SYNAPTIC RESPONSES OF NEURONS IN THE PARIETAL ASSOCIATIVE CORTEX OF THE CAT TO STIMULATION OF THE RED NUCLEUS

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Acute experiments on anesthetized and immobilized cats using intracellular recording were used to study the responses of neurons in the parietal associative cortex to stimulation of the red nucleus. Efferent neurons of the parietal cortex were identified by antidromal activation on stimulation of the intrinsic nuclei of the pons and motor cortex. Oligo- and polysynaptic EPSP in response to stimulation of the red nucleus were seen. The results are discussed in the light of the morphological organization of the rubrothalamic and cerebellothalamocortical tracts.

Key words: parietal associative cortex, red nucleus, antidromal and synaptic activation of cortical neurons.

The component composition of corticorubral excitatory post-synaptic potentials (EPSP) has been investigated, and the specific importance of corticospinal and corticorubral neurons in these effects has been demonstrated [3]. Additionally, studies have been reported on the antidromal activation of cortical neurons by stimulation of the RN [2, 11].

Morphological data show that there are reciprocal connections between the RN and the cortex, via thalamic structures [4, 14]. Electrophysiological studies of this point would be of interest. We report here an analysis of synaptic potentials arising in neurons of the parietal associative cortex in response to stimulation of the RN.

METHODS

Experiments were carried out on adult cats weighing 2.5-3.5 kg, anesthetized with i.p. chloralose and sodium ethaminal (45 and 15 mg/kg respectively). Anesthesia was maintained using additional i.v. doses of sodium ethaminal. When necessary, animals were immobilized with ditilin or Flaxedil and were transferred to artificial ventilation. Intra- and extracellular recording of neuron activity was carried out in the anterior and medial suprasylvian and lateral gyri of the temporal associative cortex using glass micropipettes filled with 2.5 M potassium chloride, and with a resistance of 10-20 MΩ. Stimulating bipolar electrodes with an inter-tip distance of 0.3 mm and resistance of 10-20 kΩ were introduced at the stereotaxic coordinates of the ipsilateral RN. Similar electrodes were used for stimulation of the ipsilateral intrinsic nuclei of the pons and motor cortex for antidromal identification of efferent neurons of the parietal associative cortex. Stimulation was applied using square-wave stimuli lasting 0.1 sec at 0.4 mA. After experiments were completed, stimulation electrode tip positions were verified histologically. Other methodological details have been published previously [2].

RESULTS

A total of 481 neurons were recorded in the parietal associative cortex. Of these, 129 responded to stimulation of the RN by antidromal activation (76 neurons, 58.9%) [2] or synaptic stimulation (53 neurons, 41.0%). The latent period of
antidromal action potentials (AP) was 0.98-1.88 msec (1.32 ± 0.28 msec, n = 28). Many neurons showed both types of response, and as the stimulation intensity was increased, most cells initially produced orthodromal AP and then antidromal AP (Fig. 1).

Synaptic activation of neurons produced EPSP, which appeared with a latent period of 2.0-5.5 msec (3.23 ± 1.33 msec, n = 41) (Fig. 3, D); the characteristic depolarization rise time was 3.8-9.5 msec (5.28 ± 1.84 msec, n = 20) and the total duration was 3.6-38.5 msec (14.97 ± 7.94 msec, n = 17).

Some EPSP with short latent periods remained relatively constant when the RN was stimulated at different intensities. The time for depolarization to peak in these EPSP was also relatively constant (Fig. 2). These EPSP were regarded as being oligosynaptic. All other EPSP were regarded as polysynaptic on the basis of their longer latent periods and the variability in their other time characteristics (Fig. 4). When most of the neurons studied reached a critical level of depolarization, which was 3.8-10.5 mV (5.93 ± 3.97 mV, n = 21), they generated action potentials (Fig. 2, D; Fig. 3, C; Fig. 4, D).

In many neurons, EPSP were rendered more complex because of additional synaptic oscillations in both the ascending phase and during decay of depolarization (Fig. 3, A, B). These oscillations were reminiscent of dendritic spikes, which were first described in pyramidal neurons of the cat hippocampus [1] and in Purkinje cells of the alligator cerebellum [12].

Among parietal cortex neurons responding with synaptic potentials to stimulation of the RN, 37 cells (28.7%) were identified as efferent neurons, of which 26 neurons (70.3%) projected to the motor cortex (Fig. 2, E; Fig. 4, C) and 11 (29.7%) projected to the intrinsic nuclei of the pons (Fig. 2, F). This identification was made on the basis of their antidromal activation from the structures indicated.

DISCUSSION

The results obtained here provide evidence of the existence of ascending excitatory rubrocortical influences. There is reason to suggest that these influences are mediated by the involvement of the following two pathways. The first pathway