CUE DISTINCTIVENESS AND RESPONSE-TO-CHANGE IN SCOPOLAMINE INJECTED OR HIPPOCAMPAL RATS

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Abstract. Our previous findings indicated that hippocampal lesions (H) or scopolamine injections (Sc) affected stimulus information acquired by distant observation of the white-black T-maze arms (the passive test), but left the information intact when it was gained by T-maze exploration (the active test). Because this difference might reflect the attentional deficit in H or Sc rats, in the present experiment we attempted to investigate the effect of lowered distinctiveness of cues (dark grey vs black T-maze arms) on the performance of rats in the active test. A total of 75 rats were assigned to four groups: (i) damaged in the dorsal hippocampus (H); (ii) sham operated (C); (iii) scopolamine (Sc) injected (1.0 mg/kg i. p.) and (iv) saline injected (NaCl). Each group showed a significant preponderance of choices of the arm which was changed in brightness between the two consecutive trials, separated by 1 min break. The groups did not differ markedly among themselves in the percentage of changed arm choices (H group, 85%; C, 74%; Sc — 72%; NaCl, 72%). This result indicates that H or Sc rats are able to perceive a slight difference of brightness and to retain it over a period of 1 min. Therefore, the different performance of H as well as Sc rats in the passive and active test, observed previously, cannot be accounted for by the attentional deficit hypothesis.
INTRODUCTION

We have found previously (5,6) that the effect of hippocampal lesions or scopolamine injections on the rat’s tendency to choose the T-maze arm that has been changed in brightness between two successive trials (response-to-change) depends on the experimental procedure. If in the first trial (stimulus exposure) rats were allowed to inspect white-black arms through transparent barriers preventing the entrance (the passive test), in the subsequent free choice trial, when both arms were either white or black, H or Sc rats did not show the typical for normal rats tendency to enter the changed arm. However, in the other version of the test, when in the first trial the same rats were allowed to walk in the white-black arms (the active test), in the choice trial they entered the changed arm as readily as controls. The different performance of H or Sc rats in the passive and active test might reflect the attentional deficit, as stimuli inspected from some distance appear less distinct than those inspected in direct contact. The validity of this hypothesis was checked in the present paper by reducing the salience of cues in the active test, i.e. by using a dark grey vs black arm, instead of a white vs. black one.

METHODS

**Subjects.** A total of 75 male Wistar albino rats, 110-120 days old, were used. They were divided into four groups: (i) hippocampal lesioned (H - N = 20); (ii) sham operated controls (C - N = 19); (iii) scopolamine injected (Sc - N = 18) and (iv) saline injected (NaCl - N = 18). Rats were housed in groups of 9-10 per cage and had free access to food and water.

**Apparatus.** A wooden, unpainted T-maze was used. It had the following dimensions: the stem was 27 cm long and 13 cm wide, the arms were 40 cm long and 13 cm wide, the walls were 30 cm high. Inserts painted grey or black could be put into the arms, covering their walls and floors.

**Testing procedure.** The test consisted of 2 trials, the exposure trial and choice trial, separated by 1 min retention interval. The exposure trial lasted 3 min and the rat could explore the whole maze. One of the maze arms was black, the other dark grey (corresponding to number 6 of the 8-point Ostwald grey scale). During the retention interval the rat was taken out of the maze. Both inserts were replaced by two other inserts, either black or dark grey (both inserts were changed in order
to eliminate scent marks left by the rat walking in the arms). After 1 min the rat was reintroduced to the maze and faced with a choice between two visually alike arms. The arm that the animal entered with its four feet was noted. Rats not choosing either arm during 180 s were removed from the sample. The following measures were recorded: in the exposure trial — the time spent in black and dark grey arm and the number of shifts between the arms; in the choice trial — the response latency. The time was measured with a stopwatch.

A single test session was held in each group. Brightness was changed in the arm which was opposite to the directional preference of each rat examined 2 - 3 days earlier in the same T-maze with both arms unpainted. The direction preference test consisted of three trials, separated by 2 h intervals. Choosing the same arm 2 or 3 times by a given rat was considered as his preference for the respective direction. The rats of each group were randomly assigned to one of the four conditions resulting from the black-right, grey-left (or vice versa) position of inserts in the exposure trial and the brightness of the arms in the choice trial (both black or both grey).

**Surgery and histology.** The subjects were anesthetized with Nembutal (40 mg/kg i.p.). The lesions aimed at the anterodorsal part of the hippocampus were made at four stereotaxic locations: 2.3 and 3 mm behind bregma, 2 mm lateral to the midline and 4.3 mm below the skull at bregma. The coordinates were obtained from König and Klippel (4). The brain lesions were performed bilaterally by passing 2 mA anodal current for 15 s. The electrode was 0.4 mm diam. tungsten wire, insulated except for 0.5 mm at the tip. Control rats received a skin incision and threphine holes were drilled, but the electrode was not lowered into the brain. After surgery the animals were allowed to recover for 3 weeks.

**Drug administration.** The rats from the scopolamine group (Sc) received injections of scopolamine hydrobromide in saline solution. The Sc dose was the same as that used in our previous study (5) i.e. 1.0 mg/kg. The control subjects (NaCl group) received matched volumes of saline. The rats were injected interperitoneally with the appropriate solution 20 min prior to the test.

