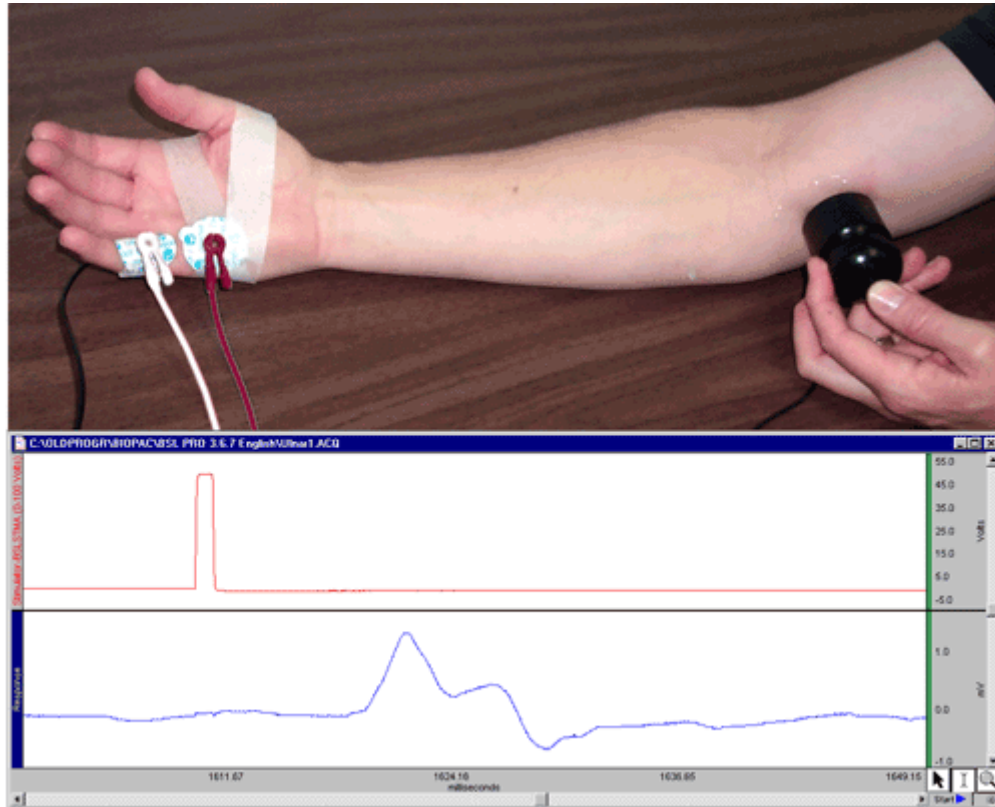


BSL PRO Lesson H03: Nerve Conduction Velocity: Along the Ulnar Nerve of a Human Subject



This *PRO* lesson describes hardware and software setup of the BSL *PRO* System to record and measure nerve conduction velocity along the ulnar nerve of a human subject.

[NEW Video Clip - experiment overview](#)

Abstract

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The nerve impulse is a wave of depolarization immediately followed by a wave of repolarization, collectively called an **action potential**, occurring on the plasma membrane of a nerve fiber. Changes in ion conductances across the nerve fiber membrane are responsible for the initiation and propagation of the action potential. Experimentally, these changes can be the result of electrical current applied through electrodes. Once initiated, an action potential is usually propagated without decrement in amplitude or velocity along the plasma membrane of a nerve fiber.

The velocity or speed of the propagated (conducted) nerve impulse is directly related to the diameter of the nerve fiber and the presence of a myelin sheath.

- The fastest nerve fibers have large diameters and are myelinated; for

- example, the motor nerve fibers that supply skeletal muscles.
- The slowest nerve fibers have small diameters and are unmyelinated; for example, sensory nerve fiber from the stomach.

