Experiment HN-3: Human Nerve Conduction

Equipment Required

PC or Mac Computer

IXTA, USB cable, Power supply for IXTA

ROAM EMG

Disposable snap electrodes

HV stimulator lead wires and round stimulating electrodes

The Equipment Setup

1. The subject should remove all jewelry from his/her right hand and wrist.
2. Obtain seven disposable electrodes.
3. Peel the protective shield off one of the electrodes and place it on the ulnar edge of the little finger of the right hand, so the electrode button/snap is just above the first knuckle (Red (+)) recording electrode.
4. Attach six additional electrodes to the subject's right hand and arm so that they are placed in the following configuration:
    - on the ulnar edge of the palm, so the electrode button/snap is halfway between the base of the little finger and the wrist crease (Black (-)) recording electrode on the hand.
    - so the electrode button/snap is on the ulnar edge of the wrist at the crease (ROAM) electrode on the hand.
    - on the ulnar edge of the forearm, so the electrode button/snap is 50-60 millimeters above the wrist crease (Black (-)) stimulating electrode.
    - right next to the negative stimulating electrode towards the radial side of the forearm 50-60 millimeters above the wrist crease (Red (+)) stimulating electrode.
    - on the ulnar edge of the forearm 200 millimeters above the wrist crease (blank electrode.
    - right next to the negative stimulating electrode towards the radial side of the forearm 200 millimeters above the wrist crease (blank electrode).

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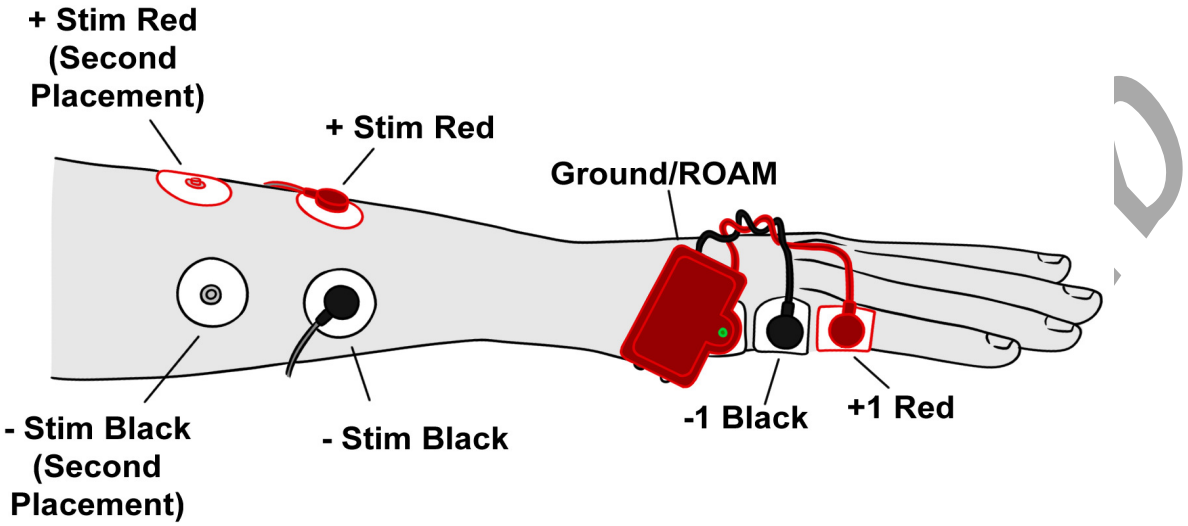

Figure HN-3-S1: Placement of the recording, ground, and two pairs of stimulating electrodes on the ulnar edge of the right hand and arm.

6. Attach three color-coded electrode cables to the ground and Channel 1 inputs on the lead pedestal and snap the other ends onto the disposable electrodes, so that:
    - the red "+1" lead is attached to the electrode (A) closest to the pinkie.
    - the black "-1" lead is attached to the electrode (B) on the center of the side of the hand.
    - the ROAM is attached to the electrode near the wrist.

