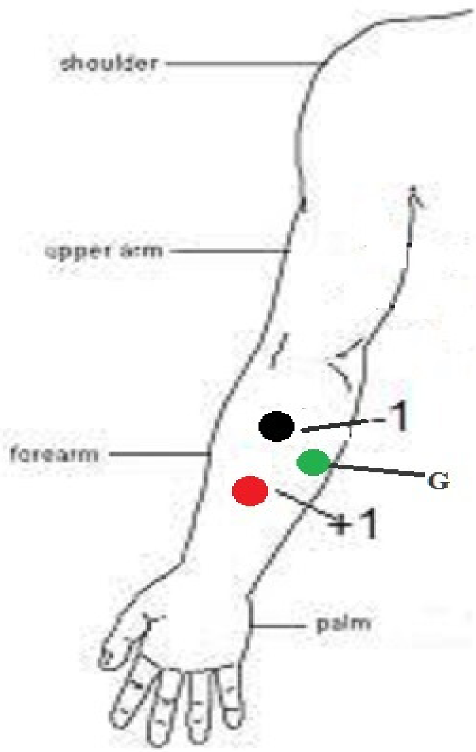


Figure HN-8-S2: Electrode and lead placement for Person A, who will be generating the signal to be carried to Person B through the stimulator. The red and black recording leads are placed on the flexors.

Person B

1. Obtain two disposable electrodes.
2. Have Person B clean the inside of their wrist of the non-dominant arm with an alcohol swab.
3. Snap the ends of the H.V. Output lead wires onto the stimulating electrodes (FigureN-8-S3), so that:
    - the red (+) lead is snapped on the electrode placed on the lateral edge of the inside of the wrist,
    - the black (-) lead is snapped on the electrode placed on the medial edge of the inside of the wrist,.
4. Have Person B lightly cup the FT-220 hand dynamometer in the palm of their hand, trying not to hold on to it too tightly. It should be just resting in their grip.

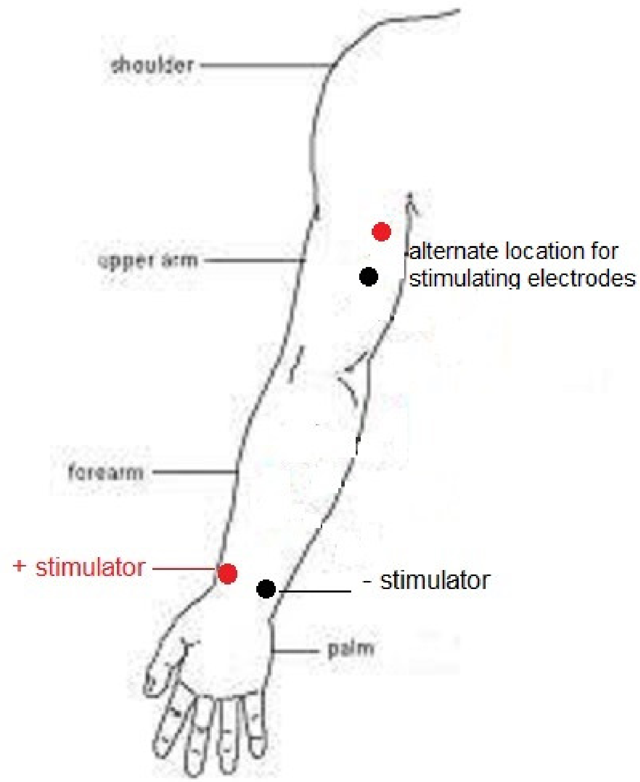


Figure HN-8-S3: Placement of the stimulating electrodes for Person B.

IXTA Isolated Stimulator

The IXTA has a high voltage stimulus isolator designed to deliver constant current to the nerve or muscle being studied. In situations where the resistance (R) along the path of the current increases, the voltage (V) increases to maintain the current (I in V = IR, Ohm's Law). The ability of the IXTA to adjust the voltage to deliver the required current is known as voltage compliance. The upper limit of this compliance by the IXTA is set at 100 Volts.

Constant current devices differ from constant voltage devices when presented with an increase in resistance, like the dehydration of the conductive gel under the electrodes. As pointed out earlier, a constant current stimulator is voltage compliant. In constant voltage stimulators, the current delivered to the tissue decreases as the resistance increases because the power supply of the constant voltage device is not designed to deliver additional current.

