

Experiment HN-6: Hoffman Reflex using the Soleus Muscle

The Hoffman reflex using the iWorx equipment was developed as part of the STEM program at Bridgewater College, Bridgewater, VA; it was funded in part by National Science Foundation Grant DUE-0756838 award "Bridging the Valley: A Step Ahead for STEM Majors."

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Background

The Hoffman Reflex is a reflex measurement for the function of lower motor neurons that is similar to a tendon tap reflex. However, the amplitude of EMG activity, a representation of the number of motor neurons that are active beneath the recording electrodes, is difficult to control using a reflex hammer; the location of the tendon strike needs to be exactly the same from trial to trial, as does the force of the strike. By delivering a steadily increasing level of current to the subject through electrodes that are fixed in a single location, we can observe reflex amplitude rise from trial to trial as additional motor neurons are recruited by the ever-increasing stimulus intensity.

It is important to remember, however, that the stimulation of motor neurons at these lower intensities is a representation of the number being recruited through the reflex arc. That is to say, we are stimulating sensory neurons which are sending their stimulus towards the spinal cord and are synapsing on the motor neurons of the analogous musculature to cause the muscle twitch. The way you can tell the entire reflex arc is being followed is by measuring the time from the point where a stimulus is delivered to the point where the EMG wave begins; it should be roughly 30 msec if you are measuring Hoffman reflexes from the soleus muscle (although exact times vary depending on the height of the individual - i.e. taller people have longer reflex arcs). If you were to record data from the vastus medialis, you would have a significantly shorter reflex arc as the distance is shorter.

The Hoffman reflex is studied regularly in sports medicine research because of its changes in response to injuries and various therapies. An example of this is clear in people who have recently sprained their ankle. The very definition of a sprain injury is damage to a ligament, however, ligaments are non-contractile. After an injury the strength measurements recorded from the individual at the involved ankle are significantly depressed. We know that with alterations to the ankle joint in experimental models like a joint effusion where a known amount of saline is injected into the joint capsule that certain muscles that cross the joint react differently in how many motor neurons are available through a reflex arc. What is happening is that inhibitory and facilitatory interneurons from joint receptors that are being activated by the effusion will cause some motor neurons to be more easily stimulated (facilitated) while others will be less easily stimulated (inhibited). This suggests two things quite clearly: 1) we adopt different strategies in response to an injured system by modifying the motor neuron pools available to us and 2) some of the new strategies we adopt are outside of our normal methods of movement, and these methods may contribute to different injuries.

In this experiment, the H-reflex test is performed using an isolated stimulator, which will deliver a square-wave pulse of short duration and small amplitude. EMG electrodes record the muscle activity. The reflex is usually a clear wave, called an H-wave (or H-reflex), 28-35 ms after the stimulus. An M-wave, an early response representing direct efferent stimulation, may be seen 3-6 ms after the onset of

stimulation. The H-wave is the later response. As the stimulus increases, the H-wave will gradually increase until we begin to directly recruit efferent neurons (the M-wave). As the stimulation current continues to increase the M-wave will continue to rise and the H-wave will become smaller and may disappear. This absence of an H-wave at higher stimulating currents is not an indicator that we are failing to stimulate afferents, but that it is being missed because of the antidromic stimulation of the analogous efferent neurons.

The stimuli that stimulate and evoke the response recorded from the muscle will be generated by the iWorx SI-200 stimulus isolation unit or the built-in stimulator of the IXTA. These units will be programmed to provide mild electrical shocks through the skin. The electrical stimulation is safe; but, standard safety precautions need to be observed. People with poor cardiac function, pacemakers, or any other condition that can be aggravated by electrical stimulation should not volunteer for this experiment.

Equipment Required

PC or Mac Computer

IXTA data acquisition unit

USB cable

Power supply for IXTA

iWire-B3G cable and three EMG lead wires

Disposable snap electrodes

HV stimulator lead wires

Disposable Razor

IXTA Setup

1. Place the IXTA on the bench, close to the computer.
2. Check Figure T-1-1 in the Tutorial Chapter for the location of the USB port and the power socket on the IXTA.
3. Check Figure T-1-2 in the Tutorial Chapter for a picture of the IXTA power supply.
4. Use the USB cable to connect the computer to the USB port on the rear panel of the IXTA.
5. Plug the power supply for the IXTA into the electrical outlet. Insert the plug on the end of the power supply cable into the socket on the rear of the IXTA. Use the power switch to turn on the unit. Confirm that the power light is on.

