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Research report

Functional difference between rat perirhinal cortex and hippocampus in object and place discrimination tasks

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ABSTRACT

The present study was designed to determine the degree of functional dissociation between the rat perirhinal cortex and hippocampus for reference memory performance on object and place discrimination tasks. In one experiment, 30 rats were trained on a two-pair concurrent object discrimination task in an elevated radial arm maze. Rats with a perirhinal cortex lesion needed significantly more days to attain the criterion in the relearning of a pre-operatively acquired object discrimination task than the control rats and rats with a hippocampal lesion. However, there were no significant differences between the three groups in the days to attain the criterion in learning post-operatively the original object discrimination task with new discriminanda and its relearning. The rats with a hippocampal lesion did not show any impairment in object discrimination. In a second experiment, 27 rats were trained on a place discrimination task in the same maze. Rats with a hippocampal lesion required more days to attain the criterion than the control rats to relearn the pre-operatively acquired place discrimination task, and they had fewer correct responses in the first three sessions with new discriminanda than the control rats. Rats with a perirhinal cortex lesion, on the other hand, showed mild relearning impairment. These results suggest that there is a functionally single dissociation between the perirhinal cortex and hippocampus for reference memory performance on object and place discrimination tasks. They also suggest the possible involvement of the perirhinal cortex in spatial reference memory performance.

1. Introduction

Lesions of the medial temporal lobe produce memory deficits in the human [10], monkey [27,46], and rat [1,4,33]. The medial temporal lobe memory system consists of the hippocampus (dentate gyrus, hippocampus proper, and subiculur complex), entorhinal, perirhinal, and parahippocampal (postrhinal in the rat) cortex [41]. These structures have been considered to form a functionally unitary system underlying all forms of declarative memory [47]. However, recent findings suggest that there are functional subdivisions in these areas [5,6,12,13,30,34,44]. In particular, the perirhinal cortex has been shown to have a unique function in perception and memory, differing from that of the hippocampus [8,34,44]. Perirhinal lesions in monkeys and rats have caused deficits in performance on delayed-(non)-matching-to-sample (D(N)MTS) tasks [1,27,33] and spontaneous object recognition tasks [44], while hippocampal lesions have brought about deficits on delayed-(non)-matching-to-place (D(N)MTP) tasks [3,37,44]. Consequently, the functions of the perirhinal cortex and hippocampus have been considered to be dissociated from each other in the working memory for object and place. However, recent research has shown that monkeys and rats with a perirhinal lesion show deficits in working memory for place [23,43,45].

It is not clear whether the perirhinal cortex and the hippocampus are involved differently in reference memory for object and place. Lesions of the hippocampus have produced severe deficits in water maze tasks [28] but mild or negligible deficits in object discrimination [31] and brightness discrimination tasks [35] in rats. Perirhinal lesions and N-methyl-D-aspartate (NMDA) or muscarinic blockade in the perirhinal cortex impair performance in multiple-pair concurrent or simple object discrimination, particularly in relearning or retaining a pre-operatively acquired discrimination ability [2,16,26,32]. In contrast, perirhinal lesions produce no deficits, or, if any, very subtle ones, in spatial reference memory performance in rats [21,42]. However, it is too early to conclude that the perirhinal cortex and the hippocampus are differentially involved in reference memory for object and place, respectively. This is because the spatial reference memory of rats has generally been examined using the Morris water maze [32,42], while non-spatial reference memory has generally been examined for object

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or pattern discrimination in an operant box or Y-maze [12,20]. In addition to the differences in the stimulus properties, there is a significant difference in the level of motivation between the two tasks: one is for escape from an uncomfortable situation and the other is for reward. Furthermore, the number of stimuli used as discriminanda was generally not the same for the two types of tasks. For the object discrimination tasks, the rats needed to discriminate between a correct stimulus and an incorrect one, while in the Morris water maze task, the rats needed to locate a platform under a wide pool surface. Therefore, the number of stimuli can be controlled for object discrimination tasks but not for the Morris water maze task. The number of discriminanda (i.e., the size of the stimulus set) is an important factor in the magnitude of the deficits, following a perirhinal lesion, for object discrimination tasks in monkeys [7,17].

