Experiment HN-12: Nerve Conduction Velocity & Hand Dominance

This lab written with assistance from: Nathan Heller, Undergraduate research assistant; Kathryn Forti, Undergraduate research assistant; Keith K. Schillo, PhD, Associate Professor, Biology Department, SUNY Oneonta, Oneonta, NY

Work Sample Lab

Equipment Required

PC or Mac Computer

IXTA , USB cable, Power supply for IXTA

ROAM EMG

Disposable snap electrodes

HV stimulator lead wires and stimulating electrodes

EM-220 Event Marker

The Equipment Setup

1. The subject should remove all jewelry from their right hand and wrist.
2. Obtain seven disposable electrodes, 3 recording and 4 stimulating.
3. Locate and mark the sites listed as shown in Figure HN-12-S1; place electrodes over these locations and attach the colored recording leads. *Note: It may be necessary to trim the adhesive of the electrode to prevent overlapping.*
    - Just above the wrist: Ground (ROAM).
    - Slightly distal to the first metacarpophalangeal joint: Recording '+' (Red).
    - Midway between the first metacarpophalangeal joint and the wrist crease: Recording '-' (Black).
4. Locate and mark the following sites, place electrodes over these locations and attach the colored stimulating leads which are attached to the red and black stimulator channels.
    - Short distance (80 mm):
        - At the center of the wrist crease 50 mm from the Recording '-' (Black) lead and then 30 mm superior to the center of the wrist crease along the midline of the forearm: Stimulating '-' (Black) lead.
        - On the midline of forearm, proximal to the Stimulating '-' (Black) lead: Stimulating '+' (Red) lead.
    - Long distance:
        - Just below the elbow crease: Stimulating '-' (Black) lead slightly to the radius side.
        - On the medial side of the of the Stimulating '-' (Black) lead: Stimulating '+' (Red) lead.

Note: This location will vary among subjects, so measure the distance between this site and the black recording electrode.