Start the Software

1. Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows Start menu, move the cursor to All Programs and then to the listing for iWorx. Select LabScribe from the iWorx submenu. The LabScribe Main window will appear as the program is opens.
2. On the Main window, pull down the Settings menu and select Load Group.

3. Locate the folder that contains the settings group, IPLMv6Complete.iwxgrp. Select this group and click Open.
4. Pull down the Settings menu, again. Select the Soleus-HReflex settings file.
5. After a short time, LabScribe will appear on the computer screen as configured by the Soleus-HReflex settings.
6. For your information, the settings used to configure the LabScribe software and the IXTA unit for this experiment are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.
7. 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)

Preparation of the Subject

1. Locate:
 - the soleus muscle just inferior to the belly of the gastrocnemius muscle
 - the popliteal fossa behind the knee joint
 - the anterior thigh just superior to the patella
 - any bony landmark (mid tibia and either malleolus will work)
2. If necessary, shave the areas using warm water and the disposable razor
3. Gently rub away dead skin cells at each location using the abrasive pad
4. Cleanse the area with an alcohol wipe and give approximately 60 seconds of time to dry
5. Apply disposable electrodes ([Figure HN-6-S1](#)):
 - 2 in line with the soleus muscle fibers approximately so the centers of the electrodes are approximately 2 cm apart
 - 1 in the popliteal fossa
 - 1 just superior to the patella
 - 1 over the bony landmark you chose
6. Connect leads accordingly ([Figure HN-6-S5](#)):
 - Red and black EMG leads will attach to the two electrodes over the soleus
 - Black stimulator lead will go on the electrode in the popliteal fossa
 - Red stimulator lead will go on the electrode just superior to the patella
 - Green EMG lead will go on the electrode on the bony landmark you've chosen

7. You may need to place a small wooden block on top of the electrode in the popliteal fossa and secure it with an elastic bandage. This is recommended, but may not be required in all subjects.

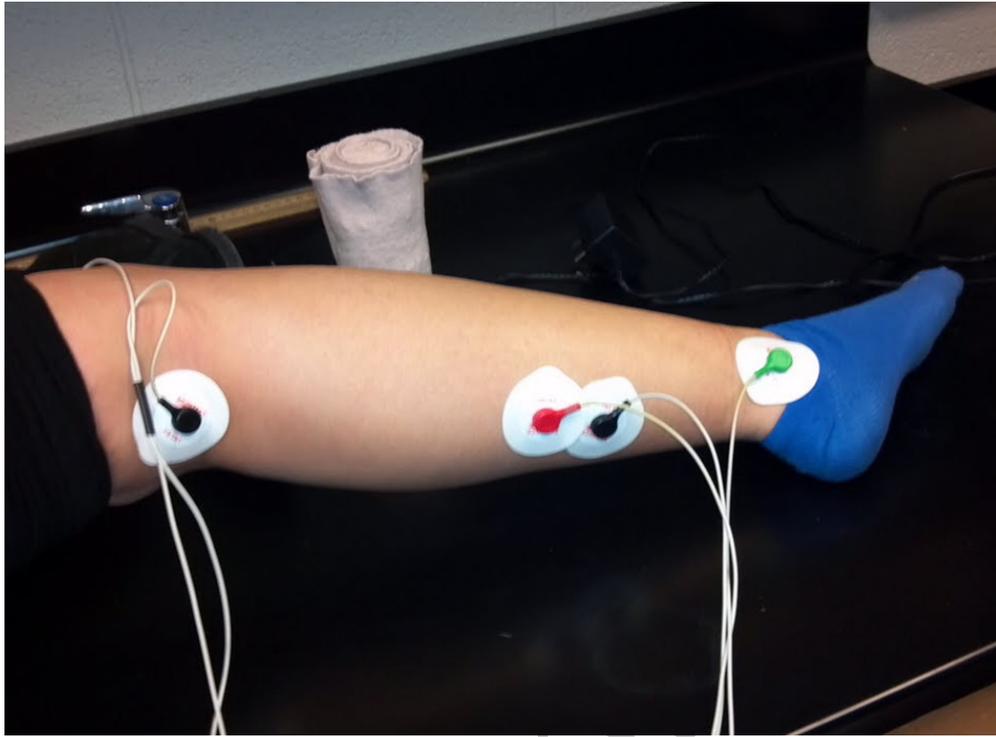


Figure HN-6-S1: Electrode placement for recording the Hoffman Reflex from the soleus muscle.

