EFFECT OF STRIATECTOMY ON RELEARNING THE AVOIDANCE RESPONSE IN RATS IN A Y-SHAPED MAZE

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The ability of rats to change the direction of the avoidance response was determined in a Y-shaped maze. During one experiment four training sessions were given, requiring the choice of a new direction (to the right or left) each time. The results obtained with four groups of animals were compared: intact, with bilateral and unilateral striatectomy, and with bilateral destruction of the parietal cortex. Most intact rats preferred to turn to the right. After striatectomy the character of preference changed: The rats began to run more regularly toward the side of severest damage to the striatum. Bilateral striatectomy also led to an increase in the number of mistakes, an increase in the latent period, and disturbance of the passive component of the avoidance response.

KEY WORDS: striatal injury; avoidance reflex.

Injury to the corpus striatum interferes with the performance of behavioral tasks involving choice of the correct direction of the avoidance response or pressing on a reinforced lever in a Skinner's chamber. Defects of conditioned behavior of this type are frequently taken as indicators of worsening of discrimination processes [2, 4, 7]. However, another factor responsible may be that when solving a three-dimensional problem after striatectomy animals more often choose one particular direction, for the corpus striatum is known to participate in the formation of turning movements [1, 5, 9].

To assess the role of this factor the effect of striatectomy on repeated change of the direction of the avoidance response was studied in experiments on rats.

EXPERIMENTAL METHOD

Experiments on 50 noninbred albino rats of both sexes weighing 180-280 g were carried out in a Y-shaped maze, the floor of which could be electrified. The program of each experiment consisted of four consecutive training sessions with ten tests in each session. Initially, in response to a conditioned acoustic stimulus, in order to avoid an electric shock the animal had to run ten times into the right compartment of the maze. The direction of the avoidance response was then changed to the left (the back walls of the compartments were painted different colors), after which two more consecutive changes of direction of the avoidance response were made. To detect a tendency of the animals to move in one particular direction during avoidance responses a conventional "index of preference" was calculated. With allowance for the sign, the differences determined between the number of mistakes (entering the wrong compartment of the maze) was determined in series requiring running in the opposite direction (1 and 2, 3 and 4). The mean value of the difference was taken as the required index for each rat. Also, to judge the degree of extinction of the conditioned response, the averaged difference (irrespective of sign) was determined between the number of mistakes in each session (1-2, 2-3, 3-4), the latent period of the responses, and the number of times the animal came out of the correct compartment of the maze during the 45 sec after stimulation.

After these indices had been determined the animals were divided into four groups: Group 1 was the control; in the other three groups foci of electrolytic destruction were formed unilaterally or bilaterally

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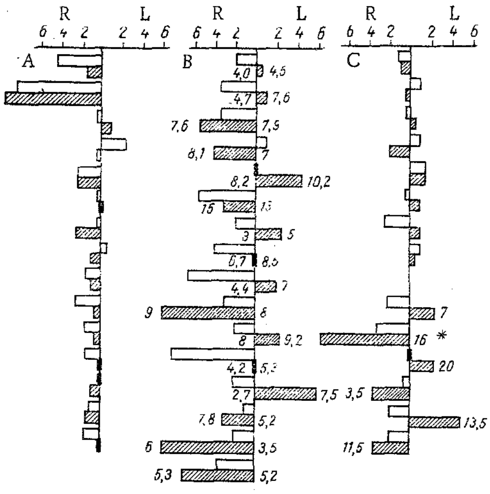

Fig. 1

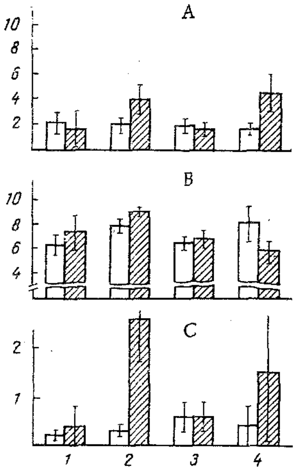

Fig. 2

Fig. 1. Directional preference in intact rats and rats with brain damage: A) intact animals; B) bilateral stiatectomy; C) bilateral injury to the parietal cortex; D*) unilateral striatectomy. Columns show degree of directional preference (in conventional units), plotted along the horizontal line above, allowing for the direction taken (R – right, L – left) by each animal. Unshaded columns show results of first experiment, shaded columns results obtained 1 week after operation (control determinations in the case of intact rats). Numbers near columns show volume of focus of injury (in %) to the corresponding (right or left) corpus striatum.