To determine whether the hippocampus and the perirhinal cortex are functionally differentiated from each other for reference memory on object or place discrimination, we needed to examine the effects of a perirhinal lesion on the performance of reference memory tasks with a constant number of cues. For this purpose, we prepared object and place discrimination tasks in which rats were required to discriminate between objects or arms in a pair at a single trial. To clarify how hippocampus and perirhinal cortex lesions affect the acquisition and retention of object and place discrimination learning, we conducted two experiments. In one experiment (Exp. 1), we examined the effects of a perirhinal cortex or hippocampus lesion on a rat's ability to perform an object discrimination task. In the other experiment (Exp. 2), using different rats, we examined the effects of a perirhinal cortex or hippocampus lesion on a rat's ability to perform a place discrimination task. We

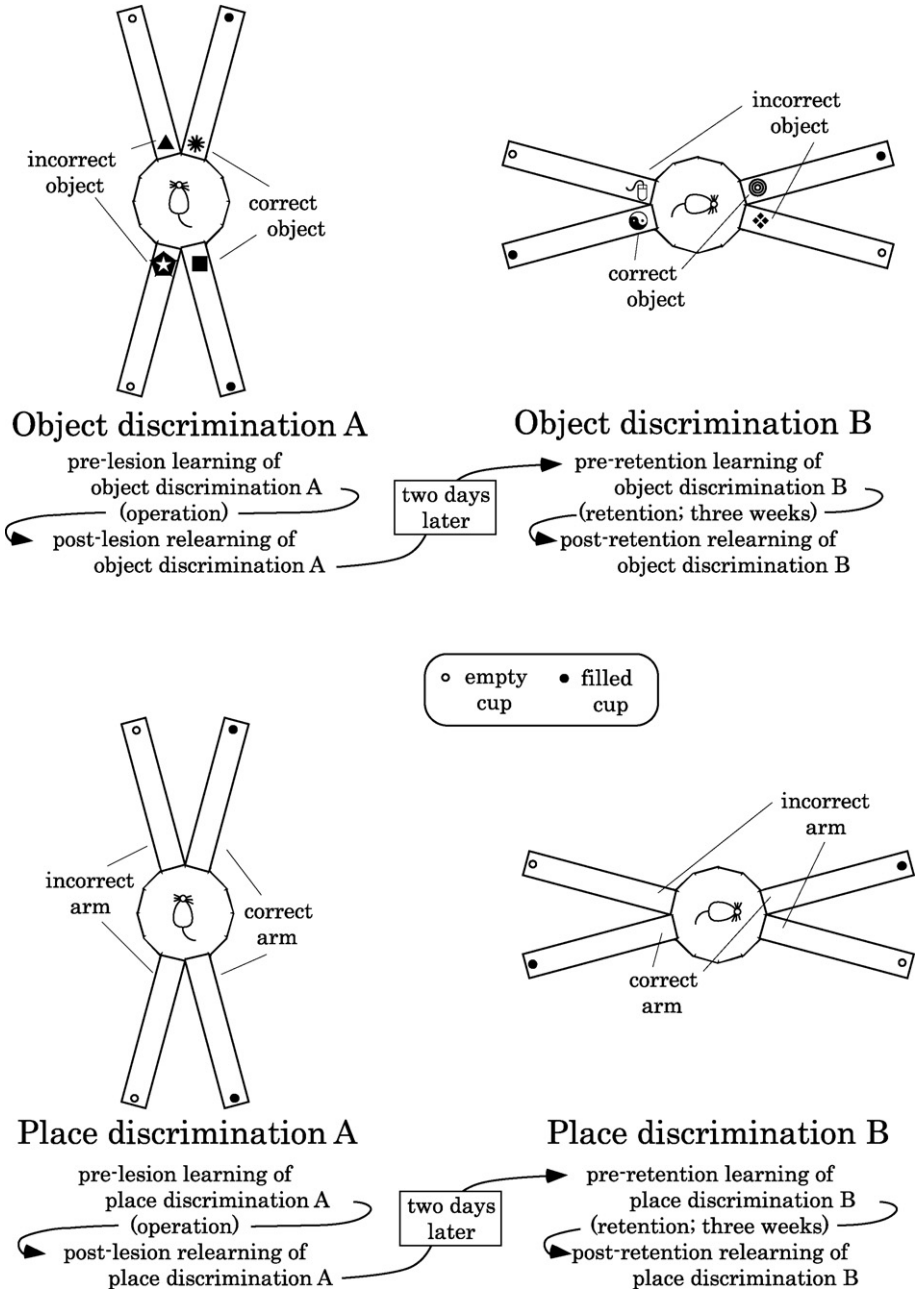

Fig. 1. Object (upper) and place (lower) discrimination tasks using elevated radial maze. In object discrimination tasks A and B, rats were rewarded if they reached the food cup on the tip of the arm on which a correct object was placed at the entrance. In place discrimination tasks A and B, rats were similarly rewarded if they entered the correct arm.