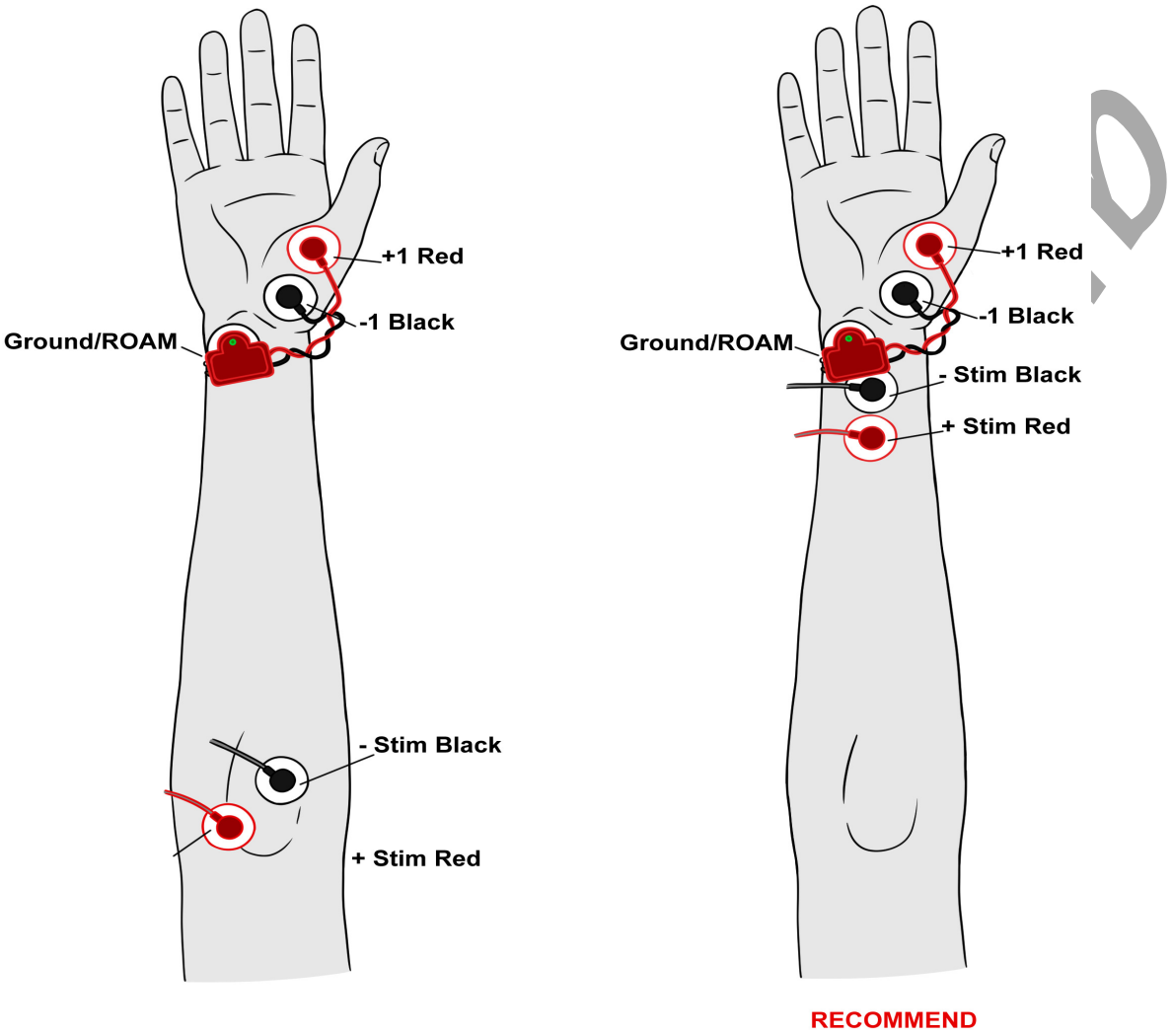

Figure HN-12-S1: The red and black recording leads are placed on the thumb, the ROAM is placed just above the wrist, and the red and black stimulating leads are placed just above the wrist crease. The long distance positioning is shown on the left

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Table HN-12-S1. Summary of Electrode and Lead Placement

Electrode	Lead	Placement
Ground - From ROAM	ROAM	Just above the wrist crease on the ulnar side.
Recording '+' From ROAM	Red	Placed just distal to the first metacarpophalangeal (MCP) joint.
Recording '–' From ROAM	Black	Placed along the pollicis brevis muscle, the midpoint between the first MCP joint and the wrist crease.
Short Stimulating '–' From iWorx TA box	Black	80mm from recording '–' electrode. Measure 50mm from the recording- electrode toward the center of the wrist crease. Then measure 30mm superior to this point along the midline of the arm.
Short Stimulating '+' From iWorx TA box	Red	Placed just superior to the short stimulating '–' electrode, along the same axis.
Long Stimulating '–' From iWorx TA box	Black	Placed at a point just below the elbow crease
Long Stimulating '+' From iWorx TA box	Red	Placed just superior to the long stimulating '–' electrode.

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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

1. Place the IXTA on the bench near the subject.

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.

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

Figure HN-12-S2: The IXTA stimulating electrodes.

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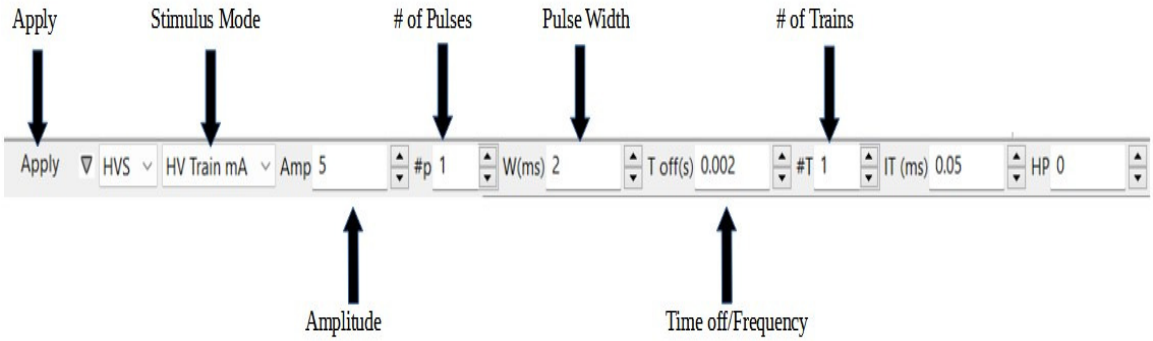
Figure HN-12-S3: The front panel of the IXTA with the stimulating electrodes connected correctly.

Warning: Make sure the Amplitude is set to zero.