In the peripheral nervous system, nerve fibers of various diameters and functions (motor and sensory) are bundled together by connective tissue to form nerves. A **compound action potential** is the sum of all the action potentials occurring in the individual neurons of the whole nerve. The **velocity** of the compound action potential signal can be a measure and can indicate the state of health of the nerve. Diseases that damage the myelin, destroy neurons, or constrict the whole nerve will decrease the nerve's conduction velocity. However, the nerve conduction velocity may remain normal until late in a disease process as long as a few normal neurons survive. In addition, the nerve conduction velocity reflects conduction of the fastest nerve fibers, usually motor neurons.

The nerve conduction velocity is determined by recording the motor (EMG) response of a muscle to the stimulation of its motor nerve at two or more points along the nerve course. The time between stimulation and response is measured and compared to the distance between the point of stimulation and point of response. Precise parameters of measurement have been developed for the ulnar nerve and the motor response is measured over the abductor digiti minimi.

Objectives

1. To record a charge from the stimulus electrodes to recording electrodes.
2. To observe the Threshold, Maximal and Supra-Maximal response levels.
3. To determine nerve conduction velocity along the ulnar nerve.

Equipment

- PC running Windows or Macintosh computer
- BIOPAC Software: Biopac Student Lab PRO
- BIOPAC Data Acquisition Unit (MP30)
- BIOPAC Stimulator (BSLSTM)
- BIOPAC disposable electrodes (EL503)
- BIOPAC electrode lead set (SS2L)
- BIOPAC human stimulator probe (HSTM01)
- Abrasive pads (ELPAD)
- Electrode gel (GEL1)
- Ruler (cm)
- Adhesive Tape (TAPE1)
- Pen for marking skin

IMPORTANT! BIOPAC HSTM Series Probes must be used when stimulating humans. HSTM probes have current-limiting features, enhanced isolation and a user-operated "dead man" switch for optimum safety.

WARNING! Even with the HSTM probe, you must **never create an electrical path across the heart** (i.e. touching an active tip in each hand while the switch is engaged) and you should never use on subjects with pacemakers.

Setup

Hardware

1. Plug the **BSLSTM Trigger** cable into the *Analog Out* port on the back of the MP30 unit
2. Plug the **BSLSTM Reference Output** cable into CH1 on the front of the MP30 unit.



BSLSTM Trigger cable connection

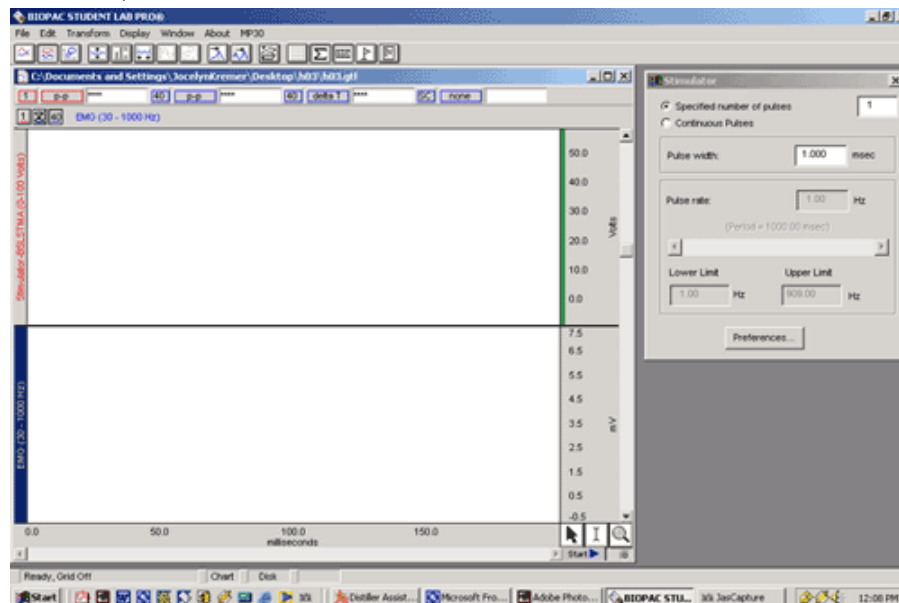


BSLSTM Reference cable, SS2L lead and HSTM01 stimulating probe connections

3. Plug the **SS2L electrode lead** into CH2 on the front of the MP30 Unit.
4. Turn on the MP30 unit.
5. Turn on the BSLSTM stimulating unit.
6. Set the BSLSTM Level to "0" and the Range to "0-100V"
 - o Turn the **Level** knob counterclockwise until it stops and turn the key to the left to set the **Range** at "100V."
 - o If using older model stimulators without digital display, [click here for setting details](#).
7. Plug the **HSTM01 human stimulator probe** into the *Stimulus Output* port on the front of the BSLSTM Unit.

