Intracellular recording was employed in experiments on rats with the nervous system intact and after acute pyramidotomy to study the postsynaptic effects produced in the lumbar motoneurons on stimulation of the nucleus ruber. Stimulation of this nucleus with single stimuli and with a short series of stimuli caused excitatory and inhibitory postsynaptic potentials (EPSP and IPSP) to develop in the motoneurons. Most of the EPSP recorded were disynaptic, but response development involved a monosynaptic segmental delay in five of the 124 cells that exhibited EPSP. A capacity for high-frequency potentiation was a characteristic feature of the disynaptic excitatory and inhibitory effects. Transmembrane polarization of the motoneurons had a marked influence on the amplitude of the disynaptic EPSP and IPSP. The properties of the disynaptic rubrospinal influences were similar to those described for the cat.

INTRODUCTION

The nucleus ruber and rubrospinal pathways of mammals have been investigated systematically in recent years. Data have been obtained on the structure and somatotopic organization of the nucleus, its afferent pathways, the course of the rubrospinal fibers, and the location of their endings [14, 15, 17-19, 21, 25]. Experiments on cats have shown that rubrospinal influences reach the motoneurons both through complex multisynaptic pathways [3, 4, 10, 11, 12, 14, 20] and through simple disynaptic and monosynaptic projections [2, 5, 6, 8, 11, 22].

The character of the rubrospinal projections on the alpha-motoneurons of other mammals has still not been studied. The present investigation was conducted to study rubrospinal synaptic effects on the lumbar motoneurons of the rat by the microelectrode technique.

METHOD

Our experiments were conducted with 27 male white rats weighing 330-470 g. Operative preparation was carried out under nembutal anesthesia (65 mg/kg administered intraperitoneally). During the experiment, the animals were immobilized with D-tubocurarine and their respiration was maintained artificially. The procedure was described in detail previously [1, 23].

The responses of the lumbar motoneurons were recorded intracellularly with glass microelectrodes filled with 0.6 M K$_2$SO$_4$; their resistance, measured in tissue, was 5-30 MΩ. Use of a bridge circuit [7] made it possible to effect transmembrane polarization simultaneously with the intracellular recording. The cells were identified as motoneurons from their antidromic response to stimulation of the anterior roots and classified as flexors or extensors from their responses to stimulation of the n.n. popliteus lateralis et medialis.

As was shown by extracellular recording of the electric field, there was no noticeable distortion of the intracellular responses by extracellular focal potentials. In parallel with the intracellular recording, we recorded the potential of the dorsal surface of the spinal cord with a unipolar silver ball electrode. Many tests were superimposed on the photographic records.
The nucleus ruber was stimulated with bipolar nichrome electrodes with a tip diameter of 80-100 μ and an interpolar distance of 0.2-0.4 mm. A unit of two such electrodes was usually assembled and implanted in accordance with the coordinates in the Fikova–Marsala atlas [9] in the rostral (AP 4.5, L 0.8, H 8.2) and caudal (AP 5.5, L 0.8, H 7.8) portions of the nucleus ruber (contralaterally). Figure 1A shows diagrams of sections of the rat brain stem cut at 1-mm intervals in the rostrocaudal direction and of the stimulation points. The current that evoked a minimal effect on application of paired stimuli is indicated. The stimulation points were checked histologically (Fig. 1B). Stimulation was conducted with square pulses lasting 0.1–0.3 msec. In order to preclude the possibility of incoming descending impulsion from the pyramidal tract, one animal was subjected to acute pyramidotomy. The effectiveness of the operation was checked histologically (Fig. 5C). The data obtained was processed with Student’s criterion.

RESULTS
Stimulation of the contralateral nucleus ruber with single pulses or series of two or three stimuli evoked postsynaptic potentials in 166 motoneurons. We observed EPSP in 124 of these and IPSP in 28; 14 neurons exhibited composite synaptic reactions. Eighteen motoneurons classified as flexors on the basis of their responses to stimulation of muscle nerves produced EPSP, two produced IPSP, and two yielded composite reactions. EPSP were observed in 44 extensor motoneurons, IPSP in 11, and composite responses in two.

Excitatory Influences. The histogram in Fig. 2A, 1 shows that a substantial proportion of the rubrospinal EPSP were characterized by a short latent period, from 3.0 to 4.5 msec. The latent period for three cells was 2.6–3.0 msec. Short-latent EPSP developed in response to single stimuli, but a brief