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 stated above.
5. Start with the stimulator programmed in this manner:
    - On the Stimulator Control Panel that appears 2 lines above the upper recording panel.
        - Amps will be the only variable changed (between 3-20 amps). Begin with 3 amps and increase until a consistent response is achieved (7 amps has yielded consistent results).
        - Make sure to hit ***APPLY*** after choosing the settings.



Stimulator Control Panel

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NOTE: The experiments in this lab will be completed on BOTH the dominant and non-dominant arms/hands.

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

Exercise 1: Stimulus Strength and Muscle Response in the Dominant Arm.

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

Approximate Time: 30 minutes

Procedure

1. Ask the subject to place their right hand on the bench with the palm up. 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" to make the change).
3. Click Record button on the LabScribe Main window. 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 abductor muscle.
4. Increase the output amplitude to 0.5 in the software for the IXTA and click Apply. 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 (Figure HN-12-L1).
5. Continue to increase the output amplitude by 0.5 increments (click "Apply").
    - Click the Record button to record a single sweep after each increase in the stimulus amplitude.

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- Continue to increase the output amplitude and record the response until the muscle impulse reaches a good strong response.

6. Perform the following steps for both the short and long stimulation sites:
   - To administer the stimulus, press 'Record' in the upper right hand corner of the computer screen.
   - Repeat this procedure until a response is generated for each distance and measure the amount of time between the start of the stimulus and the peak voltage of the CAP.

   Note: *You many need to continue to increase the amplitude until a 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).