Although the IXTA can generate up to 100 Volts, the current delivered by the unit is limited to a maximum of 20 milliamperes, for a maximum duration of 10 milliseconds per pulse, and a maximum frequency of 50 pulses per second (Hz). At these levels, the maximum amount of power delivered by the IXTA will not cause injury or tissue damage.

The current is selected using the Stimulator Control Panel. The HV Stimulator can deliver a maximum output of twenty milliamperes

The duration, frequency, and number of stimulus pulses generated by the stimulator are also controlled by making changes to the values in the Stimulator Control Panel. The initial values of the pulses generated by the IXTA are programmed by the same settings file that configured the recording software. For example, if a pulse from the IXTA is programmed for a duration of 1 millisecond and a frequency of 1 Hz, the stimulator will generate a stimulus pulse with the same duration and frequency.

IXTA Stimulator Setup

1. Place the IXTA (Figure HN-8-S1) on the bench near the subject.

Warning: Before connecting the IXTA stimulating electrodes to the subject, check the Stimulator Control Panel to make sure the amplitude value is set to zero (0).

Note: Disconnect the subject from the IXTA prior to powering off the device.

2. Instruct the subject to remove all jewelry before beginning the experiment.

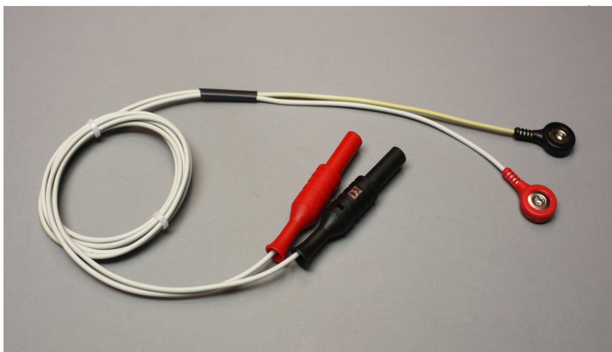


Figure HN-8-S4: The IXTA stimulating electrodes.

Warning: Make sure the Amplitude is set to zero.

3. For any of the HVS labs, the stimulator preferences panel will initially come up showing S1, even if S1 is off - use the menu to select the HVS settings.
4. Connect the color-coded stimulator lead wires to the High Voltage Current Stimulator. Make sure you push the safety connector of each lead wire into the appropriate socket as far as possible (Figure HN-8-S4).
5. Connect the 2 stimulating electrodes as stated above.
6. Start with the stimulator programmed in this manner (Table HN-8-S1):
    - On the Stimulator Control Panel that appears 2 lines above the upper recording panel.
        - Amps will be the only variable changed (between 3-10 amps). Begin with 3 amps and increase until a consistent response is achieved (5 amps has yielded consistent results). Do not go above the 8 amps.
        - Make sure to hit ***APPLY*** after choosing the settings.
        - OPTIONAL – change the number of pulses up to, but not to exceed, 10.

Table HN-8-S1: Settings on the Stimulator Window Used to Configure the Stimulator of the IXTA for Experiment HN-8.

Parameter	Setting	Parameter	Setting
Stimulator	HVS	Delay (sec)	0.001
Stimulus Mode	HV Train (mA)	Amplitude (mA)	5
Start Stimulator with Recording	uncheck	Pulses (#)	5
Time Resolution (msec)	0.01	Pulse Width (msec)	1
Toolbar Step Frequency	1	Time Off (msec)	10
Toolbar Step Amplitude (V)	0.1	Number of Trains	1
Toolbar Step Time (sec)	0.1	Holding Potential (V)	0

WARNING – The Stimulator should only be used for the method of application for which it is intended as shown in the directions below.

Note: Disconnect the subject from the IXTA prior to powering off the device.

NOTE: Any changes in amplitude are entered directly into the Stimulator Control Panel. Click "APPLY" to make the change.

Exercise 1: Human to Human Muscle Control

Aim: To determine the effect of a "squeeze" by Person A on Person B's response.

Approximate Time: 30 minutes

Procedure

1. Ask Person A to hold a tennis ball, or other squeezable object, in his or her hand. Lay the hand on the bench with the palm up. Make sure Person A is not squeezing the ball and to relax.
    - If preferred, Person A can just curl their hand at the wrist rather than squeezing a ball. This works equally well and generates a good signal.