The Equipment Setup

1. Attach the iWire-B3G EMG cable to the iWire 1 input on the front of the IXTA.

Note - Be sure to connect the iWire-B3G prior to turning on the IXTA.

2. Go to “Edit” and “Preferences”. Ensure you have the Channel tab selected. Confirm you are recording from 10-10 Khz 12V. Acquisition mode should set to “Chart” and Start mode to “User”. Stop will be timed to 0.120 seconds. Sampling rate will be 2000 samples*sec⁻¹. It is easiest to view each trial if you set the viewing window to 0.120. Do not 'X' out of the window.
3. Click the stimulator tab. Confirm values align with [Figure HN-6-S2](#) below. Now you may close the window.

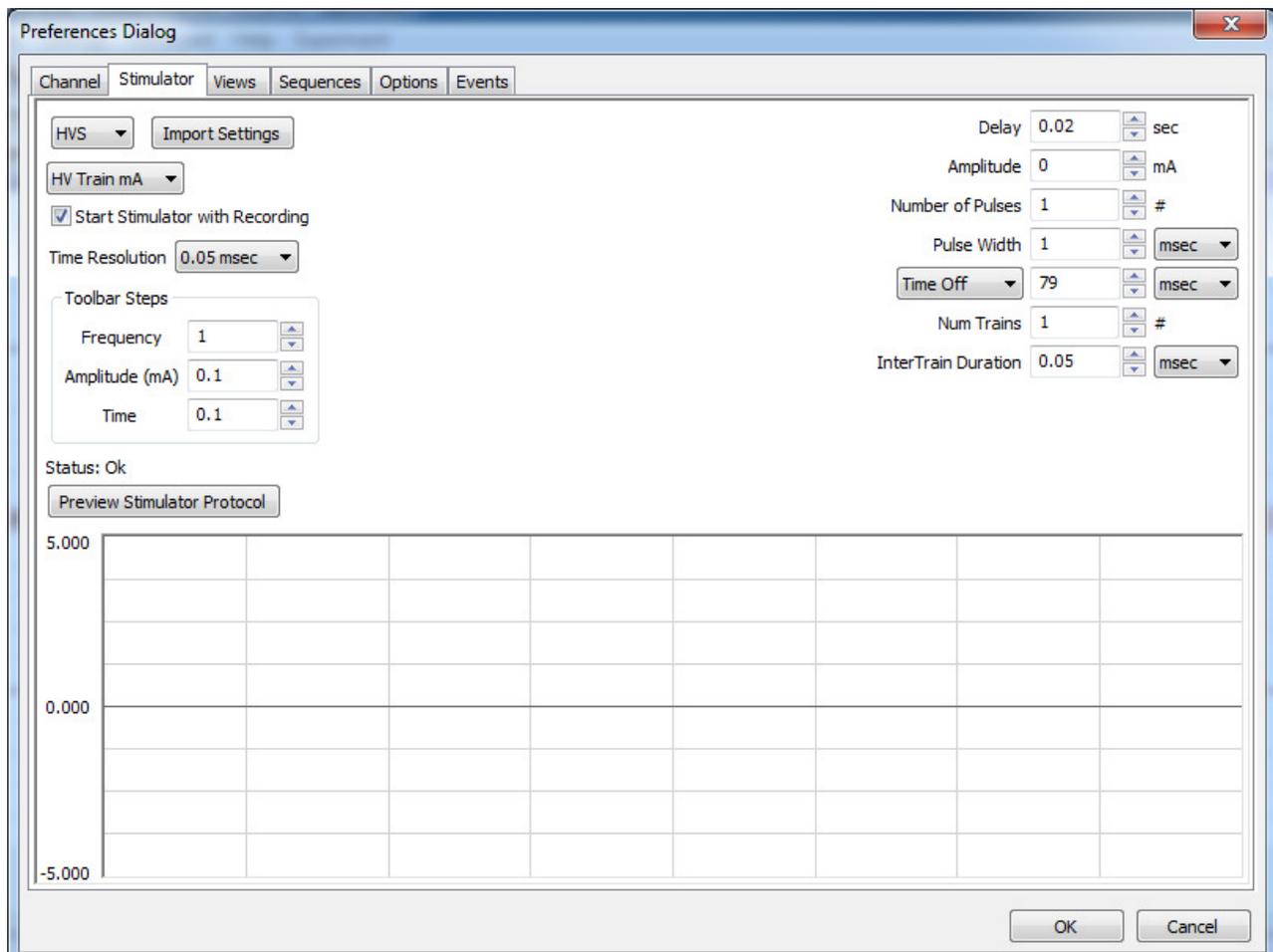