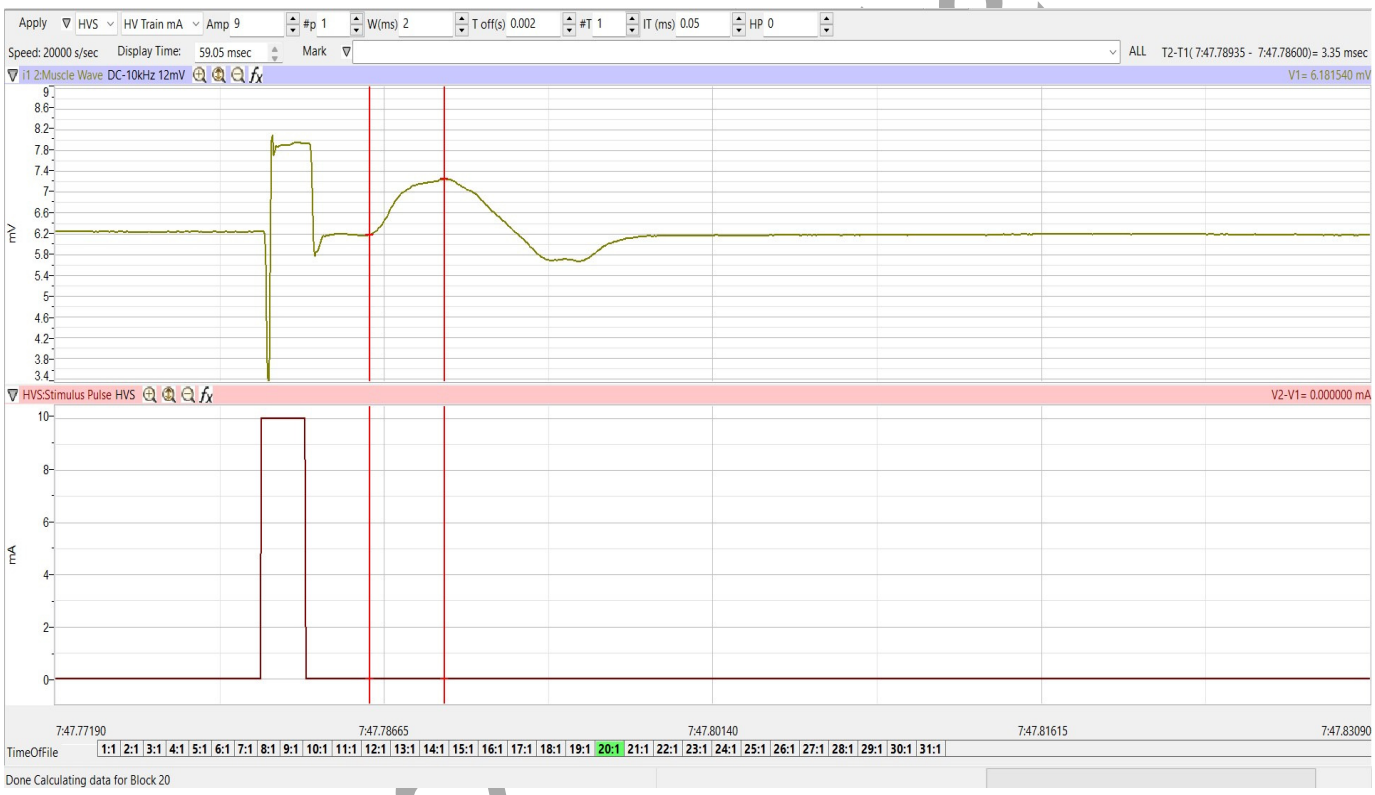

Figure HN-12-L1: A CAP from the median nerve; measuring the amplitude of the response.

Data Analysis

1. Click the Analysis icon in the LabScribe toolbar to view all the recorded sweeps.
2. Use the Windows control-click function to select the sweeps of interest 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. See the figure below.

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3. Select V2-V1 and T2-T1 from the Add Functions list if they are not already listed. Data analysis can also be performed on the main window.

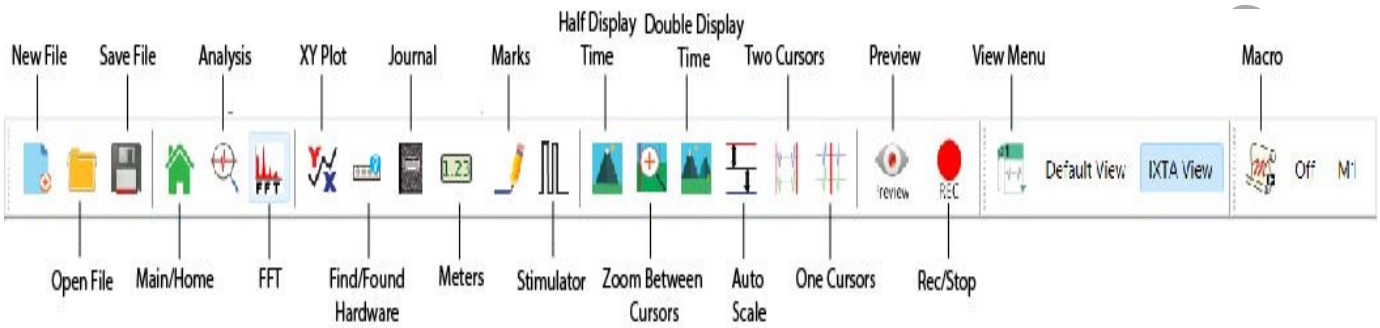

Figure HN-12-L2: The LabScribe toolbar.

4. Go to the Sweep List at the top of the Analysis Window and select the sweep that has the lowest muscle response from the short distance. Selecting a sweep from this menu 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-12-L3: Comparison of muscle responses to different stimulus amplitudes. Sweeps are superimposed in the Analysis window. Values for sweep #21 are shown.

Sample

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. 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 the 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.
9. Graph the amplitude of the muscle response as a function of the stimulus amplitude.
10. Place one cursor on the start on the stimulus and one cursor on the peak of the response and perform these calculations:
    - Calculate the average amplitude of the three responses for each distance.
    - Calculate the difference between the long (B) and short (A) distances (mm) = $$\mathbf{D_B - D_A = \Delta D}$$
    - Calculate the difference in the average conduction times between the two distances (ms) $$\mathbf{T_B - T_A = \Delta T}$$
    - Calculate the Nerve Conduction Velocity (mm/ms or m/s) $$\mathbf{\Delta D / \Delta T}$$
11. Repeat the procedure three times and calculate the nerve conduction velocity for each of these replicates. Calculate the average of these three measurements.
12. Table 1 shows nerve conduction velocities in the median nerves of eight subjects who underwent the procedure outlined in this laboratory protocol.
13. According to values reported in the scientific literature conduction velocity of the median nerve ranges between 40 and 78 $m \cdot s^{-1}$. All but two of the test subjects had velocities that fell within this range.
    - It is noteworthy that the three lowest conduction velocities were from the three oldest subjects, one of whom was previously diagnosed with a mild case of Carpal Tunnel Syndrome. According to previous studies the mean conduction velocity of the median nerve is 57 $m \cdot s^{-1}$. The mean conduction velocity measured with this protocol is 51.4225 $m \cdot s^{-1}$.