Note: *Person A should make sure to relax his/her forearm and hand completely. Any tensing of the muscles will interfere with the recording and could elicit an unexpected response from Person B.*

2. Ask Person B to sit quietly, with their hand lightly cradling the hand dynamometer. Little to no pressure from the fingers should be holding the sensor.
3. Click Record button on the LabScribe Main window.
4. Instruct Person A to squeeze the ball or curl his or her hand towards the wrist. It should be a quick, firm reaction.
5. Click the AutoScale All button on the toolbar to improve the display of the stimulus and the muscle's response (Figure HN-8-L1).
6. Have Person A squeeze the ball or flex the hand five (5) times.

Note: **Person B should have a response each time Person A flexes or squeezes.**

7. Select Save As in the File menu, type a name for the file. Click the Save button to save the file (as an *.iwxdata file).

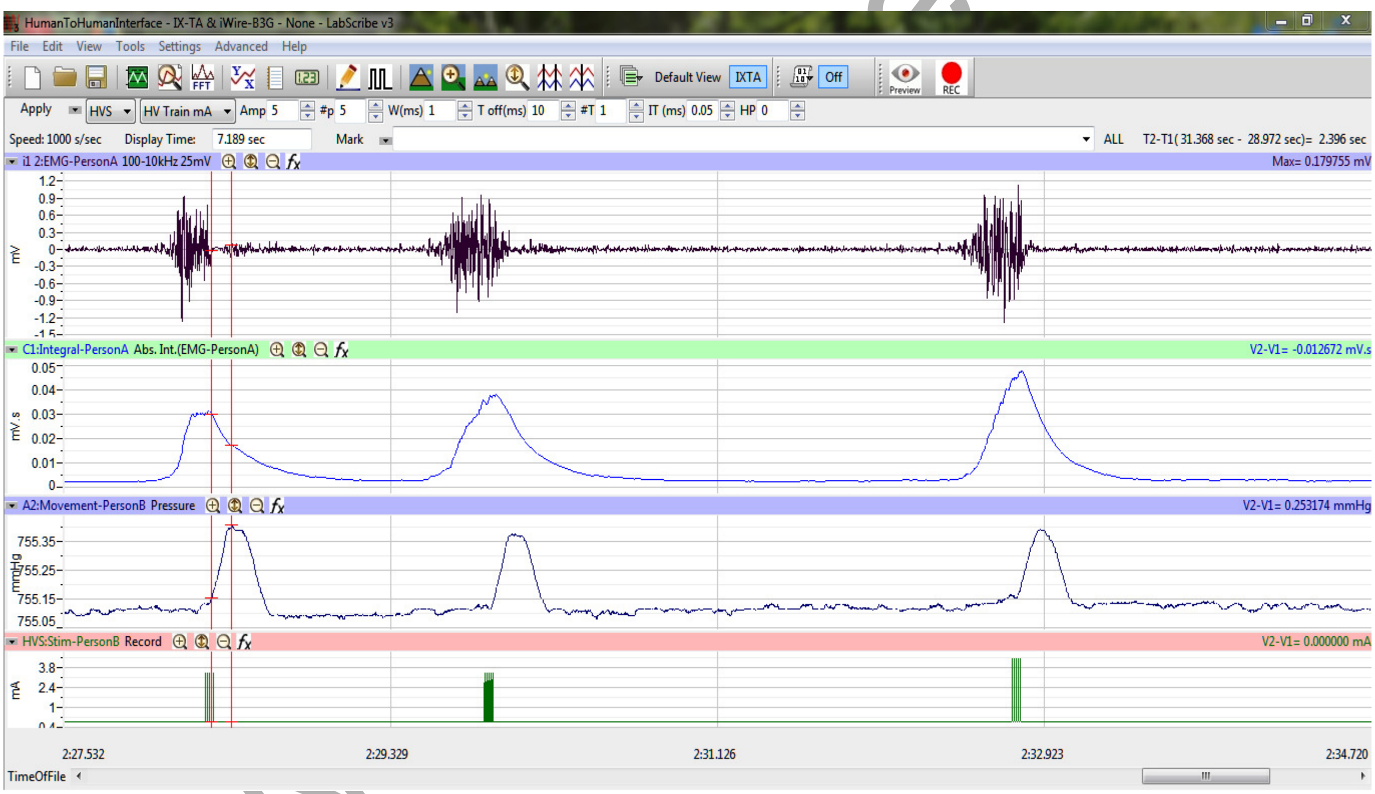


Figure HN-8-L1: A recording showing Person A squeezing or flexing and the subsequent response from Person B. The red vertical cursors are in position to measure the time from the peak of the Integral to the response from Person B.