Figure HN-6-S2 – Stimulator Preferences window.

IXTA Stimulator Setup

1. Place the IXTA ([Figure HN-6-S3](#)) 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.

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-6-S4](#)).
5. Connect the 2 stimulating electrodes as stated above.

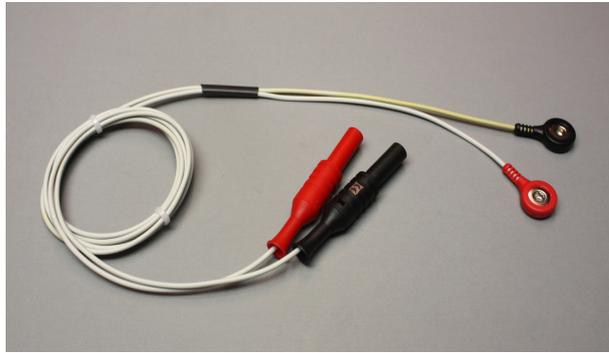


Figure HN-6-S3: The IXTA stimulating electrodes.



Figure HN-6-S4: The front panel of the IXTA with the stimulating electrodes connected correctly.

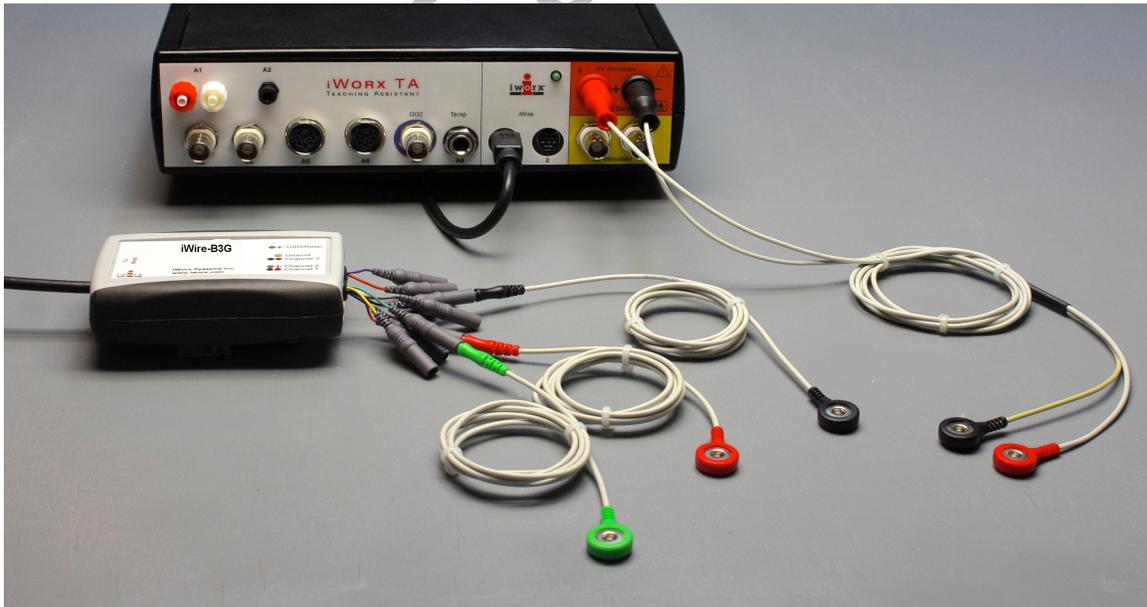


Figure HN-6-S5: IXTA with the iWire-B3G electrodes and the stimulator cables for the Hoffman Reflex lab.

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

Exercise 1: To investigate the H and M reflex responses.