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Questions

1. Does the amplitude of the action potential in each fiber in the median 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?
4. How do conduction velocities differ by:
    - age?
    - gender?
    - Handedness?

Table HN-12-L1. Median Nerve Conduction Velocity in Eight Subjects.

Subject	Gender	Age	Conduction Velocity ($m \cdot s^{-1}$)
1	F	20	67.72
2	M	44	37.59
3	F	21	62.34
4	F	19	51.19
5	F	19	52.8
6	F	63	44.9
7	M	21	58.76
8	M	61	36.08
Mean			51.42
Standard deviation			11.40

Exercise 2: Stimulus Strength and Muscle Response in the Non-Dominant Arm.

Aim: To determine the effect of stimulus strength on the response of the innervated muscle in the non dominant arm.

Approximate Time: 30 minutes

Procedure

Repeat the procedure for Exercise 1 on the non-dominant arm for both recording and data analysis.

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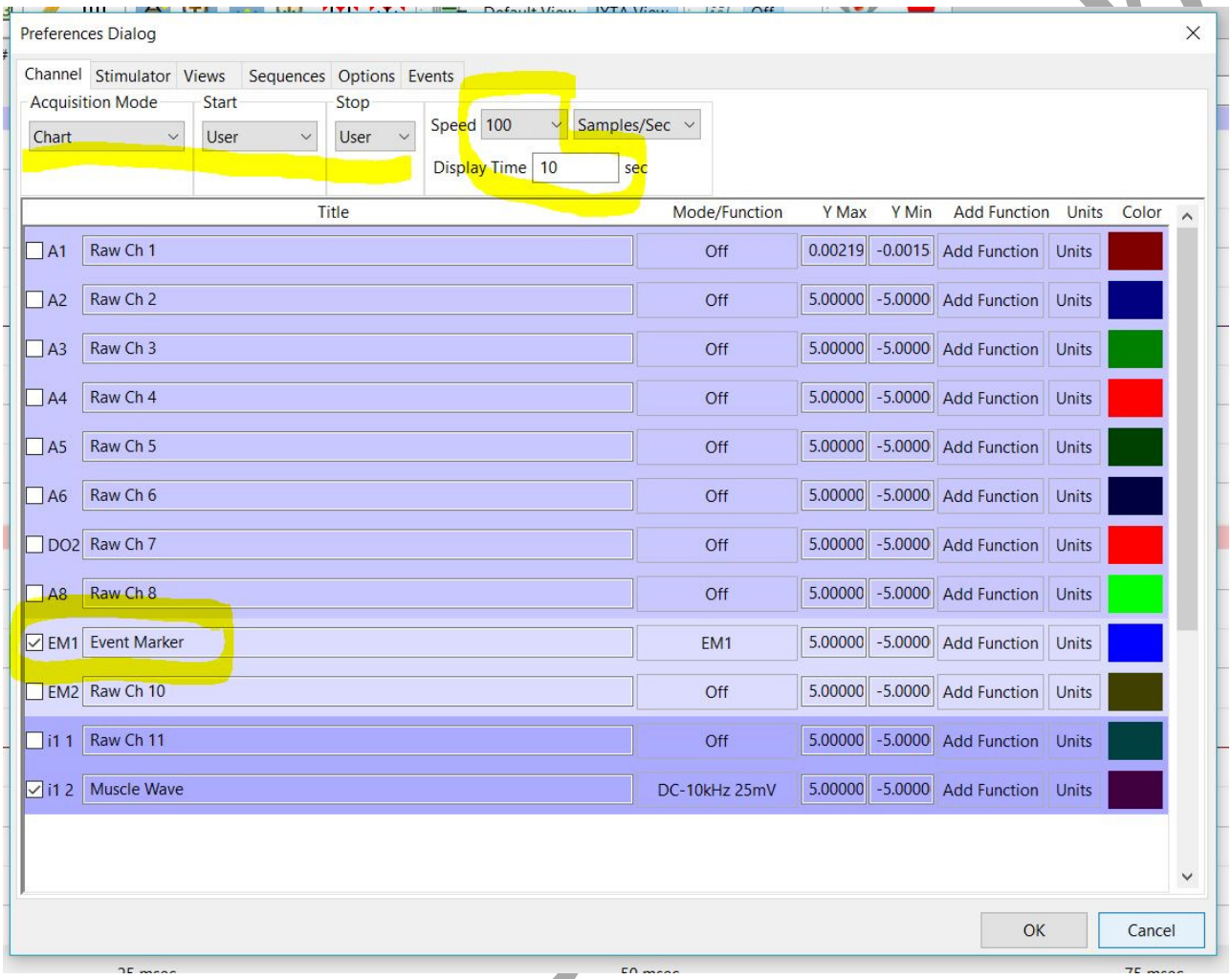
ADJUST THE SETTINGS FILE:

To complete Exercises 3 and 4 – you will need to adjust the settings file:

1. Click Edit → Preferences to open this screen:



2. Make the following changes:
   - Change Acquisition Mode from ScopeMultiple to **Chart**
   - Start and Stop = **User**
   - Speed will be changed from 20000 to **100**
   - Display time = **10**
   - Put a check mark in channel **EM1**, and change the name = **Event Marker**
   - Uncheck **i1-2** and **HVS**
   - Click **OK**

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Exercise 3: Reaction Time and Visual Signals using the Dominant Hand

Aim: To measure the reaction time of a subject to a visual signal using the dominant hand.

Approximate Time: 15 minutes

Procedure

1. Read all instructions carefully before beginning to record.
2. Information for the subject:
    - Instruct the subject to sit in a chair and face the computer screen.
    - Watch the right side of the computer screen and quickly press the event marker when the signal appears on the computer screen.
3. Directions for the other student(s):

- Out of sight of the subject, another student should prepare to quietly press and release the F1 key on the keyboard to generate a black line on the screen.
    - In this exercise, the other student(s) will help the subject perform ten trials.

Warning: In this exercise, it is important to press and release F1 key quietly because any sound could be used by the subject as a signal.

4. Click on the Record button.
5. Type “Visual-Dominant” in the Mark box to the right of the Mark button. Press the mark button to mark the recording.
6. Instruct the subject to press the event marker as soon as he or she sees black line on the right side of the computer screen.
7. Use the F1 key to deliver ten visual signals to the subject. The signals **should not be less than three seconds nor more than six seconds apart.**
8. After the tenth response, click Stop to halt recording.
9. Click on the Save button to save the data file.

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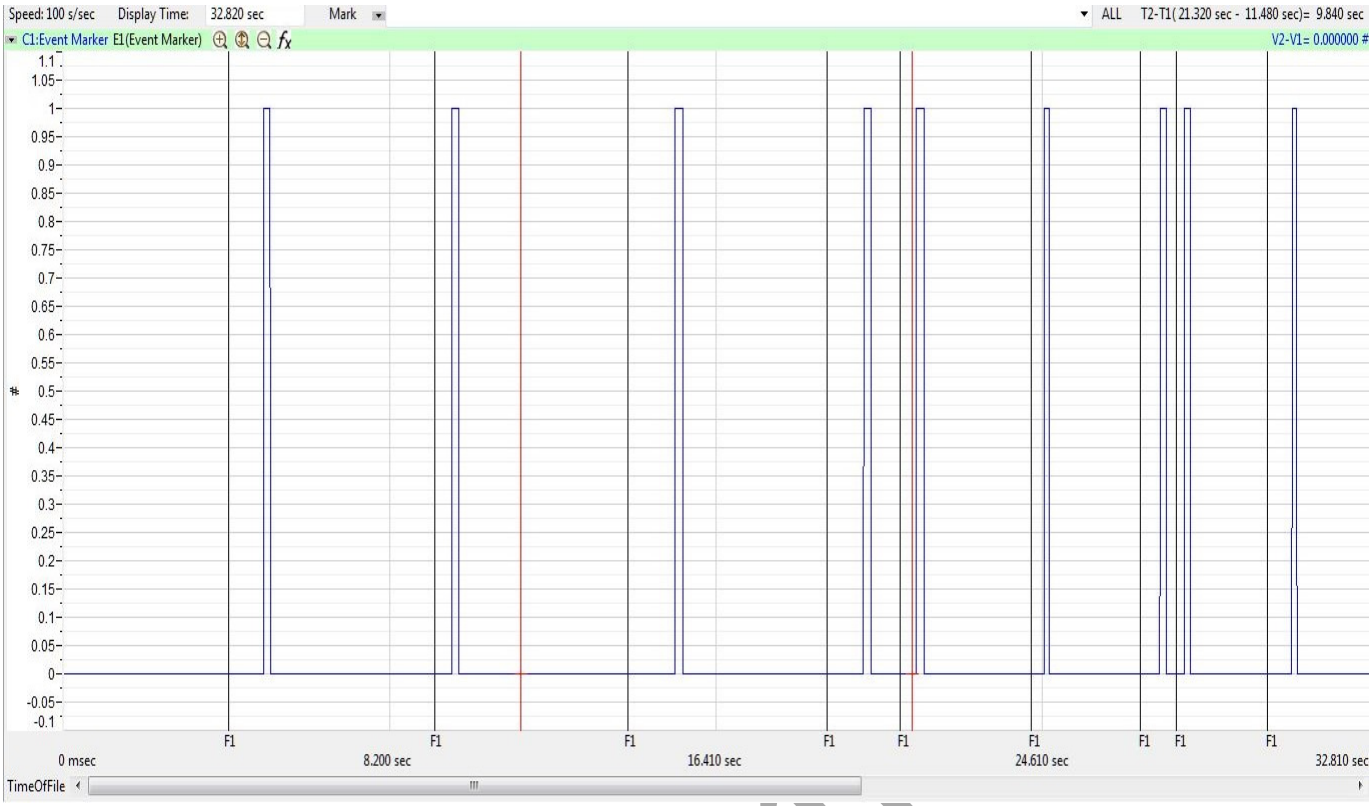