IworX Sample

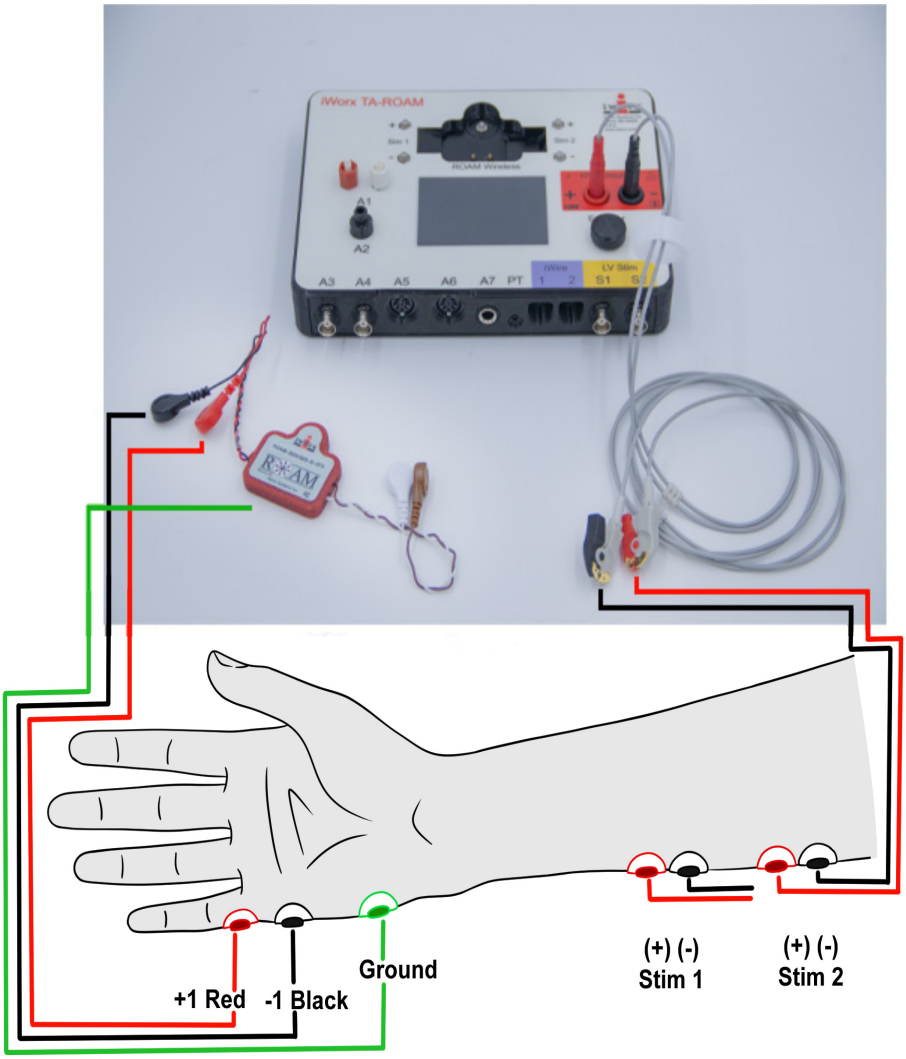

Figure HN-3-S2: Equipment needed to stimulate the ulnar nerve and record the impulses from the abductor muscle of the little finger. This shows a slightly different set-up than the photograph and can be used as an alternate configuration.

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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

Warning: Before connecting the IXTA stimulting 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.

Figure HN-3-S3: The IXTA stimulating electrodes.

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3. 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.
4. Connect the 2 stimulating electrodes as follows:
    - Connect the black (-) stimulating lead to the electrode (D) on the ulnar edge of the forearm 50-60mm above the wrist.
    - Connect the red (+) stimulating lead to the electrode (E) adjacent to the one on the ulnar edge of the forearm 50-60mm above the wrist.
    - The “blank” electrodes (F and G) will be used when the nerve conduction velocity is determined.

Figure HN-3-S4: The front panel of the IXTA with the stimulating electrodes connected correctly.

Warning: Make sure the Amplitude is set to zero.

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Experiment HN-3: Human Nerve Conduction

WARNING - The Stimulator should only be used for the method of application for which the Stimulator is intended as shown in the directions below. If the subject feels a painful stimuli, then the electrodes are in the wrong place.

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

NOTE: If using the IXTA and built in HV stimulator – all changes in Amplitude are entered directly into the Stimulator Control Panel. Click "APPLY" to make any changes.

