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Rearing Avoidance Behavior in Rats with Anterodorsal Hippocampal Lesion

(rearing avoidance/hippocampal formation)

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The present study was an attempt to determine whether the facilitative effect of Ra could be found in rats with unilateral anterodorsal (CA1 field) hippocampal lesion in the rearing escape/avoidance situation. Obtained results showed the facilitative Ra in rats with the hippocampal lesion. This suggests that the anterodorsal hippocampus might play a critical role for the establishment of the avoidance responses, but because of jumping Ra dominancy rather than rearing Ra dominancy, the question of whether the facilitative effects might be due only to increased activity induced by the hippocampal lesion remains to be answered.

The extensive hippocampal lesions produce a large number of behavioral changes (1, 2, 3, 4). In an aversive situation, the facilitative effects of avoidance performance was found in two-way shuttle box situation in rats with hippocampal lesions, but not in the lever-press escape/avoidance situation. Such a conflicting observation might be the result of situational difference — a difference in the required response topography and a difference in the change of the stimulus situation after responding — and/or resulted in the "extensive" hippocampal lesions which should interfere with several different functional systems. For the latter factor, Andersen *et al.* (5) suggested in a electrophysiological study that the two main subfields of the hippocampus, CA1 and CA3, might subserve different functions since they had different outputs.

The present study was an attempt to determine whether the facilitative effect could be found in rats with unilateral anterodorsal (CA1 field) hippocampal lesion in the rearing escape/avoidance situation, recently reported by Shishimi and Imada (6), in which rats were trained to avoid shock by cutting the light beams which the animal accomplished by upward change of its posture.

MATERIALS AND METHODS

Subjects

Thirty-six male albino Wistar rats, weighing 265—300 g at the time of surgical operation were assigned to three groups which were matched for the weight and the activity score obtained in the Open Field Situation ; 14 rats lesioned unilateral (left) anterodorsal hippocampus (HL : hippocampal lesioned), 11 lesioned unilateral (left) neocortex (OC : operated control) and 11 controls

given no surgical treatment (N : normal).

Surgical Operation

Rats were anesthetized with sodium pentobarbital (50 mg/kg) i. p. and after a suitable opening had been the skull, the dura was incised. Unilateral (left) anterodorsal hippocampus and its overlying neocortex was aspirated by means of a glass suction tip of small diameter in the HL group. In the OC group, the hippocampus was exposed similarly but not damaged, and in the N group no surgical treatment was given.

Apparatus

For the escape/avoidance training a rearing avoidance box was used (the inside dimensions ; 200 × 148 × 300 mm), which was described in detail by Shishimi and Imada (6). In brief, several invisible light beams run at the height of 150 mm from the grid floor and thus the rat's upward movement greater than the height of the beams at any floor position resulted in interruption of beams. The required response for the escape or avoidance of CS and/or US was to interrupt the beams.

The CS was a 1000-Hz tone presented through a speaker 290 mm directly above the ceiling of the box. The intensity of the tone was 85 dB (c), measured inside the box. The US was a constant current 0.8 mA ac scrambled grid shock.

Escape/Avoidance Training

Escape/avoidance training began at the 8th and 13th postoperative day in the HL group and in the OC group, respectively. All experimental treatments were identical for the three groups.

The subject was put into the shock box and habituated to the box for 5 min after which the first trial began. If the subject did not make the appropriate response within 5 sec after CS onset, the US was delivered and both stimuli on until the subject made the required response. If the rat made the appropriate response within 5 sec after CS onset, the CS was terminated immediately and no US was presented. The intertrial interval was variable, ranging from 10 to 40 sec with an average of 25 sec. Sixty trials were run per session, and three sessions were run approximately 23 hr apart.

Histological Examination

On the day following the escape/avoidance training, rats were perfused with a 10% neutral formol solution under sodium pentobarbital anesthesia, and the brains were carefully removed from the cranium. After keeping them in a 10% neutral formol solution for at least 5 months, the frozen serial frontal sections (40μ thickness) were obtained and prepared with the Nauta-Gygax silver impregnation technique for the tracing of hippocampo-fugal fibers for the further research.