Aim: To investigate the H-reflex response and the M-wave response during muscle stimulation.

1. Increase the current of the SI-200 to 2 mA (1.0 on the dial or using the IXTA Stimulator Control Panel).
 - Check the Setup file to determine the initial stimulator preferences.
2. Click Record.
 - A 120 msec tracing will be displayed on your computer screen.
 - There should be 20 msec of inactivity followed by the 1 msec stimulus.
 - You will notice the artifact from the stimulus in your EMG channel. Approximately 30 msec later you will see the H-reflex appear if the stimulus was large enough and threshold was reached.
3. If nothing appears, confirm with the participant a stimulus was delivered and if the subject felt any tingling sensation.
4. If so, increase the current on the stimulator by 1 mA, then deliver the stimulus again.
5. Click Stop.
6. Repeat steps 2-5 until an H-reflex is recorded so its peak to peak maximum is at its highest. To do this you will need to use the double cursor function as show in [Figure HN-6-L1](#). A tracing example is shown in [Figure HN-6-L2](#).
7. Repeat the procedure with a slightly increasing stimulus, no more than 1mA at a time. Stop at any time the subject does not wish to continue.

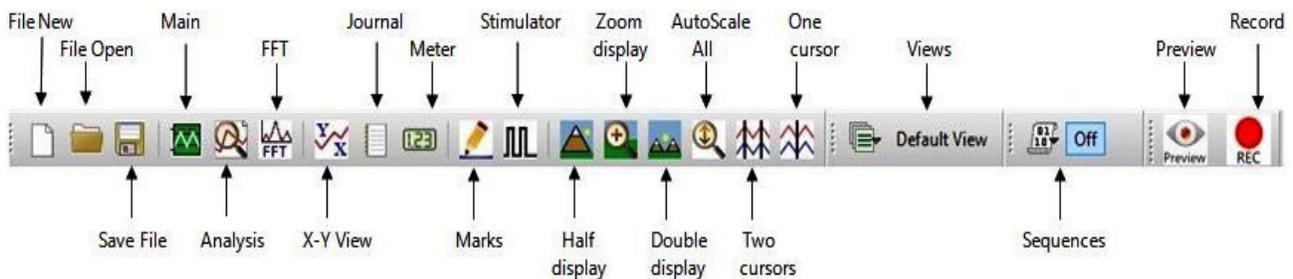


Figure HN-6-S1: LabScribe Toolbar

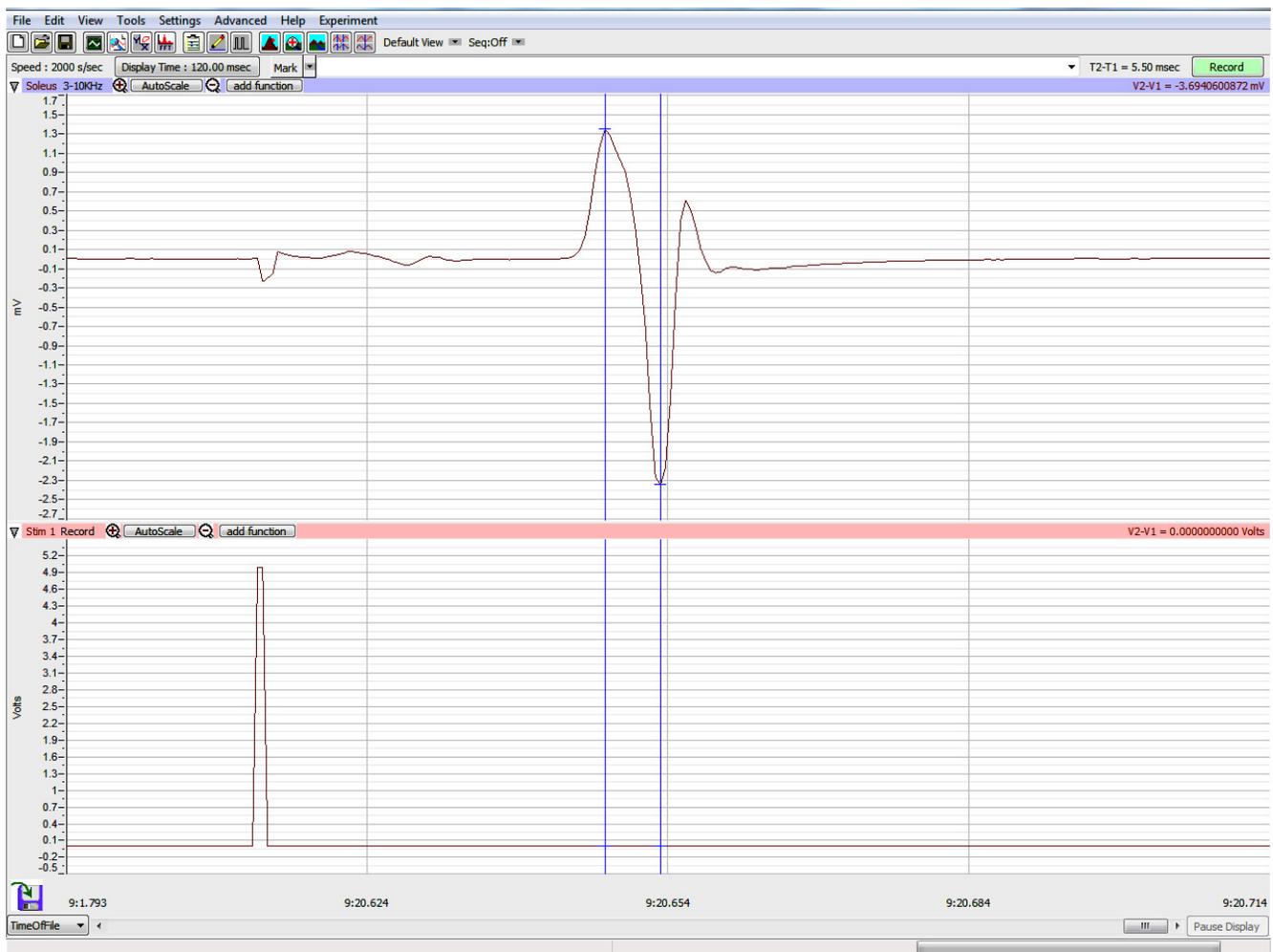


Figure HN-6-L2: Hoffman Reflex shown in the main window with cursors in position to measure the amplitude (V2-V1) of the full H-reflex.

Note: If the trace is upside-down, click the Invert button using the down arrow to the left of the Soleus channel.

Data Analysis

Background Information

The maximal peak to peak EMG amplitude is considered the maximal H-reflex. Note that the tracing is very similar to that seen in a reflex hammer test of the Achilles tendon – see the Achilles Reflex Lab.

The value of the H-reflex is that the location of the stimulus and the intensity of the stimulus are easily controlled via bypassing the muscle spindle completely. Afferent neurons receive direct stimulation from the electric current provided by the stimulator.