Exercise 1: Stimulus Strength and Muscle Response

Aim: To determine the effect of stimulus strength on the response of the innervated muscle.

Approximate Time: 30 minutes

Procedure

1. Ask the subject to place their right hand on the bench with the palm down. Tell the subject to relax.

   Note: *The subject should make sure to relax their forearm and hand completely. Any tensing of the muscles would interfere with the recording.*

2. Set the Amplitude to zero or in the Stimulator Control Panel for the IXTA. Click APPLY.
3. Click Record. LabScribe will record a single sweep with a display time of 50 milliseconds. Since the output amplitude is set to zero, there should be no response from the muscle.
4. Increase the output amplitude to 0.5 in the software for the IXTA. You must click the "APPLY" button to make the change.
5. Click the Record button again and record another single sweep. Click the AutoScale button for the Muscle channel to improve the display of the muscle's response.
6. Continue to increase the output amplitude by 0.5 in the Stimulator Control Panel for the IXTA.
   - Click the "APPLY" button is using the IXTA.
   - Click the Record button to record a single sweep after each increase in the stimulus amplitude.
   - Continue to increase the output amplitude and record the response until the muscle impulse reaches a maximum level.

Note: *You many need to continue to increase the amplitude until a good twitch response is generated.*

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

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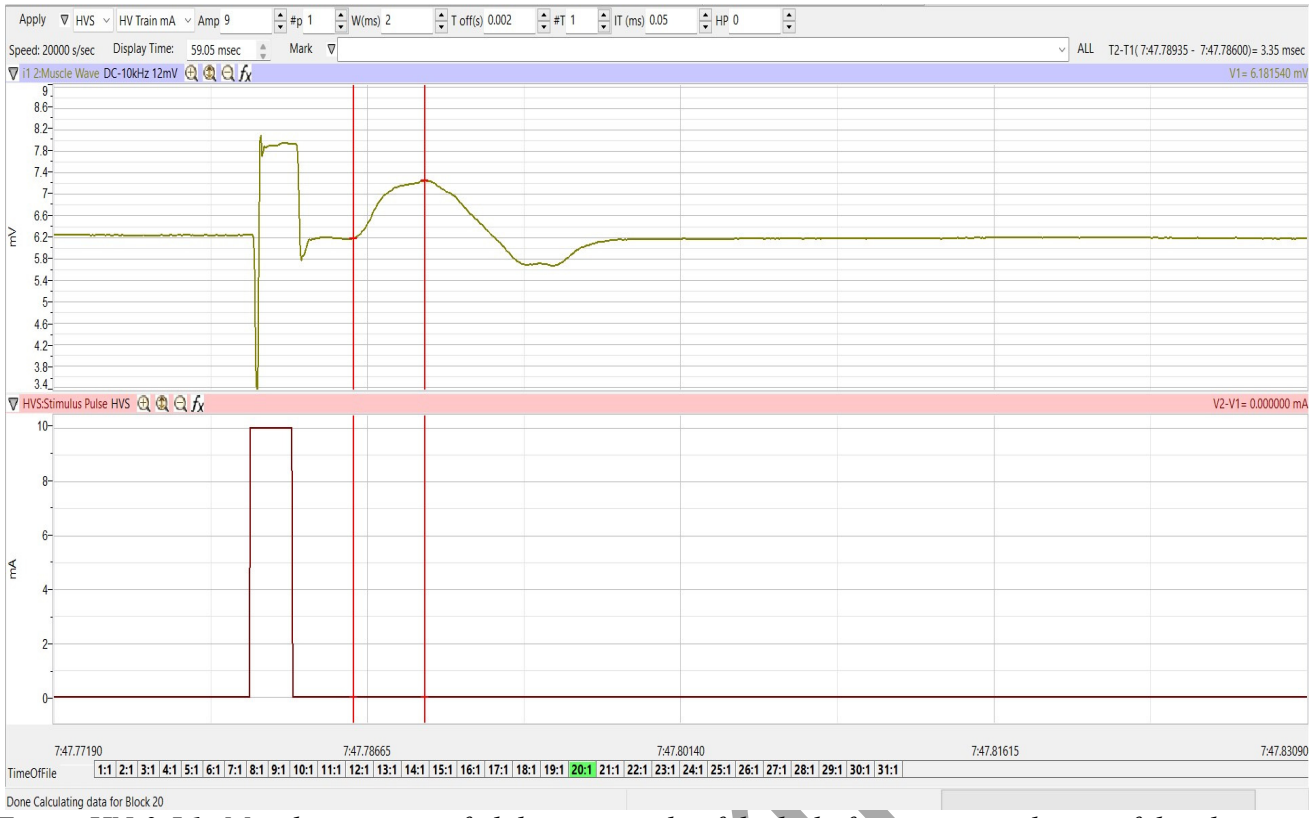

