appears that the 2-WH group is comparable to the 2-WN group early in training, whereas the performance of the former group has improved considerably by the end of training, to a point more similar to the 1-WH group. In order to assess this effect, analysis of variance and Scheffé's test were applied to both early (Trial Blocks 1-3) and late (Trial Blocks 6-8) portions of training. Results of the analysis of percent avoidance responses early in training showed a significant effect [$F(2,15) = 177.42$, $p < .01$], with group means of 6.67 (2-WN), 6.00 (2-WH), and 75.00 (1-WH). Analysis of data from the late portion of training also showed a significant effect [$F(2,15) = 94.63$, $p < .01$], with group means of 17.17 (2-WN), 81.00 (2-WH), and 99.00 (1-WH). Scheffé's test revealed significant differences between the 2-WN and 2-WH groups ($p < .01$), and also between the two-way and one-way handled groups, although in this case only at the .05 level. These effects are reflected in Fig. 1 by shift of the 2-WH function from the 2-WN level in early training to a level much closer to that of the 1-WH group at the end of training.

DISCUSSION

The performance of the 2-WN and 1-WN groups is in accord with results of other investigators making the same comparison (Theois & Dunaway, 1964; Olton & Isaacson, 1968). By the end of training, the performance of the 2-WH group is what would be anticipated on the basis of the results presented by Wahlsten et al (1968)—in fact, both the 1-WH and the 2-WH groups of the present study appear to be superior to the handled and handled-escape groups of the Wahlsten study at comparable points in training. The relatively poor performance of the 2-WN group requires a note of explanation, although it is typical of standard shuttle groups run in this particular apparatus. The low percentage of avoidance responses appears to be the result of the 2-WN animals withdrawing or cringing from the noise of the door dropping. The Ss in this group then tend to remain crouched until shock onset causes them to run to the other compartment.

It is particularly important to consider the performance of the 2-WH group over the entire course of training. This group, which starts at a level identical with that of the 2-WN group, improves rapidly during the middle phase of training, so that by the end of training the 2-WH group is more similar to the 1-WH than to the 2-WN group. This change is indicative of a conditioning effect and suggests that handling acquired some significance as an

additional cue during training. That handling did not merely serve to disrupt freezing behavior is suggested by the number of trials required for the two-way handled Ss to show an improvement in performance. In other words, the effects of such disruption should be evident earlier in training than these data show.

The results of two other studies also seem to be related to the effects of additional cues in shuttle avoidance. Olton & Isaacson (1968) found a decrement in performance when a light in the safe compartment, which originally served as a discriminative stimulus (but not as a CS), was left on continuously. On the other hand, Freedman & Callahan (1968), using either light or tone as a CS on different trials, reported no differences between a group that always received a particular CS on a particular side and a group that received these same CSs on a random schedule. Those authors concluded (p. 342) that rats do not attend to the CS as a differential cue. Collectively, the data from the present study and these latter two suggest that shuttle-avoidance responding might be facilitated by use of an additional cue prior to CS onset, which can serve a function analogous to a "ready signal" in signal-detection studies. Similarly, the spatial reorientation of the apparatus in the Baum & Bobrow (1966) and the Olton & Isaacson (1968) studies, since it occurred shortly before CS onset, could also have

served as a warning stimulus.

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Scopolamine's effect on passive avoidance*

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Comparison in performance on active and passive retention tests was made for mice that had received scopolamine prior to a single passive-avoidance training trial. Control animals performed well with either retention test procedure, while the scopolamine group performed well for the active test but poorly for the passive test.

