VARIED INFLUENCE OF DAMAGE TO THE MOTOR CORTEX ON PRECISION AVOIDANCE AND ESCAPE REACTIONS IN DOGS*

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The influence of local extirpation of the representation of the forelimb in the motor area of the cortex on the performance of precision elevations of this limb was investigated. Even imprecise avoidance reactions to an acoustic signal did not recover spontaneously. Irregular motoric reactions which were insufficient in amplitude could easily be restored in the course of retraining, but precise movements (both rapid fused, as well as relatively slow stepwise movements) did not recover for at least a half year after the operation. By contrast with this, precise rapid reactions in response to electrical stimulation of a “working” limb (inducing unconditioned reflex flexion) remained essentially preserved, i.e., the capacity to stop the movement in the correct (previously learned) position of the limb was preserved. The capacity to fix the position of the raised limb was not lost, but was persistently impaired. The capacity to overcome the unconditioned reflex flexion during the performance of extensor “slow” escape reaction was reduced sharply and persistently. Limb presentation reactions regulated by vision were essentially spontaneously and nearly completely restored within a month.

In many studies, in accordance with the atlas of Adrianov and Mering [1], the entire posterior sigmoid gyrus of the dog brain has been regarded as the motor cortex. However, the results of electrical stimulation of this region, supplemented also by some morphological investigations, have led Konorski et al. [11, 19, 20] to the conclusion that it includes both the motor (MI) as well as the somatosensory (SI) cortex (their boundary passes approximately in the middle of the posterior sigmoid gyrus (through the dimple), i.e., somewhat more caudally than in the cat [15]). The authors of [11, 19, 20] have carried out an investigation of the differences in the functional role of these regions in the control of instrumental reactions. However, the reflex that they have used, of placement of the forelimb on the food dispenser, was preserved after unilateral ablations of both the SI and the MI, while with bilateral extirpations of SI or MI, the disturbances were expressed mainly in the absence of the reflex for two to three weeks in the case of each of the lesions. Thus, differences were not identified directly in the functional specificity of these cortical regions.

It was demonstrated in our previous study [7] that spontaneous (without retraining) restoration of previously developed precision avoidance reactions takes place over the course of two weeks after the operation following the extirpation of the representation of the forelimb in SI. By contrast with this, prolonged coarse disturbances in the precision of the reactions were observed with local lesions of the MI [2]. However, whether it is necessary to speak of a specific disturbance of precision in particular in this case, or whether this was more likely a matter of a reduction of a capacity to initiate flexor reactions, remained unclear. The elucidation of this question was initially the basic objective of the present study.

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Fig. 1. Localization of the region of ablation (hatched) in the motor cortex in D1 and D2. The regions of fiber degeneration are denoted by dots in the sections. The region of the representation of the forelimb in accordance with [11, 14] is outlined in the left intact hemisphere of D2. A deformation (compression) at the site of the ablated cortical area can be seen from the comparison of the right and left hemispheres.

METHODS

The experiments were carried in adult mongrel dogs (D1, D2). Throughout the experiment the animal was kept on a bench in a soundproof box. Each of the limbs was tied to four rods which could shift freely 17 cm along the vertical. The elevation of the rod of the left forelimb was recorded on an automatic writer. The bearing force of each of the limbs was also recorded by means of four strain gauges. An acoustic tone of 200 Hz, lasting 15 sec, served as the conditional signal (CS). The dog was required to raise and maintain the limb during the isolated action of the CS (5 sec) for the following 10 sec at a height from 7 to 11 cm, in the “safety zone” (SZ). In case of an imprecise reaction or when the limb left the SZ as a result of its being imperfectly sustained in that zone, electrodermal stimulation was applied to it (EDS), which the dog could escape by shifting the limb into the SZ. The EDS was applied in the region above the radiocarpal joint (an ESu-1 stimulator; 1 msec, 30 Hz, 3–8 mA).

The correct choice of the strength of the EDS has great significance for the development of the precision reflex and the testing of its state following the operation. The jerk (T1) or elevation (T2) thresholds of the limb (usually 0.6–1.2 mA) cannot serve as adequately defined indicators. We considered the value of the TV [unexpanded acronym (PZ in Russian), here speculatively interpreted as “threshold value” — Translator], which can provisionally be termed the threshold of pain sensitivity (usually 2.8–4.4 mA) as the principal indicator. In order to determine the TV, elevation of the limb into the SZ was induced at first by turning on a weak, gradually increased EDS. The dog then periodically tried to lower the limb below the SZ and again escaped the EDS (as in Fig. 4A). If these escape reactions were performed in a stable manner for no longer than 0.1 sec (as a result of rapid unconditioned reflex flexion with a latency of about 40 msec), we considered the strength of the EDS to have reached the magnitude of the TV (the EDS was not turned on during these measurements in the case of elevations of the limb above the SZ). EDS up to 1.5–2.0 TV in strength was required for the development of the avoidance reactions; this approximately corresponded to the threshold of the vocal reaction. In order to stabilize a reflex, 1.2 TV was sufficient.