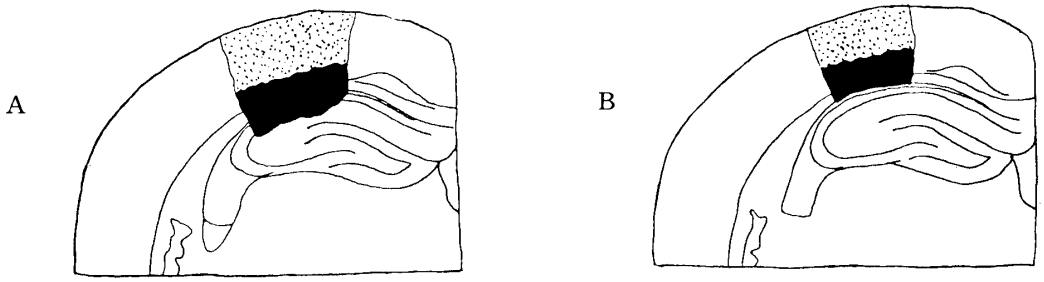

Fig. 1. Anterodorsal hippocampal lesion (A) and neocortical lesion (B), displaying the complete lesion (darkened area) and the incomplete lesion (dotted area).

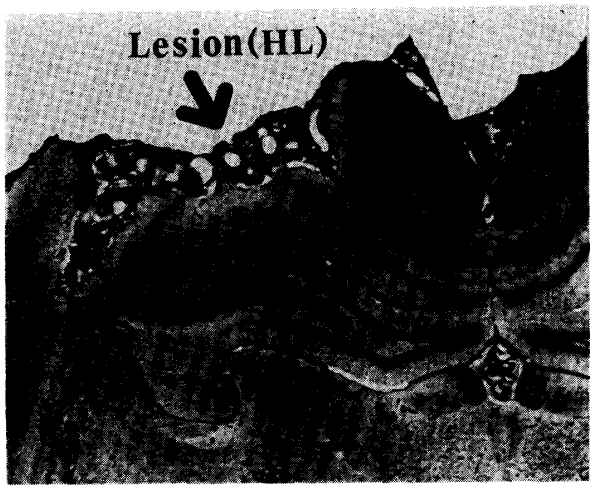

Photo 1. Anterodorsal hippocampal lesion (arrow) (Nauta-Gygax method).

RESULTS AND DISCUSSION

*1) Histological Findings**

The lesions in 11 of 14 rats in the HL group appeared quite uniform and generally were localized in the anterodorsal hippocampus (Fig. 1 & Photo 1). In no case did the lesions extend into the dorsal parts of the thalamus. In the remaining 3 rats, the lesions did not reach the subcortical area, data of which were lost. The lesions in 8 among 11 rats in the OC group were localized in the dorsal neocortex but in the remaining 3 rats there was slight damage to the hippocampus, data of which were also lost.

2) Escape/Avoidance Behavior

Fig. 2 shows the mean number of avoidance responses (Ra) of the three groups, in blocks of 10 trials. A 3 by 3 by 6 Lindquist's Type VI ANOVA was conducted on the data, with groups as the between-factor, and blocks and days as within factors. All the main effects were significant (groups : F

* Though the histological examination in this study was done using Nauta-Gygax silver impregnation technique for the tracing of hippocampo-fugal fibers, in this section only the results concerning overall damage of hippocampus and/or neocortex are described. Detailed results related to the hippocampo-fugal fibers will be reported elsewhere.

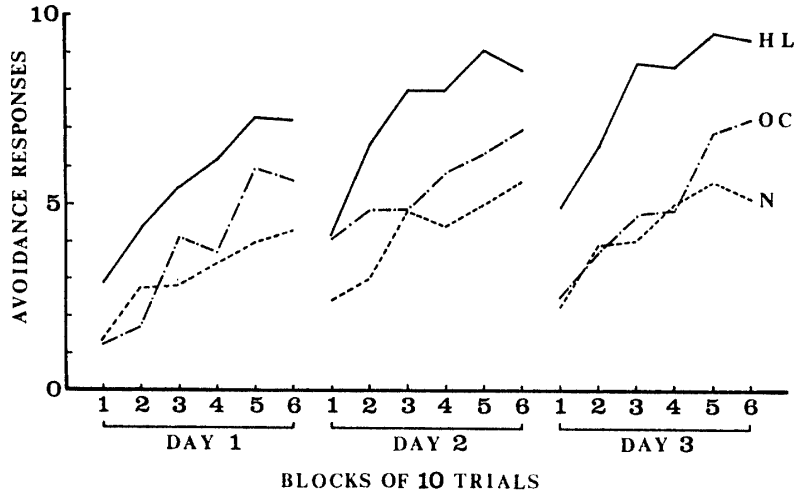

Fig. 2. Mean number of Ra in the three groups as a function of surgical treatment.