Figure HN-3-L1: Muscle response of abductor muscle of the little finger to stimulation of the ulnar nerve.

Data Analysis

1. Click the Analysis icon in the LabScribe toolbar to view the recorded sweeps.

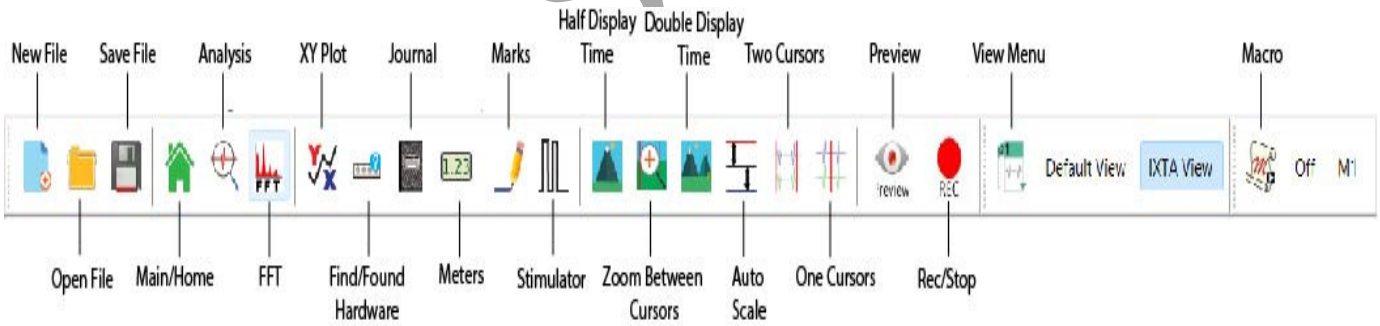

Figure HN-3-L2: The LabScribe toolbar.

2. Use the Windows control-click function to select any sweeps you want to look at from the Sweeps list on the bottom of the Analysis window. For comparison, superimpose the selected sweeps on each other by clicking the sweeps of interest.
3. Select V2-V1 from the Add Functions list if they are not already listed.

Work Sample

4. Go to the Sweep List in the Analysis Window and select the sweep that has the lowest muscle response. Selecting a sweep will display the measured values of that sweep in the table at the top of the Analysis window.
5. Click the 2-Cursor icon in the LabScribe toolbar. Drag one cursor to the left of the stimulus artifact and the second cursor to the peak of the muscle response. The value for V2-V1 in the table at the top of the Analysis window is the amplitude of the muscle response.

