Neuroscience Letters, 133 (1991) 61–64

NSL 08193

Impairments in reaching during reversible inactivation of the distal forelimb representation of the motor cortex in the cat

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(Received 19 June 1991; Revised version received 16 August 1991; Accepted 16 August 1991)

Key words: Motor cortex; Adaptation; Motor learning; Plasticity, Muscimol; Reversible inactivation; Cat; Reaching

We report changes in the performance of a prehension task in the cat following focal inactivation of the rostrolateral subregion of the distal forelimb area of motor cortex (MCx) produced by muscimol microinjection. Animals reached into a cylindrical target to retrieve a morsel of food. Movements consisted of distinct lift and forward thrust phases following which the food was grasped and retrieved. In separate blocks of trials an obstacle was inserted in the path of the limb. Impact evoked an immediate compensatory trajectory change to bypass the obstruction and, on subsequent trials, an adaptive trajectory change to avoid impact. Inactivation produced three major defects: (1) uncompensated aiming biases to a location above the target; (2) loss of coordination of the grasp and food retrieval; and (3) impairment in trajectory adaptation to avoid impact of the limb with an obstacle. Thus, focal inactivation of the distal forelimb area of MCx produced disordered control of all forelimb joints. The impairment in trajectory adaptation and failure to compensate for aiming biases suggests that the MCx is important in motor learning.

The motor cortex (MCx) is a major component of the neural systems controlling movements of the limb [17]. However, some fundamental principles underlying the topographic organization of function within this area remain elusive. On the one hand, the results of stimulation experiments have suggested that groups of MCx neurons form overlapping populations devoted to the control of individual or small groups of synergistic muscles [7] (for review, see ref. 14). Such neuronal populations may be represented at multiple loci in MCx. On the other hand, recent single neuron recordings in primates have suggested that neurons in radial arrays might code a superordinate, muscle-independent, representation of movement direction [12]. In addition, the spinal terminations of individual corticospinal neurons in both cat [25] and monkey [26] are more extensive than was once thought. In the present experiments, we sought to determine whether the effects of reversible inactivation of local regions within the arm area gives rise to functional deficits confined to small groups of muscles operating at a given joint. Instead, the results show that focal inactivation of a portion of the distal forelimb representation of MCx [21] impairs the coordinated control of all joints of the forelimb in reaching and in the adaptation of the reach to avoid obstacles.

Cats were trained to perform a task requiring them to reach into a baited target well with their left forelimb to grasp and retrieve a small piece of beef (approx. 0.5 cm^3) [13]. The target was a cylindrical tube (1.25″; i.d.) located approximately 12 cm in front of the starting position of the paw of the performing arm. Three different target heights were used, one at shoulder height and two at approximately 5 cm above and below the shoulder. Animals were loosely restrained in a hammock. During behavioral sessions the height of the tube was changed every 10–20 trials. In order to assess the animals' ability to adaptively modify limb trajectory, in some sessions an obstacle (cylindrical bar, 1/2″; diameter) was placed unexpectedly in the path of the limb and left in place for a block of 8–20 trials. Responses were videotaped using a Super-VHS camcorder with a shutter speed of 1 ms. Critical points on the limb and the locations of the target and the obstacle were digitized from individual video fields at a sampling rate of 60 Hz. Joint paths and stick figures were constructed from the digitized joint coordinates.

After the animals were trained, they were anesthetized (Nembutal, 30 mg/kg i.v.) and, under aseptic conditions, a craniotomy was made over the right motor cortex and a recording/injection chamber was implanted. A coarse

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