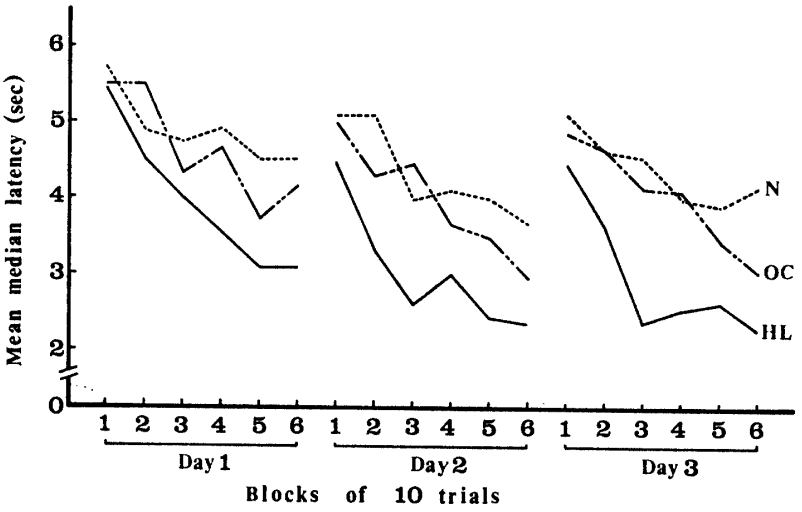

Fig. 3. Mean median latency in the three groups as a function of surgical treatment.

$= 8.61$, $df = 2/27$, $P < .01$; days : $F = 21.13$, $df = 2/54$, $P < .01$; blocks : $F = 56.93$, $df = 5/135$, $P < .01$). But the groups by days, groups by blocks, days by blocks, and groups by days by blocks interactions were not statistically reliable. No statistical significances were found between the N group and the OC group.

Fig. 3 shows data for the mean median latency of the three groups, in blocks of 10 trials. A 3 by 3 by 6 Lindquist's Type VI ANOVA was conducted on the data. All the main effects were significant (groups : $F = 6.59$, $df = 2/27$, $P < .01$; days : $F = 17.24$, $df = 2/54$, $P < .01$; blocks : $F = 41.21$, $df = 5/135$, $P < .01$). No interactions were found as for the possible combination of the three factors. Statistically significant differences were not obtained between the N group and the OC group.

TABLE I. *The Number of Avoidance Responses Accomplished by Jumping (J) and Rearing (R) in the Three Groups*

	Day 1		Day 2		Day 3	
	R	J	R	J	R	J
HL	167	200	194	294	220	305
OC	104	89	178	127	162	130
N	89	116	62	217	53	234

In Table I the results regarding the topography of Ra are summarized. It should be noted that the frequency of the jumping Ra was remarkably high in all groups - which might be contrasted with the results of Shishimi and Imada (6) who found that the rearing Ra was dominant.

Our results show the facilitative Ra in rats with the hippocampal lesion—in this study the lesion was restricted to the anterodorsal CA1 field hippocampus. Similar results were obtained in the present rearing avoidance situation as in previous studies in which locomotive Ra was required (7). This suggests that the anterodorsal CA1 field hippocampus might play a critical role for the establishment of the avoidance response.

Myhrer (8) reported the notion of a functional differentiation between the subfields CA1 and CA3. In his study, medial fimbrial lesions caused changes in avoidance behavior (impaired avoidance performance) that were not seen after CA1 damage. On the other hand, the fimbrial lesions did not significantly increase locomotor activity, which was seen after disruption of the CA1 output. The CA1 neurons, which project to the subiculum (9), may make up a neuronal system, the disruption of which produces increased locomotor activity.

The CA3 cells, which have one of their outputs through the fimbria hippocampi, presumably constitutes another system which appears involved in the organization or guidance of avoidance behavior. The increased avoidance responses in rats with hippocampal lesion in this study may only result in increased activity in the shock situation because of the jumping Ra dominancy in this study in contrast to the rearing Ra dominancy—more "operantly"—in the study of Shishimi and Imada (6).

In among studies in which the effects of the extensive hippocampal lesions on Ra were examined, several postulations for the functions of hippocampus were proposed. The hippocampus is postulated to have an inhibitory function, stimulus-response bond suppression or inhibition of attention and/or stimulus imput (8). The hippocampus probably also plays a crucial role in working memory mechanism (2). Another interpretation emphasizes attenuated species-specific freezing response as one major effect after extensive hippocampal damage (10). Other physiological studies show that hippocampal lesions produce increased basal corticosterone levels which may play a role in improvement of Ra (11). Common to most notions is the tendency to regard the hippocampus as exerting uniform function. A number of interacted functions in the subfields of the hippocampus might result in a number of postulations.

From the present data, the hypotheses of hippocampal function appear somewhat simplified, but the question of whether the facilitative effects of Ra in lesioned rats might be due only to the increased activity induced by the selective CA1 field lesion remains to be answered.

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