Figure HN-12-L5: Visual signals, each followed by the subject's response, are displayed on the Main window. Each visual signal is made by clicking the F1 key; each response mark is made by the subject pushing the event marker.

Data Analysis

1. Scroll to the beginning of the data recorded for Exercise 1 to display the trials on the Main window.
2. Use the Display Time icons to adjust the Display Time of the Main window to show both the visual signal made with the event marker and the mark made by the subject's response on the Main window. Double the display time to show all the responses.

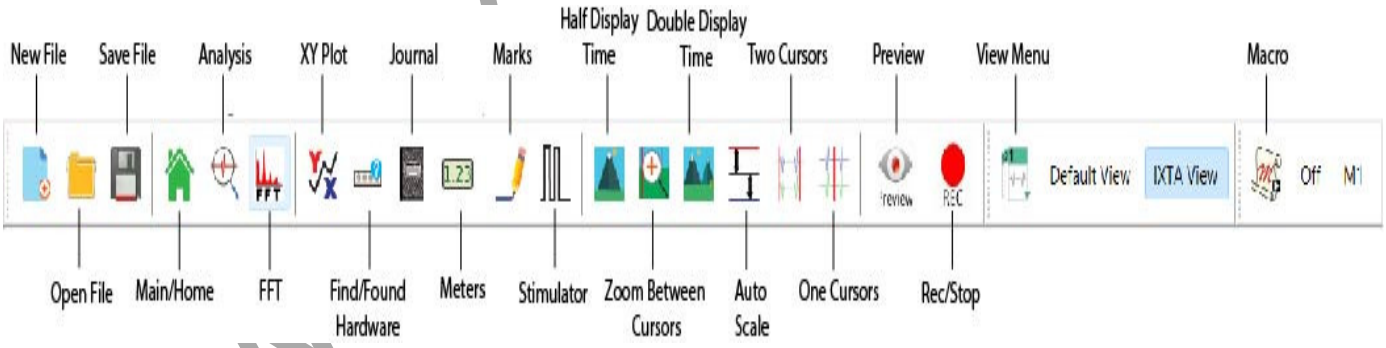

Figure HN-12-L6: The LabScribe toolbar.

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3. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
4. The value T2-T1 is shown in the upper right of the Main window or the upper left of the channel in the Analysis window.
5. Use the mouse to click on and drag a cursor to the onset of the visual signal. Drag the other cursor over to the onset of the mark made by the subject responding to the visual signal.
6. Once the cursors are placed in the correct positions for determining the reaction time, record the value for T2-T1 on a separate data table.
7. Once the reaction time in the first trial is measured and recorded, repeat Steps 5 and 6 on the data from the second trial. Continue for all 10 trials.

