Effects of scopolamine and eserine on position discrimination learning with an exploratory incentive¹

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Scopolamine injected rats performed significantly better than controls on original learning and after reversal of a T maze position discrimination motivated by the opportunity for exploration. They ran slower than controls early in training but showed speed increases as training progressed while the controls showed speed decreases. No effects were found with eserine. The data were interpreted as showing that scopolamine disrupts habituation to novelty.

Carlton (1963, 1968) has suggested that the attenuation of brain-acetylcholine (ACH) activity disrupts the process of habituation. Exploratory behavior is well suited for the evaluation of habituation because such behavior is assumed to decrease as a result of habituation. If approach tendencies to an exploratory incentive are reduced in the normal animal through habituation, an animal with impaired habituation should show prolonged approach tendencies. Disruption of habituation then should lead to better than normal performance in discrimination learning motivated by an exploratory incentive. This possibility was evaluated by studying the effects of an anticholinergic drug (scopolamine) on a position discrimination motivated by the opportunity for exploration. An anticholinesterase drug (eserine), which should prolong ACH activity, was studied for comparison.

METHOD

Subjects. Twelve experimentally naive, male albino rats of Sprague-Dawley strain, approximately 90 days old, were randomly divided into three groups to be treated with either scopolamine, eserine, or saline. All Ss were individually housed and given free access to food and water throughout the experiment.

Apparatus. The Ss were tested in a T maze identical, except for minor dimensional changes, to that described in detail by Leaton (1965). One of the large goal boxes contained various junk objects (Exploratory Box) and the other was the same size but empty (Neutral Box). Guillotine doors just beyond the choice point in each arm prevented retracing, and the goal boxes could not be seen from the choice point. White noise masked extraneous auditory stimuli. Starting time, running time in the stem and arm, and choice time were recorded to the nearest .01 sec.

Procedure. All Ss were given preliminary exposure to the maze on five consecutive days. The goal boxes were never in place during this pretraining and the ends of the arms of the T maze were blocked. Training began on the sixth day with both goal boxes in place. The Exploratory Box was on the left for half the Ss in each group and on the right for half. Each S was given eight trials a day and on each trial was removed from the maze 30 sec after entering the goal box. A noncorrection procedure was used and the intertrial interval was approximately 1 min. Trials 4 and 8 each day were forced trials which served to force S to his less preferred side for that day. All Ss were trained on this position habit for 12 days and then each S's positive and negative side was reversed and 12 days of reversal training were given with the procedure otherwise unchanged.

One of the groups of four Ss was run following injections of 0.5 mg/kg scopolamine hydrobromide, one following injections of 0.3 mg/kg eserine sulfate (later increased to 0.5 mg/kg), and the third following injections of an equal volume of normal saline. All Ss were run approximately 20 min after the daily injections and testing was completed within 50 min of the injections. All parts of the procedure, including pretraining, were run following the appropriate injections. Drugs were administered intraperitoneally in a volume of 1 cc/kg.

RESULTS

The distribution of scores for the eserine injected group (both with the 0.3 mg/kg and the 0.5 mg/kg dose) overlapped almost

completely with the saline control group. The results for the eserine group will thus not be treated further.

Figure 1 shows the exploratory choice performance for the scopolamine (Sc) and the saline (Na) groups for the initial 12 days of training and for the 12 days of reversal. For the first 12 days combined, the Sc group chose the Exploratory Box on 94% of their free trials while the Na groups mean was 66% ($t = 4.22$, $df = 6$, $p < .01$). For the last seven of these days no animal in the Sc group made a free choice to the Neutral Box. No animal in the Na group in the present experiment ever ran 100% correct for a day. All Ss attained their maximum performance very rapidly and there were no assayable differences in speed of learning.

The Sc group performed worse than the Na group on the first few days following the reversal. (One S in the Na group died before reversal training.) The mean number of trials until the first two consecutive free-trial responses were made to the new positive side was 21.25 for the Sc group and 1.33 for the Na group ($t = 5.25$, $df = 5$, $p < .005$). Animals in the Sc group tended to reverse in an all-or-none fashion. Once an animal made his first free-trial response to the new positive side, he began responding consistently to that side. The Sc group was again running more frequently than the controls to the Exploratory Box over the last six days of reversal training. The mean daily exploratory choices for these days was 90% and 60% for the Sc and Na groups, respectively ($t = 4.41$, $df = 5$, $p < .01$).

For statistical analysis times were converted to reciprocals and are called speeds. Figure 2 shows the choice speeds for the free trials over the first 12 days of testing. Analysis of variance over these 12 days showed that the groups differed significantly ($F = 40.65$, $df = 1/6$, $p < .001$) and a significant Groups by Trials interaction ($F = 3.28$, $df = 11/66$, $p < .005$) showed that the speed changes over trials were significantly different for the two groups.

DISCUSSION

These results suggest that scopolamine disrupts an animal's ability to habituate to novelty. This conclusion is supported by (a) the superior choice performance of the Sc group, and (b) the failure of the Sc group to show speed decrements over test days while the control Ss showed the speed decrements characteristic of habituation.

It is assumed that a normal animal fails to achieve 100% choice performance in the exploratory maze because he habituates to the novelty of the Exploratory Box as he is exposed to it. The incentive value of the Exploratory Box is thus reduced, along with its novelty relative to the Neutral Box, and choice behavior is

Fig. 1. Mean exploratory choices for the six daily free trials of original learning and reversal.

Fig. 2. Mean reciprocal choice time (speed) for the six daily free trials of original learning.

impaired as the difference in incentive value between the goal boxes is reduced. If the animal does not habituate, the relative novelty and incentive value of the goal box remain unimpaired and choice performance will remain at a high level. The reduced response speeds which the control Ss showed as training progressed are assumed to reflect habituation, and the Sc group's failure to show these speed decrements to reflect deficits in habituation. The Sc group's initially slower running speed, although possibly caused by drug side effects unrelated to habituation, is consistent with the habituation interpretation since

an animal will be slowed by a deficit in his ability to habituate to general maze stimuli.

That the choice behavior is being directed by the incentive and not merely reflecting an initial turning tendency is clearly shown by the reversal data. The initially inferior post-reversal performance of the Sc group probably reflects that group's superior pre-reversal performance but could be contributed to by a general response inhibition deficit.

No evidence is presented here relating the behavioral effects of scopolamine specifically to brain-ACH activity. However, in view of the comparability of the present results to results found with other anticholinergic drugs and the repeated failures to find such effects with anticholinergics which have primarily peripheral effects (e.g., Carlton, 1968), it may be safe to assume that the effects are related to the attenuation of central-ACH activity. The failure to find any effects of eserine is not surprising without dose-response data and in view of the difficulty of predicting neural activity from cholinesterase inhibition (cf., Carlton, 1968).

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