Fig. 2. Effect of striatectomy on some indices of the avoidance response: A) variation in number of mistakes between sessions; B) latent periods (in sec); C) number of times animal left compartment it previously occupied; 1) intact animals; 2) bilateral striatectomy; 3) bilateral cortical injury; 4) unilateral striatectomy. Unshaded columns – before, shaded columns – after operation (for intact rats, data of repeated determination without brain destruction.

in the brain under pentobarbital anesthesia (silver electrodes 0.2 mm thick, current 1.5 mA passed for 30-35 sec). The rats were investigated by the same program 1 week after the operation. The location of the injury was determined in frontal brain sections which were compared with the atlas of Fifkova and Marsala, and the volume of the focus of destruction also was calculated.

EXPERIMENTAL RESULTS

The intact rats easily learned the avoidance response when taught for the first time and made only a few mistakes at the end of the session. Changing the direction through the maze at first led to an increase in the number of incorrect responses, but later as the response first acquired became extinguished, avoidance took place with steadily increasing accuracy.

Although the mean number of mistakes was low, definite preference of some animals for an avoidance response in a certain direction was noted. Judging from the sign of the index of preference, most animals (80% of those examined for the first time) ran into the right compartment of the maze more accurately, sometimes with a high degree of preference (Fig. 1A). Similar results with rats have been obtained by other workers [3, 6]. This fact cannot evidently be attributed entirely to the experimental design (the animals were trained first to take the right turn). In 14% of cases the rats preferred to turn to the left, and in 6% they had no preference.

The results of the second experiment showed that most animals still retained their initial preference 1 week later, although it varied in degree. In 20% of cases the index of preference was reversed (Fig. 1A). This applied mainly to rats with a low initial level of directional preference.

No Figure 1D histogram given in Russian original – Consultants Bureau.

Bilateral electrolytic destruction of both caudato-putamen complexes led to an increase in the number of mistakes and to a change in the preferred direction. After the operation, the animals found it more difficult to relearn from one session to the next. At the same time, they more often (56%) preferred to turn in the other direction and, most important of all, the amplitude of this reversal (to judge from the index of preference) was considerable. This phenomenon probably cannot be explained entirely by brain damage. After bilateral destruction of the parietal cortex, for instance, although the rats rejected the direction they had preferred previously, the amplitude of the shift was small (Fig. 1B and C).

One cause of the effect of striatectomy described above is the character of injury to the corpus striatum itself. Analysis of the localization and size of the focus of striatal destruction shows that, despite the use of a current with the same parameters for brain destruction, the size of the lesions could vary in different nuclei. On the average about 7% of the total volume of the structure was destroyed. Differences in the scales of injury were sometimes slight (0.1-0.3%), but sometimes very considerable (3-4.8%). However, although there was no question of direct dependence on the degree of the differences (although this had a role to play), clear correlation was found: The animals always ran with greater regularity into the compartment on the side of greatest damage to the corpus striatum (Fig. 1B). For example, whereas before striatectomy the animals prefered to turn to the right, after more severe destruction of the left nucleus this preference became weaker, it disappeared completely (although initially it was well enough defined), or it was reversed so that they went into the left side more accurately. If the right striatum was more severely injured, the original preference became more marked still. Dependence of the side of preference on the degree of striatal injury was very clearly revealed in experiments on animals with unilateral striatectomy. Reversal of the direction of running was observed regularly in these animals, except in one case (marked by an asterisk in Fig. 1D). Morphological investigation showed a massive hemorrhage in the corpus striatum of this animal, which evidently irritated the structure but did not inactivate it.

Besides the disturbance of directional preference, inactivation of the nucleus led to a worsening of the other indices of the avoidance response. After both unilateral and bilateral striatectomy, extinction of the previously established response was much more difficult. The animals found it more difficult to relearn, as a result of which the mean value of the drop in the number of mistakes between sessions was greater in both groups of the experimental series than under normal conditions or after destruction of the cortex (Fig. 2A). Bilateral striatectomy also was followed by a significant increase in the latent period of the conditioned response. In the case of injury of only one nucleus, on the other hand, the latent period was shortened, probably because of the sharper increase in spontaneous locomotion. Finally, severe striatal deficiency led to a marked increase in the number of times the rats left the compartment occupied previously (Fig. 2C), in good agreement with the important role ascribed to the corpus striatum in the processes of passive avoidance [8, 11].

The ability of rats to choose the proper direction of their motor response and to modify it and perform it thus depends on integrity of the corpus striatum. Most of the changes can be explained on the grounds that the corpus striatum plays a role in the formation of the spatial orientation of animals [10]. One outward manifestation of this statement is the contralateral rotations of the head and trunk in response to stimulation of the caudate nucleus and ipsilateral rotations after blocking of that nucleus [5]. In the study of spatial tasks involving alternation or discrimination in animals with striatal hypo- or hyperactivity, the functional characteristics distinguishing this structure must be taken into account.

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