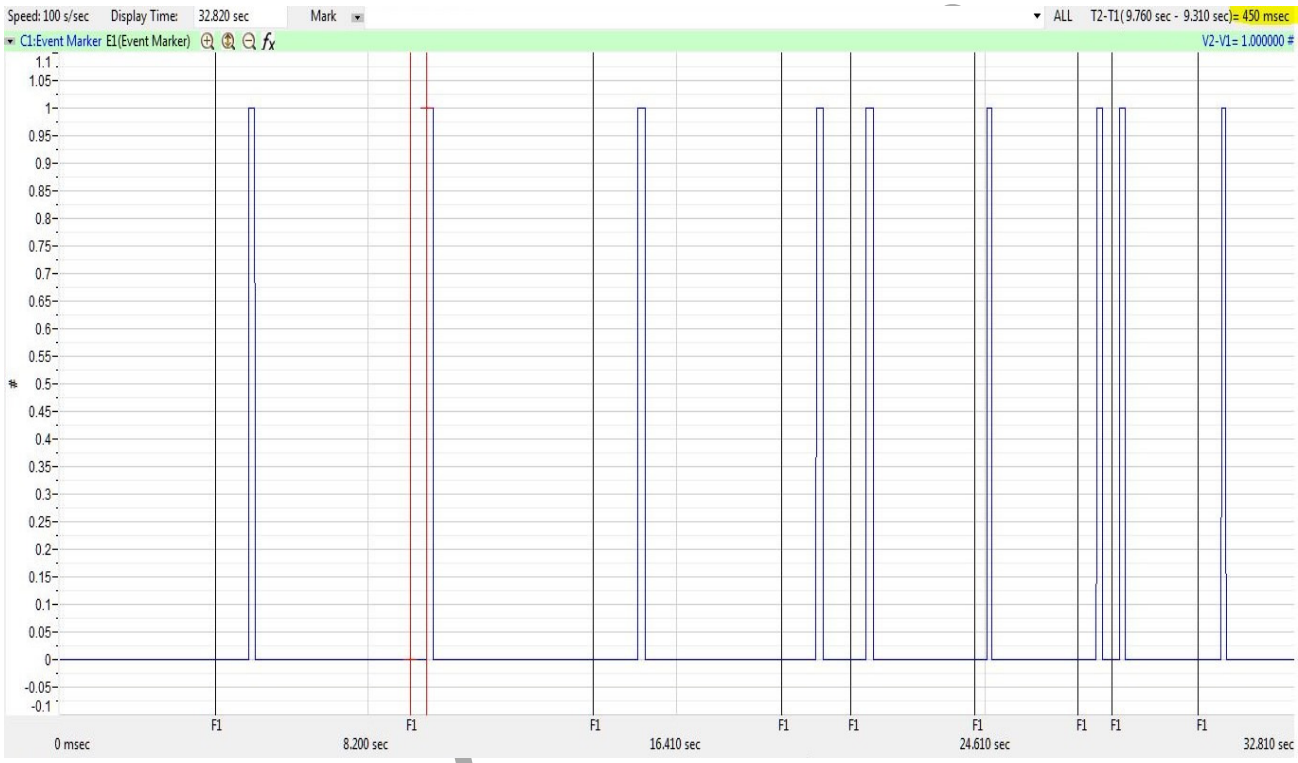

Figure HN-12-L7: A visual signal, followed by the subject's response. The two cursors are positioned at the beginning of the visual signal and on the mark for measurement of the subject's reaction time (T2-T1) in this trial = 450 msec.

Exercise 4: Reaction Time and Visual Signals using the Non-Dominant Hand

Aim: To measure the reaction time of a subject to a visual signal using the non-dominant hand.

Approximate Time: 15 minutes

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Procedure

Repeat the procedure for Exercise 3 using the non-dominant hand for both recording and data analysis.

Questions

1. Does handedness affect the reaction time to the visual stimulus?
2. What could be the reasons for your answers to question 1?
3. Is nerve velocity different in the dominant vs non-dominant arm?
4. Does nerve velocity have any effect on handedness or is it the other way around? Is there any effect at all?
5. What is the physiological explanation for the data you have found?

References

Buschbacher RM and Prahlow ND. 2006. Manual of Nerve Conduction Studies. 2nd ed. New York: Demos Medical Publishing; 2006. p. 10-17.

Palmieri, R. M., Ingersoll, C. D., & Hoffman, M. A. 2004. The Hoffmann Reflex: Methodologic Considerations and Applications for use in Sports MEdicine and Athletic Training Research. Journal of Athletic Training, 39(3), 268-277.

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