ADInstruments

Application Note

Human Sensory Nerve Conduction

This note discusses the use of the PowerLab system to record averaged sensory nerve action potentials (SNAPs) and to measure conduction velocity, in experiments suitable for courses in physiology and clinical neurophysiology.

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Introduction

The technique of averaging is important in many branches of experimental physiology. It is a method for improving the signal-to-noise ratio, and thus allows detection and measurement of responses that are individually too small to be reliably distinguished from noise and interference. A good introduction to averaging is provided by sensory nerve conduction studies, in which surface electrodes are used to record action potentials whose amplitude is only a few tens of microvolts.

Students of health sciences should become acquainted with the principles of electrodiagnosis and transcutaneous electrical nerve stimulation (TENS). The experiments on sensory nerve conduction described here serve to illustrate both.

Evoked responses can be recorded with surface electrodes from most superficial nerves in the body. For detailed descriptions and diagrams see Kimura (1989); Sethi and Thompson (1989); Robinson and Snyder-Macklin (1995); Dumitru (1995). The median nerve is especially suitable for student lab classes. Responses to stimuli at the wrist or elbow are easily recorded from the middle finger (Figure 1). These responses are conducted in the reverse (antidromic) direction.

Equipment needed

Any PowerLab unit with Scope software is suitable for recording the data. In addition you will need:

- ML132 Bio Amp and MLA1340 Bio Amp cable
- MLA1092 Abrasive pad
- MLA1090 Electrode cream
- MLA DDB-30 Bar Recording Electrode
- MLT YDG Dry Earth Strap
- ML180 Stimulus Isolator
- MLA DDF-30 Bar Stimulus Electrode
- Adhesive tape

MLA WBT-9 EEG/EMG Recording Electrodes may be used in place of the Bar Recording Electrode and Dry Earth Strap.

Connections

To minimise electrical interference, the subject should sit well away from from power cables and the computer monitor. The stimulus and recording leads should be kept apart to minimise stimulus artefacts.

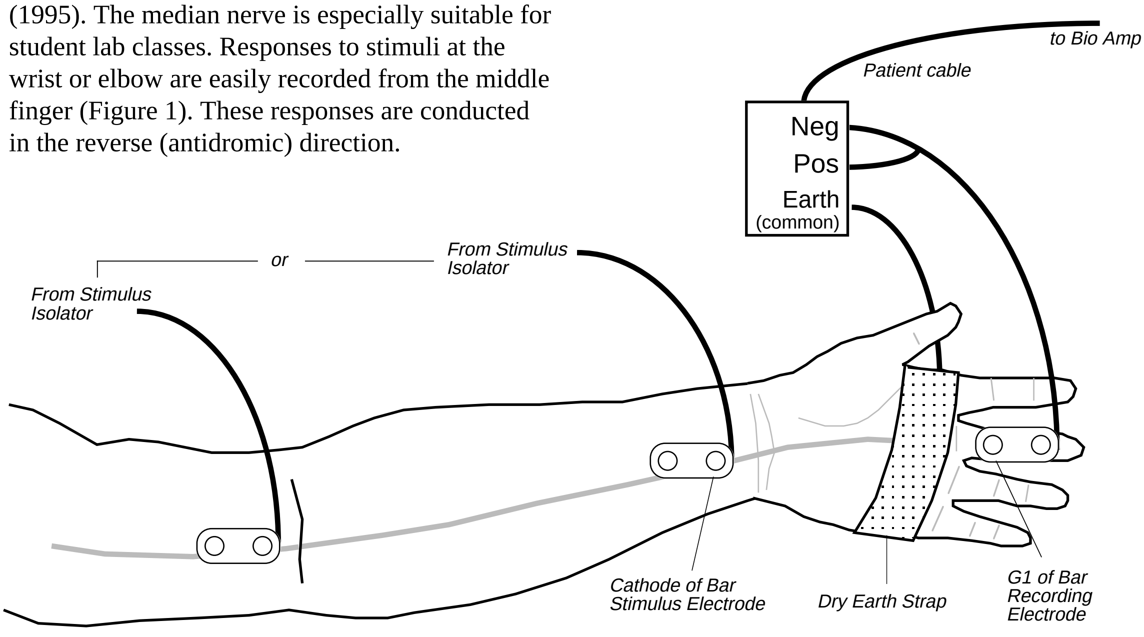

Figure 1. Connections for antidromic conduction studies of the median nerve. Two alternative positions are shown for the stimulus electrodes.