Software

1. Turn on the computer.
2. Launch the BSL PRO software on the host computer.
 - The program should create a new "Untitled1" window
3. Open the Nerve Conduction Velocity template by choosing **File menu > Open > choose Files of type: GraphTemplate (*.GTL) > File Name: h03.gtl**. Note that this template opens a data acquisition window and the Stimulator control window, as shown below.



BSL PRO software screens when the Nerve Conduction Template (h03.gtl) is opened

Subject — Electrode Connections**Hints for minimizing measurement error:**

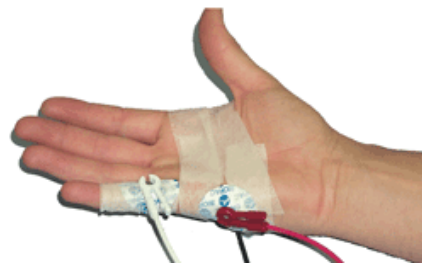
1. Abrade the skin with an ELPAD before placing electrodes.
2. Apply a small drop of electrode gel (GEL1) to each electrode, even if it is pre-gelled.
3. Begin with a low voltage, find the best position for stimulation of the nerve, then increase the voltage to a supra-maximal level.
4. Clip the SS2L to relieve cable strain and avoid pulling on the electrodes.
5. Keep the stimulus and recording leads and cable separated to minimize electrical interference.
6. If the arm is cold with respect to ambient temperature, it should be warmed to ambient temperature prior to recording.

1. Place **three EL503 disposable recording electrodes** on the subject's hand as follows:

Type	Lead	Position
Ground	Black	Center of dorsal right hand
Active	Red	Midway between distal wrist crease and base of 5th digit; at the junction between palmar and dorsal skin of right hand
Reference	White	On 5th digit

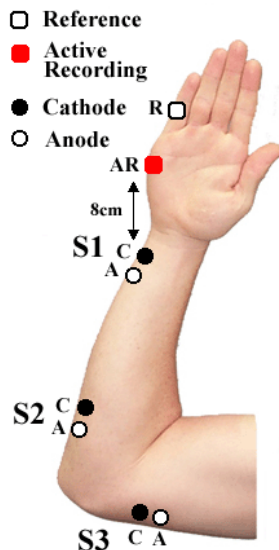


Ground (black) Lead



Active (red) and Reference (white) Leads

2. Attach the **SS2L electrode leads** by color, according to the chart above.
 - These are the recording electrodes, which will pick up the responses to the initial stimulus after they are propagated along the ulnar nerve. The polarity is important so that you get two easily measured positive peaks.
3. Locate three positions for the stimulating electrodes; measurements should be made with the elbow flexed 70 degrees.



Position	Cathode (black tip)	Anode (white tip)
S1	8 cm proximal to Active electrode, just radial to the flexor carpi ulnaris tendon	proximal
S2	4 cm distal to the medial epicondyle	proximal
S3	10 cm proximal to S2, measured in a curve behind the medial epicondyle and volar to the triceps muscle	proximal

4. Smear some electrode gel around the stimulation points.

Calibration

The MP30 needs to be calibrated with the "Reference Output" signal of the stimulator to ensure the baseline reading is 0 V.

1. Make sure the stimulator is not running (pulse light on front of stimulator NOT ON or blinking).
2. Click the mouse in the Vertical scale region of Channel 1 to generate the Vertical Scale window.
3. Click the "Scaling..." button to generate the "Change Scaling Parameters" dialog.