**RESULTS**

**Anatomy.** The typical hippocampal lesion is presented in Fig. 1. The damage comprised bilaterally the anterodorsal part of the hippocampus proper and the dorsal section of dentate gyrus, considerably sparing
the most lateral and medial aspect of these structures. Sporadically, some fibers of corpus callosum were touched. No damage to thalamic nuclei was noted in any case.

Fig. 1. Diagramatic representation of typical hippocampal lesion (shadowed area) presented on frontal sections adopted from the König and Klippel atlas of the rat brain (4).

Behavior. As seen in Fig. 2 the majority of rats, independently of the treatment, selected the changed arm. The proportion of changed arm choices was statistically significant (binomial test) in each group. All four groups performed on a similar level. A somewhat higher proportion displayed by the H group was not significant.

Measures of exploration (Table I) recorded in the exposure trial indicated that groups did not differ markedly among themselves. ANOVA revealed no significant differences among the groups with regard to the exploration of black or grey arm. Some preference for the black arm was observed in each group, however, the difference in time spent
Fig. 2. Percentage of rats choosing the changed arm. H, hippocampal group; C, sham operated; Sc, group injected by 1.0 mg/kg of scopolamine; NaCl, saline injected.

in the two arms appeared significant only in the C group ($P = 0.02$ Wilcoxon test, two tailed). The number of shifts between maze arms differed among the groups ($F = 2.72$, $df = 3$, $P < 0.05$). Duncan test indicated that the H group changed the maze arm less frequently than the NaCl group ($P < 0.05$, $F = 2.72$). Other differences did not attain the level of significance.

### TABLE I

<table>
<thead>
<tr>
<th>Group</th>
<th>Time (s) spent in black arm</th>
<th>Time (s) spent in dark grey arm</th>
<th>Shifts between arms</th>
<th>Choice latency (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>52.5</td>
<td>39.7</td>
<td>9.6</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>59.4</td>
<td>28.6</td>
<td>10.5</td>
<td>12</td>
</tr>
<tr>
<td>SC</td>
<td>48.3</td>
<td>38.1</td>
<td>12.3</td>
<td>6</td>
</tr>
<tr>
<td>NaCl</td>
<td>45.4</td>
<td>39.6</td>
<td>13.7</td>
<td>14</td>
</tr>
</tbody>
</table>

Although the scopolamine injected rats made arm choices with shorter latency than the rats under other treatments, this was not confirmed by ANOVA, probably due to a large dispersion of individual data within the examined groups.
DISCUSSION

There is evidence that the salience of relevant cues is crucial in determining whether rats with hippocampal destruction exhibit performance deficit. Plunkett and Faulds (8) found that hippocampal rats were deficient in successive discrimination when the task was low in cue distinctiveness. Ellen and Deloache (3) reported that alternation impairment may be eliminated in hippocampally damaged rats by enhancing the distinctiveness of maze cues. The use of a redundant cue ameliorated the learning of hippocampal rats in operant and discrete trial discrimination tasks (9, 11). These findings suggest that hippocampal damage might interfere with attentional processes.

Similarly, deficit in attention is considered by some authors (1, 2, 7, 10) as a main cause of behavioral effects of anticholinergic drugs. It has been frequently shown that anticholinergic drugs injection mimics the effect of hippocampal damage for a wide range of behavior. We observed previously (5, 6) that either treatment affects response to brightness change in the passive, but not in the active test.

The hypothesis stressing the attentional deficit seemed to be applicable to our results, because perception of the difference between white-black stimuli presented in the exposure trial of the passive test might be attenuated by distant observation, whereas in the active test the difference might be perceived as more salient owing to a closer contact with the stimuli during the exploration. Accordingly it was supposed that lowering this difference by using dark grey-black stimuli in the active test would impair response-to-change of hippocampal, as well as scopolamine injected rats. However, our supposition was not confirmed. The results obtained in the present experiment were closely similar to those of previous studies where white-black stimuli were used: the proportion of rats responding to stimulus change in H or Sc group significantly exceeded the chance level and did not differ from respective control groups. This indicates that hippocampal as well as scopolamine injected rats were able to perceive a slight difference of brightness and to retain it over the period of 1 min. Therefore the different performance of those rats in the passive and active tests, observed previously, cannot be accounted for by the attentional deficit hypothesis.

Comparing the performance of all four groups in the dark grey-black maze (present experiment) with performance of respective groups in the white-black maze (previous experiments, see 5, 6) it is interesting to note that no marked differences appeared between the two brightness conditions. The following percentages of responses to change were
observed in the white black maze: H group — 78, C — 86, Sc — 72, NaCl — 76 (see 5 and 6). So, the groups subjected to the same treatment showed a slightly higher or lower percentage of responses in one brightness condition (grey-black) than in the other (white-black) but no consistent direction of differences was observed.

All four treatment groups explored white-black maze arms slightly longer than grey-black arms (from 10 s in C and NaCl groups to 23 and 37 s in H and Sc groups, respectively). The preference for the black arm was more pronounced in the white-black maze than in the grey-black maze. This refers particularly to Sc rats which spent 70 s more in the black than in the white arm, while only around 10 s more in the black than in the grey arm. Also H rats showed greater preference for the black arm when it was coupled with the white one (the difference in time was 35 s) than for the black arm coupled with the grey arm (the difference was around 13 s). For the C and NaCl groups the differences were marginal. The above differences obviously did not influence the memory acquired during exploration and related to the spatial arrangement of visual stimuli. This might be inferred from the similar level of response-to-change in the two brightness conditions.

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REFERENCES


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