Direct Evidence for Recurrent Inhibition in Sliced Brain Preparation of the Cat's Visual Cortex

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KATO, H., ITO, S. and OGAWA, T. Direct Evidence for Recurrent Inhibition in Sliced Brain Preparation of the Cat's Visual Cortex. Tohoku J. exp. Med., 1979, 128 (2), 197–198 — To reveal the recurrent inhibitory circuit in the visual cortex, a depolarizing current was applied through a glass microelectrode to an impaled cell in an in vitro slice of the visual cortex obtained from a cat anesthetized with pentobarbital. The cell reported here produced inhibitory postsynaptic potentials (IPSPs) following single spikes or bursts of spikes which were elicited by intracellularly applied current. This observation indicates that IPSPs have been mediated by the recurrent inhibitory circuit via axon collaterals of the impaled cell. —— sliced brain preparation; visual cortex; recurrent inhibition; cat

It is generally accepted that recurrent inhibition plays an important role in the function of the spinal cord and also of the higher central nervous system (Eccles 1973). In the visual cortex, however, the direct evidence for recurrent inhibition is still lacking although Watanabe et al. (1966) and Hayashi (1969) have suggested it. The present experiments were undertaken to provide more convincing evidence for such an inhibitory mechanism in the cat's visual cortex using sliced brain preparations.

A small amount of brain tissue was excised from the posterior lateral gyrus of a cat anesthetized with pentobarbital (Nembutal 35 mg/kg, i.p.). The excised tissue was sliced manually at about 1 mm in thickness with a razor blade as shown in Fig. 1A. The slices were incubated for about 1 hr in a chamber filled with a medium (Schwartzkroin and Altschuler 1977) before electrophysiological recordings were made. At a recording session, a slice was transferred onto the bottom of an experimental chamber where it was fixed in place with stimulating electrodes and perfused with the well-oxygenated medium.

Stimulating and recording conditions are illustrated in Fig. 1B. A pair of needles(s) insulated except at the tip was inserted into the white matter (w) for electrical stimulation. Intracellular recordings were accomplished with a glass microelectrode(e) filled with 3M-KCl in the gray matter (g). A bridge circuit was used for passing current through the intracellular microelectrode.

Intracellularly recorded action potentials from a neuron situated in layer V are illustrated in Fig. 1B-a, which responded to stimulation of the white matter. With this neuron the following properties were obtained: the resting membrane potential -64 mV, spike amplitude 75 mV (overshoot 11 mV), the input resistance and the time constant of the neuronal membrane 10.3 M and 7.5 msec (the input capacitance 730 pF) respectively.

Passing a depolarizing current through the intracellular microelectrode caused a discharge of a spike in the same cell at 0.18 nA and also produced repetitive discharges at an increase in current strength (a to d in Fig. 1C). With a further increase in strength a
bursty pattern of spike discharges became marked as shown in Fig. 1D, where the initial portions of current-induced discharges are shown on an expanded scale.

Bursts consisting of two or three spikes were always followed by hyperpolarizing potentials ranging 10–30 msec in duration, as indicated by arrows, although single spikes were not always followed by such hyperpolarizations. These hyperpolarizations occurred with some delay ranging 3–15 msec following preceding spikes. Such features of the hyperpolarizations allow us to discriminate from an after-hyperpolarization associated with a spike. In this context, we consider that these hyperpolarizations are IPSPs which provide positive evidence for the presence of the recurrent inhibitory circuit via axon collaterals of the impaled cell.

Fig. 1. Schematic diagram for preparation of slices (A, B) and intracellular recording of a neuron (C, D). Membrane potential was depolarized to various extents by passing currents through intracellular microelectrode, the strength of which is numerically given at the right end of each tracing. Arrows indicate IPSPs occurring just after burst of spikes and asterisks after single spikes.

References