Life Science

Recording electrodes

The Bar Recording Electrode is attached to the palmar aspect of the middle finger. Before placement, the skin under each electrode pad should be lightly abraded to reduce its electrical resistance. A small amount of electrode cream is put in the concave side of each electrode pad. The bar should then be held firmly in place with adhesive tape. The Bio Amp records the potential difference between two electrodes, conventionally designated as G1 (or *active*) and G2 (or *reference*). If the proximal (G1 electrode) is connected to the Bio Amp's Neg input, the settings shown in Figure 2 give the usual polarity convention: a negative-going signal at G1 is displayed as an upwards deflection in Scope.

A third (*ground, common,* or *indifferent*) electrode is required to reduce electrical interference from the stimulus wires and from sources such as power cables. A Dry Earth Strap attached firmly around the middle part of the hand is convenient for this purpose. It may, however, be replaced by an EEG/EMG recording electrode attached to the hand. In this case, skin abrasion and application of electrode cream are recommended to ensure a low-resistance connection.

Stimulus electrodes

A very small amount of electrode cream should be applied to the two metal pads of the Bar Stimulus Electrode. No preparation of the skin is normally required, other than wiping away any excess electrode cream to prevent short-circuiting of the stimulus along the skin surface. Stimulation takes place at the cathode. In antidromic sensory nerve conduction studies, the Bar Stimulus Electrode should be oriented in such a way that the cathode (negative electrode, connected to the black terminal of the Stimulus Isolator) is distal to the anode.

At the wrist, the cathode should be placed over (or just medial to) the tendon of Flexor carpi radialis, which overlies the median nerve. The Bar Electrode can either be taped in place or held manually.

For stimulation at the elbow, the cathode should be placed medial to the biceps tendon, at the place where Korotkoff sounds in the brachial artery are commonly auscultated. The elbow should be extended and the Bar Electrode should be held in place manually. Moderate pressure exerted on the Bar Electrode helps to bring the cathode close to the median nerve. With correct placement and stimulus strength there will be noticeable contraction of the forearm muscles at each pulse.

Safety

The Bio Amp and Stimulus Isolator are specially designed to have no direct electrical connection to ground. This means that they cannot become sources of potentially fatal currents, even under fault conditions. To maintain this body-protection (BF standard), never connect the subject directly to the PowerLab hardware unit itself or to any other grounded equipment. The Bio Amp is supplied with an approved Bio Amp cable and leads, and should not be used with any other leads or connectors.

PowerLab settings

Recommended setting for the Bio Amp and stimulator are shown in Figures 2 and 3. Scope's sampling setup should be as shown in Figure 4. The time base parameters Samples and Time should initially be as shown in Figure 5.

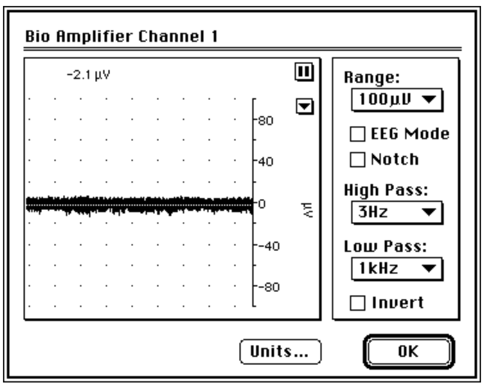

Figure 2. Suggested Bio Amp settings for sensory nerve conduction studies. If there is interference at the mains frequency, exceeding 20 µV or so in amplitude, it may be minimised by turning on the Notch filter.

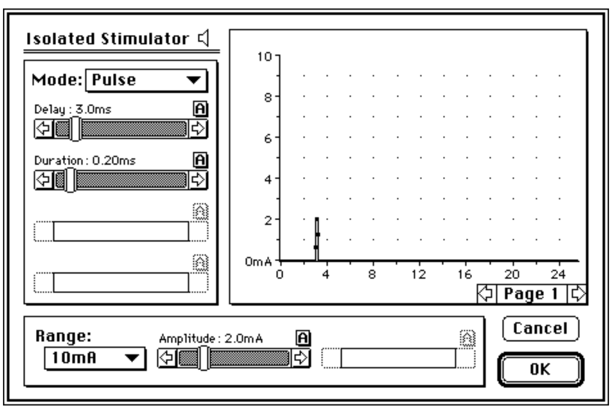

Figure 3. Initial settings for Isolated Stimulator. The amplitude should be increased in 1 or 2 mA steps during trial sweeps.