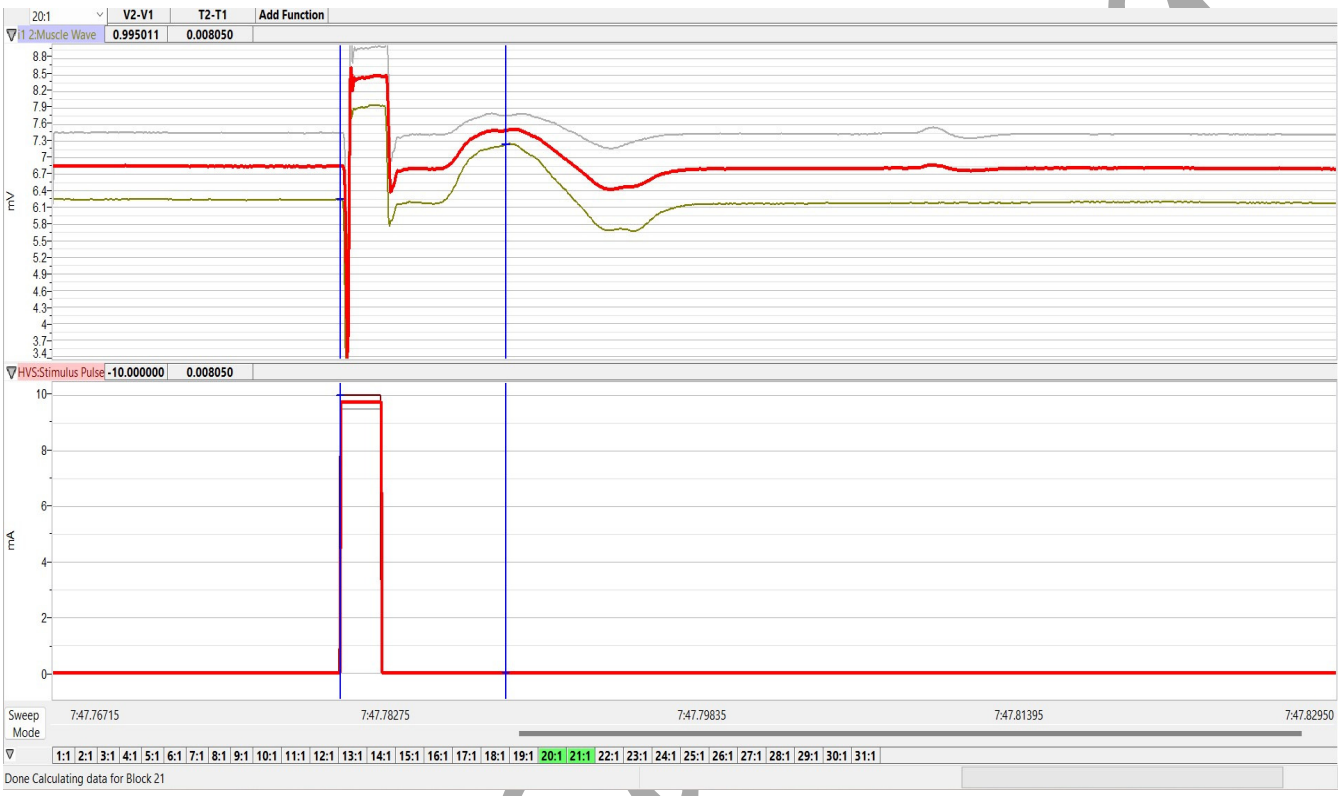

Figure HN-3-L3: Comparison of muscle responses to different stimulus amplitudes. Sweeps are superimposed in the Analysis window. Values for sweep #21 are shown.

6. The functions in the channel pull-down menus of the Analysis window can 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 muscle response.
    - Transfer the names of the mathematical functions used to determine the muscle response to the Journal using the Add Title to Journal function in the Muscle Channel pull-down menu.
    - Transfer the values for the change in muscle response to the Journal using the Add Ch. Data to Journal function in the muscle channel pull-down menu.
7. Record the stimulus amplitude used to generate the nerve response along with the other data for the sweep in the Journal.
8. Find the amplitudes (V2-V1) for any other selected sweeps in the same manner. Record these values and the values of the stimulus amplitudes used to generate these responses in the Journal.

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9. In Excel graph the amplitude of the muscle response as a function of the stimulus amplitude.

Questions

1. Does the amplitude of the action potential in each fiber in the ulnar nerve increase or do the numbers of nerve fibers in the nerve that respond increase with increased stimulus strength?
2. Does the amplitude of the muscle response increase because the response of each muscle fiber increases or the number of muscle fibers responding increases?
3. Which stimulus amplitudes are subthreshold? Which ones are suprathreshold or submaximal? Which ones are supramaximal?

Exercise 2: Effect of Stimulus Polarity

Aim: To determine if the polarity of the stimulus pulse delivered to the nerve affects the latency and amplitude of the muscle response.