Data Analysis

1. Use the display time icons to double the display time to get the entire data set on screen (Figure HN-8-L2).

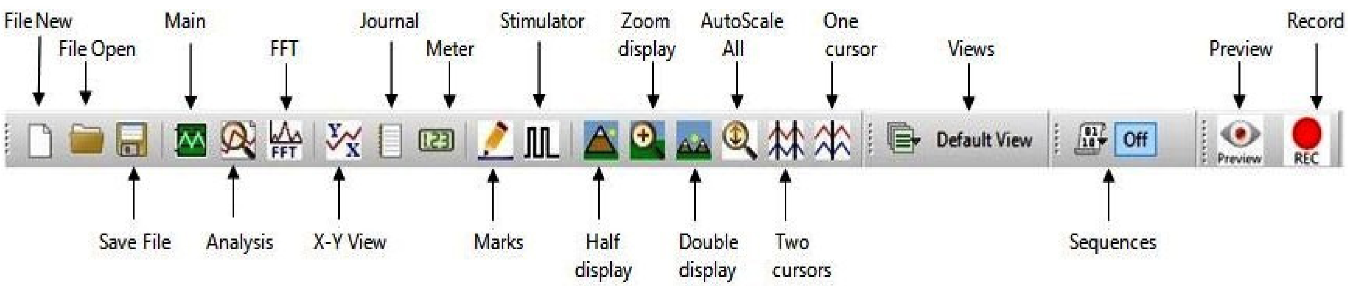


Figure HN-8-L2: The LabScribe toolbar.

2. Data can be gathered on the Main window by just looking at T2-T1 in the upper right corner, or click the Analysis icon in the LabScribe toolbar (Figure HN-8-L3) to view the recorded responses.
3. Note that T2-T1 is shown in the bar across the tops of all the channels. Measure T2-T1 by placing the two red vertical cursors on the peak of the Integral from Person A and the subsequent response from Person B. Reminder: Data analysis can also be performed on the main window.

