Differences in Action Potentials and Accommodation of Sensory and Motor Myelinated Nerve Fibres as Computed on the Basis of Voltage Clamp Data*

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Summary. 1. Voltage clamp experiments were performed on sensory and motor nerve fibres of the frog using a digital computer for automatic experiment control and data recording.

2. Rates of rise and maximum amplitudes of potassium currents were determined in both sensory and motor fibres, so that comparative values of \( n_{\infty} \) and \( \tau_n \) could be obtained.

3. The results indicate that the \( n_{\infty}-V \) curve for sensory fibres is displaced from the curve for motor fibres in a depolarising direction. The potassium kinetics are similar in both for voltage steps up to about \(-20\) mV, beyond which \( \tau_n \) becomes progressively smaller for sensory than for motor fibres.

4. These comparative values of \( n_{\infty} \) and \( \tau_n \) have been used to calculate \( \alpha_n \) and \( \beta_n \) values for a model "motor" action potential by considering the Frankenhaeuser-Huxley computed action potential to be "sensory". This modification of the potassium system, together with some alteration to the sodium inactivation system produces a satisfactory model "motor" action potential.

5. The model sensory and motor action potentials behave quite similarly to their experimentally recorded counterparts with respect to action potential shape and relative duration, repetitive firing, accommodation and the simulated action of T.E.A.

Key words: Sensory Nerve — Motor Nerve — Voltage Clamp — Action Potential Simulation.

In 1964, Schmidt and Stämpfli first demonstrated differences between sensory and motor myelinated nerve fibres from *Rana esculenta*, with respect to action potential (A.P.) shape and duration, accommodation, and the action of tetraethylammonium (T.E.A.).

The effects of T.E.A. on various properties of the node of Ranvier have since been studied in more detail (Bergman and Stämpfli, 1966; Schmidt and Stämpfli, 1966; Hille, 1967; Koppenhöfer, 1967; Bergman,

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et al., 1968; Koppenhöfer and Vogel, 1969; Armstrong and Hille, 1972). From this work there is general agreement that externally applied T.E.A. (5 mM) reduces potassium permeability almost to zero and that this is mainly responsible for the prolongation of the action potential observed in the presence of T.E.A.


Some aspects of delayed current effects on A.P. shape and duration can be deduced from the computations for the *Xenopus laevis* mathematical model of Frankenhaeuser and Huxley (1964). Their computation of the effect of simultaneously reducing "K" and "P" permeabilities to zero, with its relatively small increase in A.P. duration, does not satisfactorily imitate the action of T.E.A. on typical *Rana esculenta* fibres. Schmidt and Stämpfli (1966) suggest that species differences or the possibility that "K" and "P" permeabilities are not both reduced to zero by T.E.A. may account for the inconsistencies.

With respect to accommodation, Schmidt and Stämpfli (1964), Vallbo (1964a), Frankenhaeuser and Vallbo (1965), Bergman and Stämpfli (1966), and Honerjäger (1968) have shown that motor fibres accommodate considerably more rapidly than sensory fibres and that perhaps associated with this, sensory fibres commonly fire a train of A.P.s in response to a maintained stimulus, whereas motor fibres seldom fire more than 1 or 2 sequential A.P.s under the same conditions.

Frankenhaeuser and Vallbo (1965) show that increasing the rate and amount of sodium inactivation in their A.P. model by moving the \( \alpha_k \cdot V \) curve along the voltage axis in a hyperpolarising direction can significantly increase the rate of accommodation. Vallbo (1964b) had previously demonstrated a correlation between the \( \alpha_k \cdot V \) shift and rate of accommodation in unspecified fibres from *Xenopus laevis*. Bergman and Stämpfli (1966), however, indicate that potassium permeability at threshold is also of importance in determining the rate of accommodation.

The differences in A.P. shape between motor and sensory nerve fibres of *Rana esculenta*, as exemplified also by plots of \( \frac{dV}{dt} \) against time (Schmidt and Stämpfli, 1964) have until now, lacked any explanation. In the present paper we consider the effects on computed A.P. properties, of modifications to certain parameters as determined from voltage clamp experiments in the hope that this may increase our understanding of the basis for these various differences between sensory and motor fibres.