Approximate Time: 15 minutes

Procedure

1. Ask the subject to place their right hand on the bench with the palm down. Tell the subject to relax.
2. Set the Amplitude in the IXTA software to a value that delivers the maximal muscle response as seen from Exercise 1 (remember to click Apply).
3. Click Record button.
4. Reverse the polarity of the stimulus pulse delivered to the ulnar nerve by reversing the positions of the stimulating leads on the subject's forearm. Switch the stimulating leads by moving the red (+) stimulating lead to where the black (-) stimulating lead was snapped, and move the black (-) stimulating lead to where the red (+) lead was snapped.
5. Click Record button on the LabScribe Main window to record a single sweep at this stimulus polarity using the same stimulus amplitude.
6. Select Save in the File menu.

Data Analysis

1. Click the Analysis icon in the LabScribe toolbar.
2. Use the Windows control-click function to select the sweeps of interest from the Sweeps list on the bottom of the Analysis window.
3. Select V2-V1 and T2-T1 from the Add Functions list if they are not already listed.
4. Go to the Sweep List at the top of the Analysis Window and select the sweep generated by normal stimulus polarity. Selecting this sweep from this menu will make the values of its measured functions appear in the table at the top of the Analysis window.

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5. Click the 2-Cursor icon in the LabScribe toolbar. Place one cursor right at the beginning of the stimulus artifact and the second cursor to the peak of the muscle response. The value for V2-V1 in the table at the top of the Analysis window is the amplitude of the muscle response.
    - The value for T2-T1 is a measure of the latency of the muscle response.
6. 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 muscle response.
    - Transfer the names of the mathematical functions used to determine the muscle response to the Journal using the Add Title to Journal function in the Muscle Channel pull-down menu.
    - Transfer the values for the change in muscle response to the Journal using the Add Ch. Data to Journal function in the muscle channel pull-down menu.
7. Find the amplitude (V2-V1) and the latency (T2-T1) for the muscle's response to the stimulus of reversed polarity. Record these values in the Journal.

Questions

1. How does the amplitude and the latency of the muscle response change when the stimulus polarity is reversed?
2. What causes the difference to occur?

Exercise 3: Conduction Velocity

Aim: To measure the conduction velocity of the ulnar nerve by measuring the time required for the nerve impulse to travel from the site of the nerve stimulation to the site of the muscle response.

Approximate Time: 20 minutes

Procedure

1. Ask the subject to place their right hand on the bench with the palm down. Tell the subject to relax.
2. Set the Amplitude in the IXTA software to a value that delivered a maximal muscle response (remember to click Apply).
3. Click Record button on the LabScribe Main window to record a single sweep at this stimulus strength.
4. Move the stimulating leads from the lower placement to the higher one. Review the lab setup images.
5. Click Record button on the LabScribe Main window to record a single sweep with the stimulus delivered at this location on the forearm.

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Note: *If you do not get a muscle response with the stimulating electrodes placed farther from the wrist, move the stimulating electrodes back to the original position.*

7. Select Save in the File menu.
8. Use a measuring tape, measure the actual distance between the two electrodes used as the (-) stimulating electrodes.

Data Analysis

1. Click the Analysis icon in the LabScribe toolbar to view the recorded sweeps. From the Sweeps list, select the sweeps recorded while the stimulating electrodes were in different positions. Superimpose these sweeps on each other by clicking the sweep numbers from this list at the bottom of the window.
2. Select T2-T1 from the Add Functions list if they are not already listed.
3. Go to the Sweep List in the Analysis Window and select the muscle response generated from the proximal position of the stimulating electrodes.
4. Click the 2-Cursor icon in the LabScribe toolbar. Drag one of the cursors to the peak of the muscle response in this sweep. The other cursor will be moved in step 6.
5. Go back to the Sweep List and select the muscle response generated from the distal position of the stimulating electrodes.
6. Repeat Step 4.
7. Measure T2-T1.
    - This is the time it took the compound action potential in the ulnar nerve to travel the distance between the two positions of the negative stimulating electrode.

