A CASE OF DETERMINING NERVE ACTION POTENTIALS AND CONDUCTION VELOCITY IN A FROG

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ABSTRACT

Nerve action potentials and conduction velocity have been reported by utilizing several experiment procedures and mentioned in many physiology and exercise physiology textbooks. Although nerve action potentials and conduction velocity are a little complicated, some procedures to determine them can be simple. The purpose of this study is to show one of the simple ways of the experiment procedures to obtain nerve action potentials and conduction velocity.

A frog was killed by cutting off the upper jaw and anterior skull. The trunk and one hind leg were skinned. After the skin was removed from one leg, the right sciatic nerve of the frog was exposed and used. The intact sciatic nerve was picked up by the threads attached and the nerve was laid across the electrode wires of the nerve chamber. The stimulator, the oscilloscope and the physiograph were used in this study. Starting with a minimum voltage of long duration, chronaxie time was obtained. By using pick-up electrodes in different spaces, action potentials were gained. By stimulating the nerve with the constant voltage of

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various durations, absolute and relative refractory periods were acquired. After the nerve was damaged, the monophasic action potential was observed.

INTRODUCTION

Nerve action potentials and conduction velocity have been reported by utilizing several experiment procedures and mentioned in many physiology and exercise physiology textbooks. Action potential is known as the momentary difference in electrical potential between active and resting parts of a nerve fiber found when the two parts are connected with a sensitive galvanometer.[7)] On the other hand, conduction velocity is known as velocity of a transmitted electrical potential along a conductor.[5)] Although nerve action potentials and conduction velocity are a little complicated, some procedures to determine them can be simple.

The purpose of this study is to show one of the simple experiment procedures to obtain nerve action potentials and conduction velocity.

MATERIALS AND METHODS

A frog was killed by cutting off the upper jaw and anterior skull. The trunk and one hind leg were skinned. After the skin was removed from one leg, the right sciatic nerve of a frog was exposed. The moistened thread was carefully passed around the uppermost region of the sciatic nerve. A loose knot was tied to fasten the thread around the nerve. The nerve was cut above the ligature. The maximum possible length of the sciatic nerve was used. The intact sciatic nerve was picked up by the threads attached and the nerve was laid across the electrode wires of the nerve chamber. A saline solution was left in the bottom of the chamber to saturate the atmosphere of the chamber, keeping the nerve moist.

The stimulator, the oscilloscope and the physiograph were set as Fig. 1. The vertical spike was obtained after the nerve was

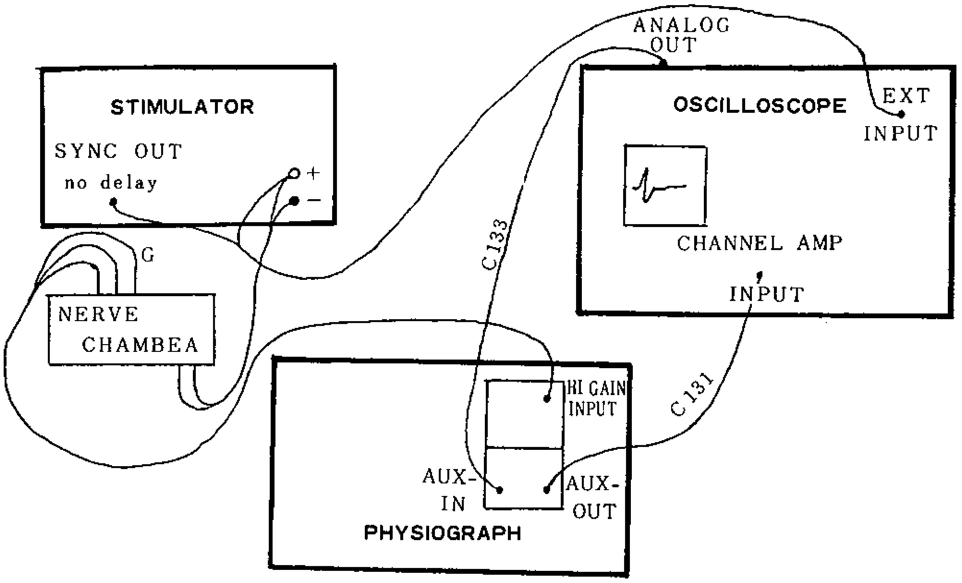

Fig. 1. Connections for nerve action potential recording

stimulated with the duration of the stimulator set at 0.2 msec. Starting with a minimum voltage (0.09 v) and a long duration (0.200 msec), chronaxie time was obtained. By using pick-up electrodes in different spaces (short and long positions), action potentials were gained. By measuring the distance between artifact and action potential, the speed of conduction was determined. By stimulating the nerve with constant voltage of various durations (long delay and twin pulse), absolute and relative refractory periods were acquired. After the nerve was damaged, the monophasic action potential was observed.