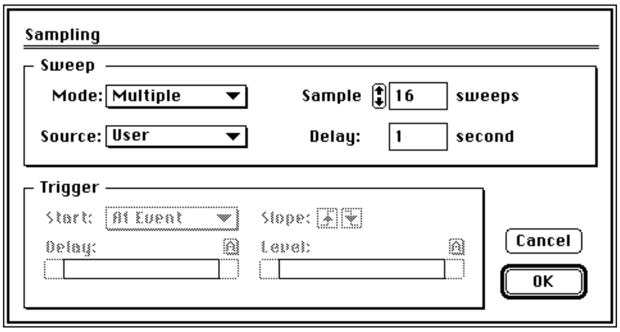

Figure 4. Dialog box presented after selection of the ‘Sampling…’ command from Scope’s Setup menu. With the settings shown, each time Scope’s Start button is clicked, 16 sweeps will be recorded, each as a separate page of the Scope file.

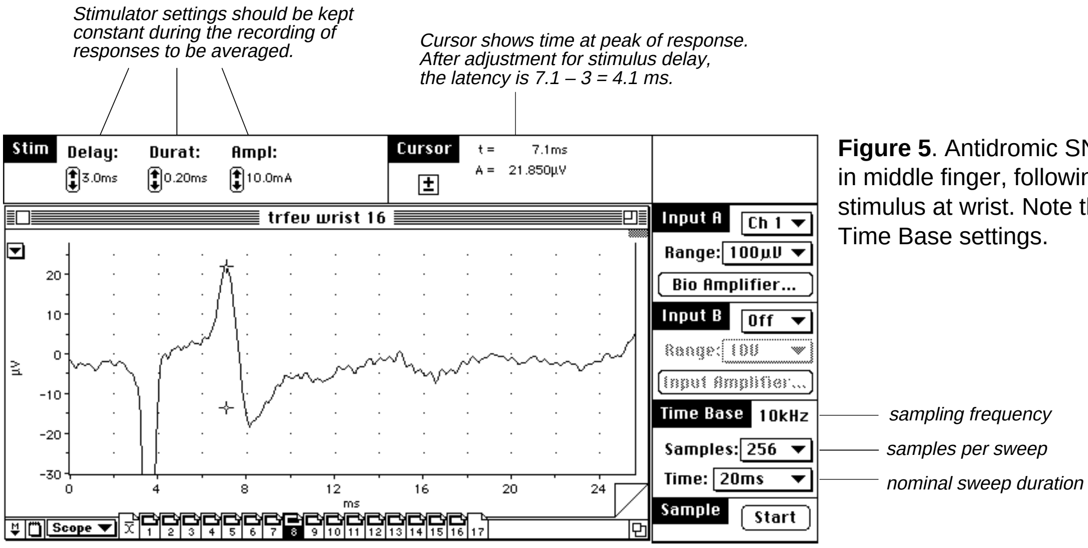

Figure 5. Antidromic SNAP in middle finger, following stimulus at wrist. Note the Time Base settings.

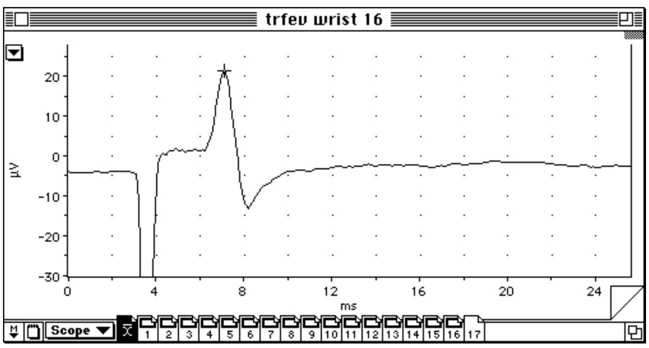

Figure 6. Average of 16 SNAPs from middle finger, with stimuli to median nerve at wrist. The Mean Page displays the average of all sweeps.

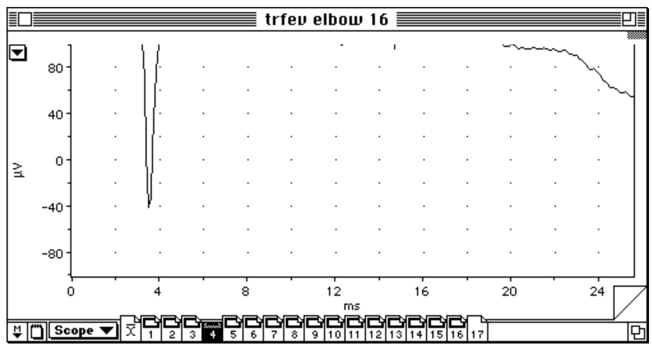

Figure 7. An unsatisfactory sweep. Some artefact has caused the input voltage to exceed the Bio Amp’s range setting (±100 µV). The sweep has been excluded from averaging, by hiding it from the overlay (note the shorter icon for Page 4).