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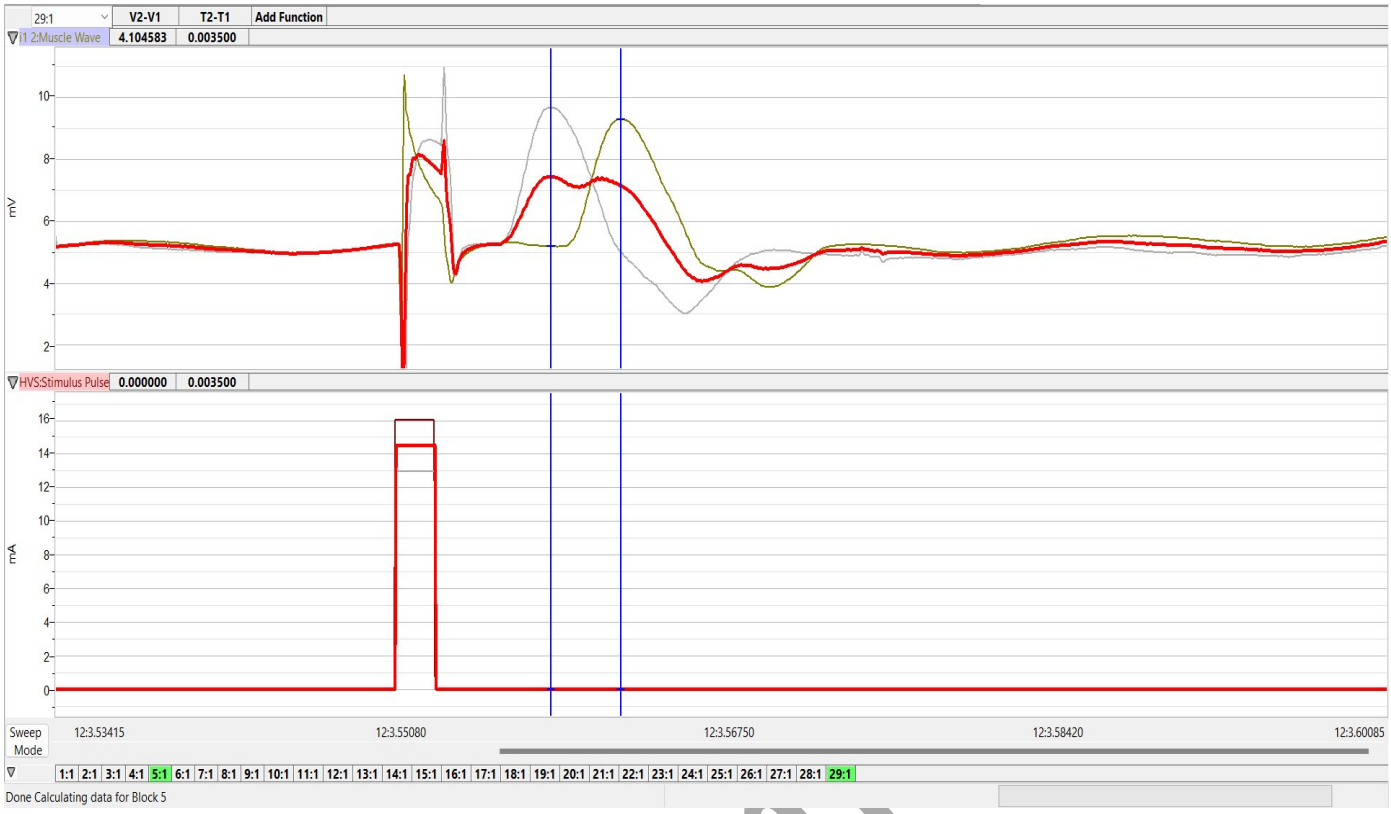

Figure HN-3-L4: Cursors mark the time difference between the peaks of the muscle responses caused by stimulating electrodes at two different positions on the ulnar nerve.

8. The functions in the channel pull-down menus of the Analysis window can 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 muscle response.
    - Transfer the names of the mathematical functions used to determine the muscle response to the Journal using the Add Title to Journal function in the Muscle Channel pull-down menu.
    - Transfer the values for the change in muscle response to the Journal using the Add Ch. Data to Journal function in the muscle channel pull-down menu.
8. Calculate the conduction velocity (in m/sec) by dividing the distance (in mm) between the two positions of the negative stimulating electrode by the time (T2-T1) between the peaks of the muscle responses from those two positions.
    - For example:

        65mm between positions of (-) electrode / 1.25ms = 52mm/ms = 52m/s

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