The template values should be as follows:

Input Value 0 mV maps to **Scale Value** of 0 Volts

Input Value 50 mV maps to **Scale Value** of 100 Volts

4. Click on the Cal1 button. The Cal1 Input Value will reflect the actual reading on Channel 1.
5. Determine the Cal2 Input Value: **Cal2 Input Value = Cal1 Input Value + 50.**
 - For example, if Cal1 Input value = .23 mV, then Cal2 Input value = .23 mV + 50 mV = 50.23 mV, so you would type "50.23" in the Cal2 Input value box.
6. Type the Cal2 Input value in the Cal2 Input value box and click OK.

Running the Experiments:**Note**

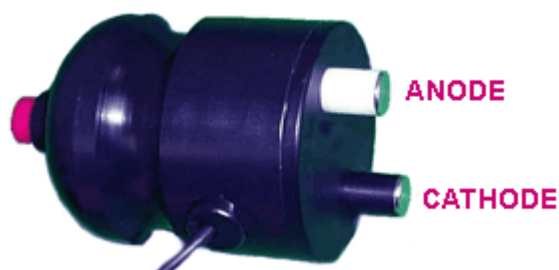
This recording is set up for the Append mode, so when the acquisition is stopped and then re-started, data will be added onto the previous data. A marker will automatically be inserted with a time stamp to indicate the new segment start time.

To save recorded data, choose File menu > Save As... > file type: BSL PRO files (*.ACQ) File name: (Enter Name) > Save button

To erase all recorded data (make sure you have saved it first), and begin from Time 0, choose:

MP30 menu > Setup Acquisition > Click on "Reset" button

1. Hold the HSTM01 stimulating probe at [position S3](#), noting the Cathode and Anode probe placement, and depress and hold the red button down for stimulation to occur.

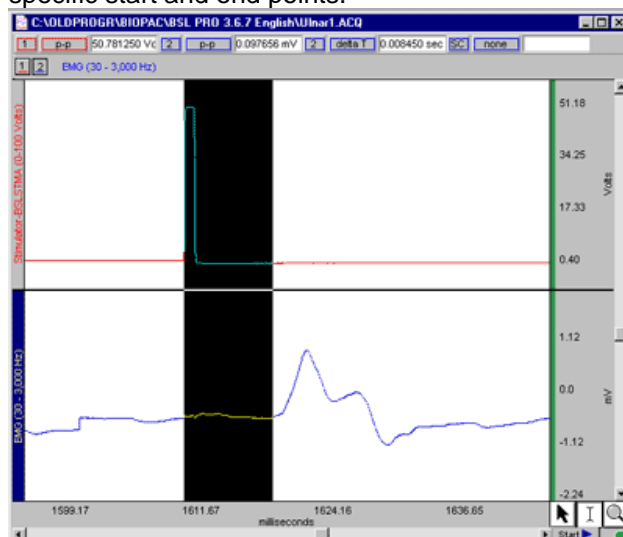


2. Click the **Start** button in the PRO software window (this will begin stimulation and 200 msec data acquisition).
3. Increase the Level setting on the BSLSTM unit to 5 V.