The stimulator was set as follows: 0.2 volts (voltage of intensity: vertical deflection), 0.12 msec (duration: horizontal deflection), variable delay, variable frequency and B 1 (output). The oscilloscope was set as follows: trig (trigger mode), external (source), x 2 (sweep), 40 - 10 ms/cm x 10 (sweep speed), 0.1 v/in (sensitivity) and DC portion (channel amplitude). The physiograph was set as follows: 3.2 x 10 (gain: high gain coupler), 10 k (filter on 7070 amplifier) and 500 mv/cm (sensitivity 7070). The following three electrodes for nerve chamber were set: pick-up electrode, stimulator electrode and ground electrode.

All of the experiments in this study were conducted for an Advanced Physiology class in Department of Physiology, School of Zoology at Brigham Young University on January 30, 1979.

RESULT

The experiment was begun with the lowest voltage possible held for long duration. With mode on repeat, gradually increased voltage and potential of desired amplitude were obtained. That was repeated with decreased duration. The result is shown at Table 1 and graphed at Fig. 2.

With stimulating voltage and duration for optimal display and repeat stimulation, time delay between stimulus and peak of action potential was determined. Stimulus was repeated but with pickup electrodes a known distance from the previous setting, i. e. 1 cm further away from stimulating electrodes. The speed of conduction was 0.7 msec/cm converted to 14.29 meters/sec. These results are

Table 1. Various intensities (voltage) and duration (msec) to elicit the action potential

Intensities (voltage)	Duration (msec)	Intensities (voltage)	Duration (msec)
0.09	0.200	0.34	0.056
0.14	0.155	0.36	0.052
0.16	0.128	0.38	0.048
0.18	0.119	0.40	0.046
0.20	0.099	0.42	0.041
0.22	0.086	0.44	0.040
0.24	0.081	0.46	0.039
0.26	0.074	0.48	0.036
0.28	0.068	0.50	0.036
0.30	0.061	0.60	0.024
0.32	0.059	0.70	0.020

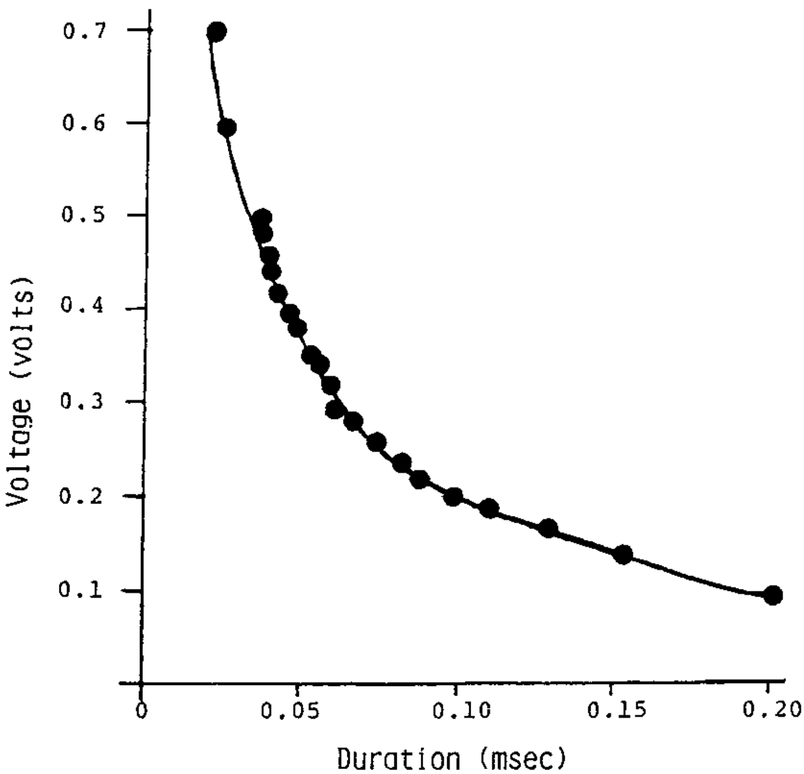

Fig. 2. Excitability of a frog sciatic nerve - various intensities (voltage) and duration (msec) to elicit the action potential

shown at Figs. 3 and 4.