The H-reflex is highly variable if the supraspinal input is not controlled. That is to say, any activity that causes the brain to function differently could lead to altered descending nerve tract information that could affect reflex activity. Interneurons synapsing with the descending tracts could facilitate or inhibit reflex output.

An example of this is the Jendrassik maneuver where you try to pull your hands apart during the reflex measurement. Changes in temperature, limb position, auditory input, visual input, stress, etc. can all affect maximal H-reflex amplitude.

Procedure:

1. In the main window, double the display time so that the recording resembles the trace shown above.
2. Click and drag the cursors so that the left hand cursor is on the stimulus and the right hand cursor is on the peak of the response. Measure **T2-T1** for the time it took for the H-reflex to occur from the delivery of the stimulus.
3. With the right hand cursor still on the peak of the response, move the left hand cursor so that it is on the maximal downward spike of the H-reflex. Measure **V2-V1** for the amplitude of the complete Hoffman Reflex of the soleus muscle.
4. Once the cursors are placed in the correct positions for determining the reflex conduction time and the amplitude of the reflex response, record the value for T2-T1, and V2-V1 in the Journal. The value can be recorded in the on-line notebook of LabScribe by typing its name and value directly into the Journal. Values can also be recorded in separate data table.

Additional Exercises

- Try using the Jendrassik maneuver and determine the result on the Hoffman Reflex.
- Add a small weight to the foot.
- Alter the temperature, using either an ice pack or moist heat pack, and determine the H-reflex in both situations.
- Try collecting a maximal M-wave. Calculate the Hmax:Mmax ratio which is the standard for reporting in sports medicine.