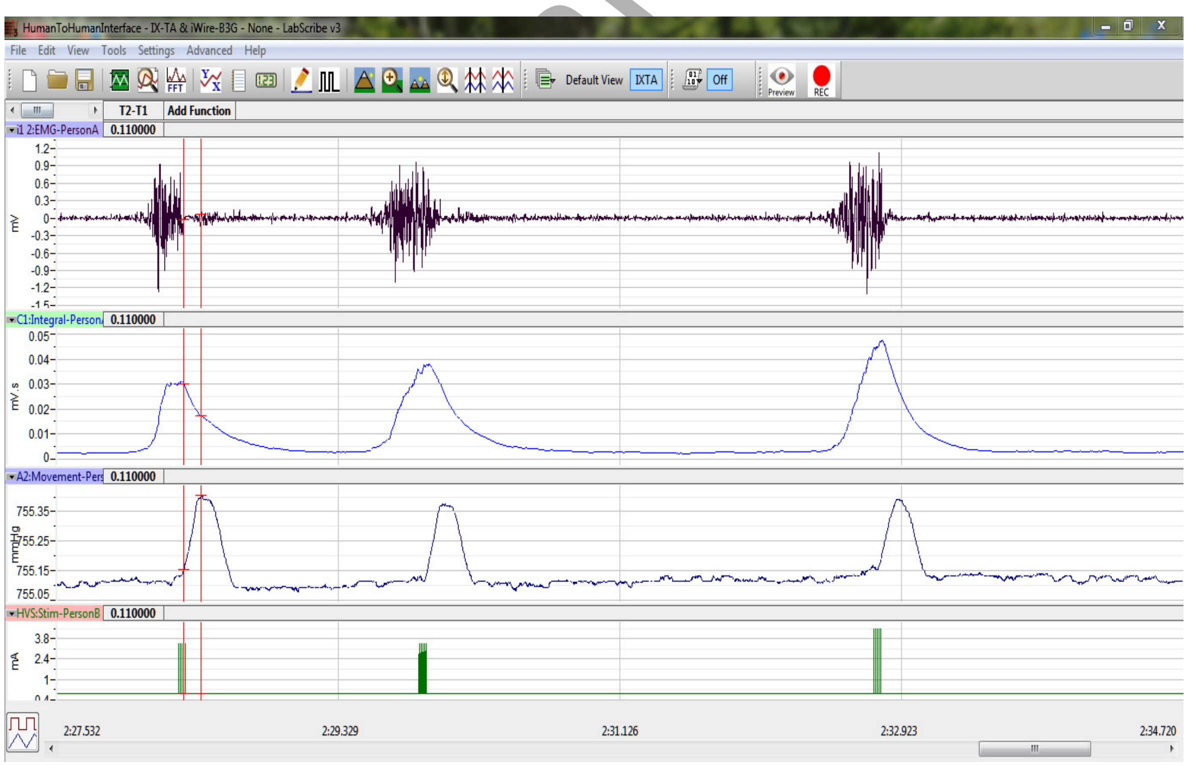


Figure HN-8-L3: T2-T1 for the time between the stimulus from Person A to the response from Person B. In this example the time is 0.110 seconds between stimulation and response.

4. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the parameters from the recording to the Journal. To use these functions:
   - Place the cursors at the locations used to measure the time for the muscle response.
   - Transfer the name of the mathematical functions used to determine the muscle response to the Journal using the Add Title to Journal function in the Movement-Person B pull-down menu.
   - Transfer the value for the time for muscle response to the Journal using the Add Ch. Data to Journal function in the Movement-Person B pull-down menu.

Question

1. Is the time of response from Person B the same for each stimulus by Person A? If not, what could be the reason?

Experimental Design

Ask students to design their own hypothesis relating to muscle responses when someone else is in control.

This can include:

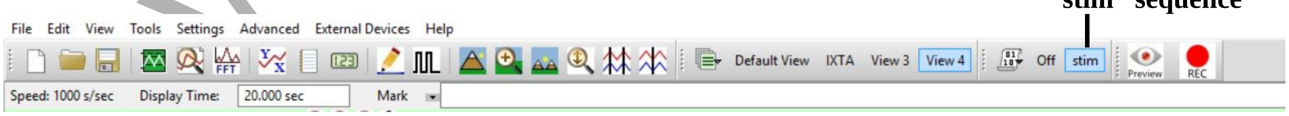
- Increasing stimulus amplitude (do this slowly as you are stimulating someone other than yourself)
- Looking at other muscle combinations (can the biceps of Person A cause a response to the same muscle in Person B?)
- Can Person A control Person B enough to balance an object, write, etc...?
- What about inanimate objects...can you build a Lego car and control that from Person A?

Have them perform their experiment and present their finding to other groups.

Troubleshooting:

1. If the stimulator does not fire when Person A squeezes the tennis ball, make sure that the "stim" sequence is chosen from the Sequences List:

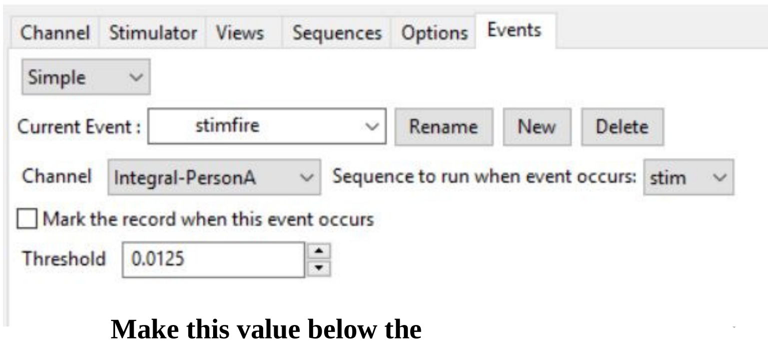
"stim" sequence



   You may need to click the down arrow and "Run Sequence".

2. If Person B does not have a response, autoscale all the channels and try again. Make sure you clicked Apply if you made any changes to the stimulator control panel.

3. If Person B still does not have a reaction, make sure the integral of Person A (EMG) – channel 2 – is high enough to trigger the response.
    - Look at the value of the Integral on the Y-axis
    - Go to Edit → Preferences → Events – change the value for the Threshold so it is below the peak of the integral for Person A



Make this value below the integral peak value