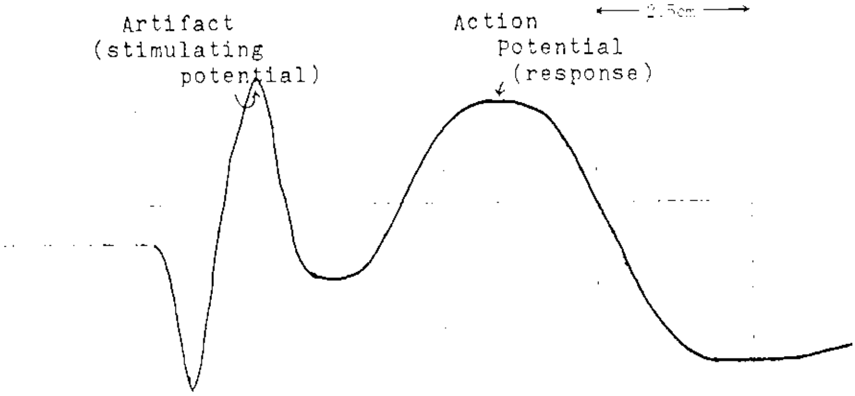

Fig. 3. Speed of conduction - short pickup spacing (paper speed: 1 msec/cm)

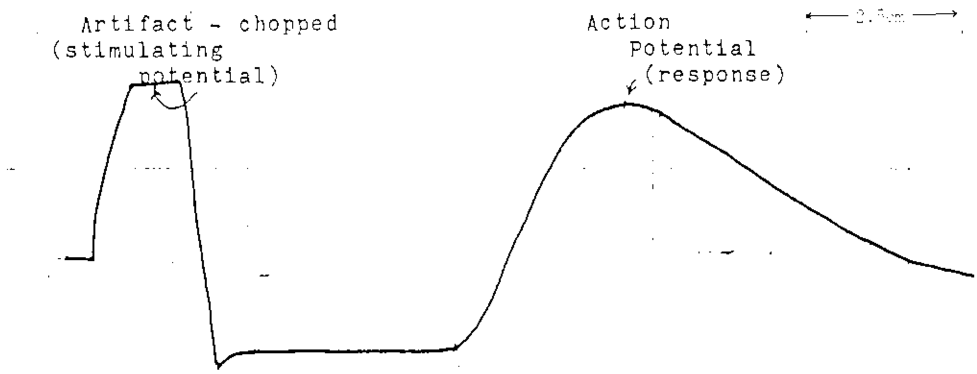

Fig. 4. Speed of conduction - long pickup spacing (paper speed: 1 msec/cm)

Stimulation was conducted without changing the settings for the above set stimulus selector at twin pulse and delay at long period. Stimulation was conducted and delay while observing for alteration of action potential was gradually decreased. The absolute and the relative refractory periods were 0.92 msec and 4.5 msec, respectively. The refractory periods are shown at Fig. 5.