4. Find the best position over the nerve.
 - a. Repeat steps 2-3, increasing the stimulus Level in 5 V increments to obtain a response at the recording electrodes.
 - A response may be indicated by involuntary twitching of the fingers.
 - A response typically occurs somewhere between a stimulus Level of 25 V to 40 V.
 - The response may have one or two upward peaks followed by a downward deflection.
 - Note the stimulus level at which a response first occurred; this is the "**Threshold**" level: _____ Volts
 - Move the probe around a little if no response occurs.
 - There may or may not be a large artifact coinciding with the stimulus pulse; sometimes moving the ground slightly can reduce the artifact amplitude.
 - If the subject experiences pain with the finger twitch, and a response has not been detected, move the stimulating probe to a new position. A response should be detected well before the subject experiences any pain.
 - If the signal appears to be clipped (top of the waveform squared off), the Gain setting in the *PRO* Software may be too high. Reduce the Gain setting by 1 level and repeat the recording.
 - b. Move the probe to maximize the response (increased amplitude on the response waveform) and identify the best position over the nerve.
5. Increase the stimulus to a Supra-Maximal Level.
 - a. Increase the stimulator Level until a maximal EMG response is obtained at that position.
 - Maximal means that further increases in the stimulation Level do not produce a corresponding increase in the response amplitude.
 - Note the stimulus level at which the maximal response occurred; this is the "Maximal" level: _____ Volts
 - b. Further increase the stimulus Level to "**Supra-maximal**" level (approximately 5V over Maximal): _____ Volts
6. Mark the position of the Cathode probe tip and label it with the position name (S3, S2, S1).
7. The Subject can release the red stimulating button and reposition the stimulating probe at [position S2](#).
8. Decrease the stimulus level to half the supra-maximal level.
9. Repeat Steps 4-6, holding down the red button on the HSTM01 to allow stimulation.
10. The Subject can release the red stimulating button and reposition the stimulating probe at [position S1](#).
11. Decrease the stimulus level to half the supra-maximal level.
12. Repeat Steps 4-6.
13. The Subject can release the red stimulating button and disconnect the SS2L leads.

Analysis

1. Measure the **delta T** in seconds from the start of stimulus to the start of the response waveform for each segment and note the value.
 - This is a **relative measurement**, so measurement consistency across segments is more important than specific start and end points.



S1 = _____ **sec delta T** from Stimulus to Response

S2 = _____ **sec delta T** from Stimulus to Response

S3 = _____ **sec delta T** from Stimulus to Response

2. Measure the **distance in cm** from the Active electrode to the marked position of the cathode tip for each site and note the values.

S1 = _____ **cm** from Active to Cathode

S2 = _____ **cm** from Active to Cathode

S3 = _____ **cm** from Active Cathode

3. Calculate conduction velocity

- Realize that the time from stimulation of the nerve to the EMG response includes not only nerve conduction, but also all the events that occur at the neuromuscular junction (release of neurotransmitter, binding to receptors, end-plate potentials, etc.) However, if you subtract the delta T for S1 from the delta T for S2, it reflects only the time required for conduction of action potentials from position S2 to S1. This distance between S2 and S1 divided by this time equals conduction velocity.

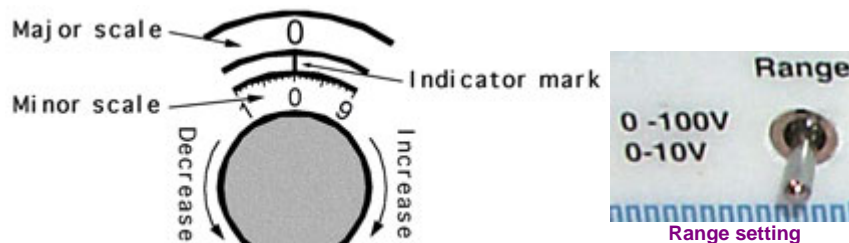
Conduction Velocity = (Distance between S2 and S1) / (delta T for S2 - delta T for S1)

- Nerve conduction velocity (m/sec) mean value is 61 m/sec
Source: Manual of Nerve Conduction Studies, Ralph M. Buschbacher, M.D., Demos Medical Publishing, ©2000.
- a. Calculate Conduction Velocity for the S2-S1 segment: _____ cm/sec
- b. Calculate Conduction Velocity for the S3-S2 segment: _____ cm/sec
- c. Convert the results to **m/sec** (multiply by 0.01 m/cm):
 - S2-S1 segment: _____ m/sec
 - S3-S2 segment: _____ m/sec

Appendix

STIMULATOR SETTINGS

On older, manual dial BSLSTM models, adjust the **Level** to "0" and the **Range** to "0-100V" as shown below:



Level setting on older BSLSTM models

GRAPH TEMPLATE SETTINGS

Click here to open a [PDF of the graph template file](#) settings. The BSL PRO Graph Template file automatically establishes the settings shown in the table.