Results

With maximal stimulation, the compound sensory nerve action potential (SNAP) is clearly recognisable even in single sweeps without averaging (Figure 5). It is however, contaminated by noise and interference at the mains frequency.

A substantial improvement in signal-to-noise ratio is evident when even a modest number of responses (8–16) is averaged (Figure 6). Scope’s sweeps are not synchronised with the mains frequency (50 or 60 Hz); interference therefore averages to zero.

Editing the ensemble

The Page buttons can be used to view each page in turn and include or exclude it from the ensemble (Overlay) to be averaged (Figure 7). To exclude a

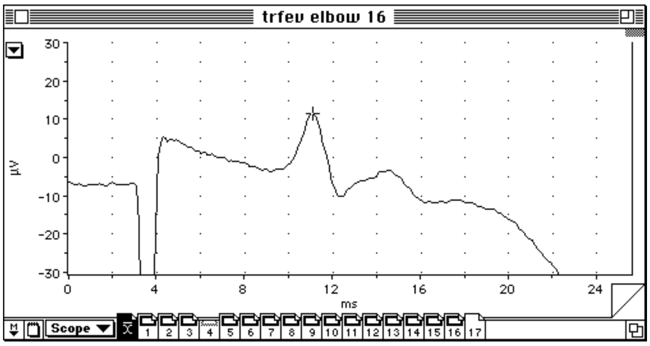

Figure 8. Averaged SNAP from middle finger, with stimuli to median nerve at elbow. The latency from stimulus to peak response is 8.1 ms. Movement artefact is evident towards the end of the sweep.

page, press its button to pop up a menu, and choose Hide from Overlay (note that the icon becomes shorter). Command-click or double-click a Page button to toggle between inclusion and exclusion.

Conduction velocity

Comparison of the latencies of responses evoked by stimuli at different places along the nerve allows the conduction velocity of the fastest sensory fibres to be determined.

$$V = \frac{\text{distance between stimulation sites}}{\text{difference between latencies}}$$

In sensory nerve studies, the latency is commonly taken as the time from stimulus to peak response, since the onset of the response is often poorly defined. For the traces in Figures 6 and 8, the cathodes at the two stimulus sites were 240 mm apart, and the latency difference was 4 ms. The calculated conduction velocity is therefore 60 m/s.

Alternative averaging method

Scope offers an alternative method for averaging (Figure 9). The advantage of this alternative method is that many more sweeps can be averaged (up to 2048). A disadvantage is that the ensemble to be averaged cannot be edited, since the original sweeps are not recorded.

Orthodromic conduction

Responses conducted in the normal (orthodromic) direction can be recorded if the stimulus and recording positions are interchanged. The electrode connections should also be reversed so that the stimulus cathode is proximal to the anode, and G1 is distal to G2.

Orthodromic responses are smaller than the antidromic counterpart, and stimulus artefacts are more intrusive. It may be necessary to average a larger number of sweeps (64 or 128). Care should be taken that the Dry Earth Strap is firmly fastened.

References

1. J. Kimura, *Electrodiagnosis in Diseases of Nerve and Muscle*, second edition (F.A. Davis Co., Philadelphia, 1989).
2. R.K. Sethi and L.L. Thompson, *The Electromyographer's Handbook*, second edition (Little, Brown, and Co., Boston, 1989).
3. A.J. Robinson and L. Snyder-Macklin, *Clinical Electrophysiology: Electrotherapy and Electrophysiologic Testing*, second edition, (Williams and Wilkins, Baltimore, 1995).
4. D. Dumitru, *Electrodiagnostic Medicine*, (Hanley and Belfus, Philadelphia, 1995).

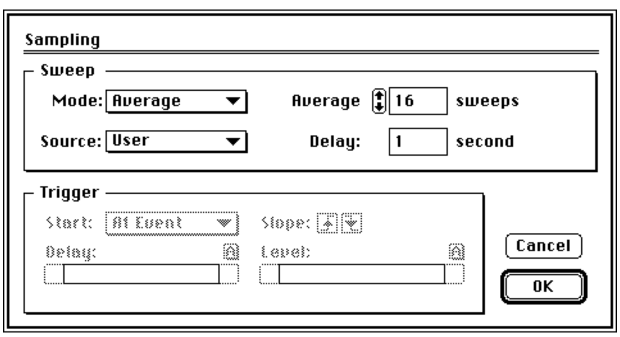

Figure 9. Alternative method for averaging. With the settings shown, 16 sweeps would be averaged each time Scope's Start button is clicked, and returned as a single page of the Scope file.