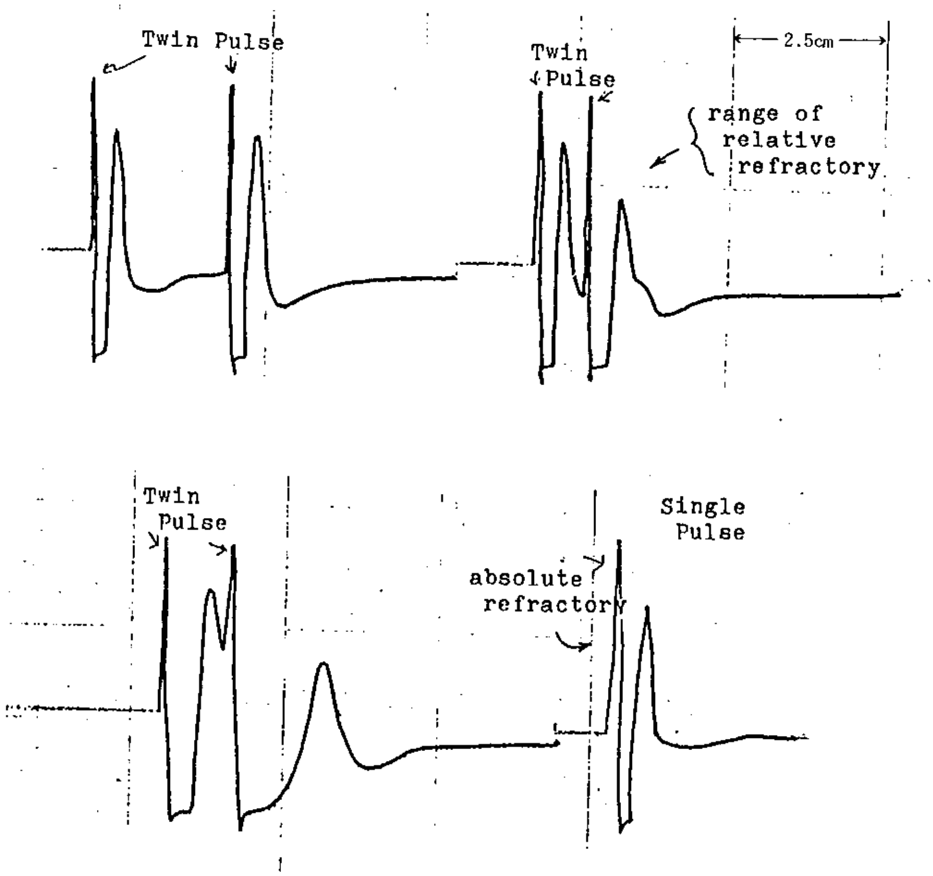

Fig. 5. Absolute and relative refractory periods

The nerve on distal pickup electrode was damaged. The monophasic action is shown at Fig. 6.

DISCUSSION

According to Fig. 2, there was an inverse relationship (inverse proportion) between intensity and duration. Therefore, the lower the chronaxie time, the more sensitive the nerve. This

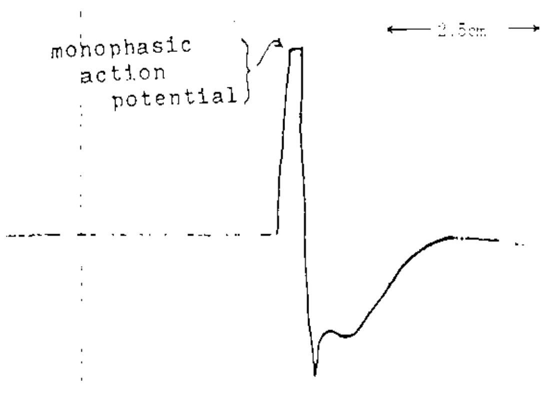

Fig. 6. Monophasic action potential

chronaxie is often used as a means of expressing relative excitabilities of different excitable tissue.[2] There is a book [3] which indicates that chronaxie is usually 0.3 m/sec for sciatic nerve of a frog. The difference between the indication and a result in this study should be investigated further to clarify.

According to Figs. 3 and 4, the speed of conduction was 0.7 msec/cm converted to 14.29 meters/sec. That the velocity of the nerve impulse varies in different nerve fibers in accordance with their diameters, the thicker fibers conducting more rapidly than the fibers of smaller diameter is well known as Schwartz [6] indicated. That nonmedullated fibers conduct more slowly than medullated fibers was reported, and some of the fibers subserving pain sensation and those of the sympathetic nervous system have a very slow conduction rate was also reported.[6]

As seen in Fig. 5, the absolute and the relative refractory periods were 0.92 msec and 4.5 msec, respectively. That following the absolute refractory period is a relative refractory period lasting about one quarter as long, and during this period, stronger than normal stimuli are required to excite the fiber is known.[4] It should be noted, however, that in some types of fibers, a short period of supernormal excitability follows the relative refractory period.[4] Regarding absolute refractory period, Åstrand and

Rodahl [1] mentioned that apparently, for a new Na+ flux to occur as a consequence of a nerve stimulation, the potential must become more negative than about 50 mv. It should be noted that the maximal frequency by which a nerve can send its message depends on the time of the absolute refractory period.[1]

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