In an earlier paper (Calhoun & Murphy, 1969), we showed that mice could be trained under conditions of passive-avoidance but tested for retention with either active- or passive-avoidance procedures. This technique is superior to one where only a single measure of retention is obtained; an animal should perform appropriately with either test

method if the initial training had been effective. From results in separate experiments, it appears that scopolamine disrupts passive-avoidance performance (Bohdanecy & Jarvik, 1967; Calhoun & Smith, 1968) but facilitates active-avoidance performance (Oliverio, 1967). To test the drug effect more thoroughly, we conducted the experiment reported here in which passive-avoidance training was used, but retention was tested with active- and passive-avoidance

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Table 1
Median Latency (.01 Sec) for the Response During Training and Retest

Treatment	N	Training Trial		Retest Condition	Retest Latency
		Latency to Enter	Latency to Escape Shock		
Scopolamine	10	39.50	22.50	Passive	59.50
Saline	10	31.75	21.25		289.50
Noninjected	10	30.00	23.00		291.50
Scopolamine	9	50.00	22.50	Active	28.00
Saline	10	38.75	25.25		30.75
Noninjected	9	35.00	25.00		26.50

procedures, and one group of mice had received scopolamine prior to the training trial.

SUBJECTS

The Ss were 60 male ICR mice obtained from Cumberland View Farms, Clinton, Tennessee, shortly after weaning. Their body weights ranged from 26 to 40 g at the time of testing. They were group housed with ad lib food and water until 2 days prior to the experiment. At that time they were transferred to individual cages with food and water available, except during the two brief testing periods. The Ss were assigned randomly to one of six groups of 10 each before the training trial.

APPARATUS

The apparatus was a box of two compartments, each of which was 15.3 x 15.3 cm. A small guillotine door connected the two compartments. Both compartments were painted gray and fitted with a grid floor; one was designated as the safe compartment. Scrambled constant-current dc shock was delivered to the other grid.

PROCEDURES

All animals were given a single training trial with what is termed passive-avoidance procedures. The mouse was placed into the safe compartment, and the guillotine door opened to provide access to the shock side, and time to enter was recorded. When the S had entered the shock compartment, the door was closed and 0.5-mA shock delivered to the grid. After 10 sec of inescapable shock, the door was reopened, but the shock continued until the animal escaped into the safe compartment, whereupon it was immediately removed, and escape latency was recorded.

Twenty of the Ss received an IP injection of 1.0 mg/kg of scopolamine hydrobromide 20 min prior to the training trial. Twenty mice received a placebo injection of saline, while the remaining 20 were not injected. Two animals were lost during the experiment due to procedural error.

The retention test was conducted 24 h later. One-half of each group was tested passively with the same procedures as the training trial but without shock. A

maximum of 3 min was allowed. The other animals were placed directly into the shock compartment, the door immediately opened, and latency to escape recorded (active test).

RESULTS

The data are presented in Table 1. First, let us examine the median times for the various groups to enter the shock side on the training trial. An obvious drug effect was to increase latency, as both drug groups averaged longer than the four nondrugged groups. The drugged mice were compared with the other groups, using the median test; the chi square was 3.85, reaching the .05 level of significance. Scopolamine does alter the behavior of mice and rats in a novel situation (Carlton & Vogel, 1967; Grant, 1968), and the longer latencies reflect this. Even though the scopolamine groups took longer to leave the safe compartment, they escaped from the shock as quickly as the control Ss (see table). This suggested that the shock experience was equal for all groups.

The critical data are the retest latencies. For the passive test a long latency indicates good retention, since the animal remained out of the compartment where it was previously shocked. For the active test a short latency indicates good retention, because the animal quickly left the compartment where it was previously shocked. The drug groups show the suspected paradoxical effect of scopolamine where mice perform well on the active test but poorly on the passive test. The active retest median latency for the drug group fell between the averages for the saline and noninjected groups, and inspection of the individual scores indicated there was no statistical difference between the groups. The passive retest measure for the scopolamine group is well below that of the other groups, and all Ss in the drug group entered the shock side on the retest. A comparison by the Mann-Whitney U-test of the scopolamine group and the combined control groups showed that the average latency for the drug group was significantly lower ($U = 55$, $p < .05$, one-tailed) than that for the nondrugged group.

DISCUSSION

The importance of this experiment is that two methods for assessing retention of a passive-avoidance training experience yielded similar results for normal animals, while it did not for drug-treated mice. The animals that had received 1.0 mg/kg of scopolamine hydrobromide prior to the training trial and were retested passively, behaved as if they had not received the shock experience. All 10 of those mice entered the grid compartment within the 3-min retention test period. The drug group was not reinjected prior to the retention test, so their performance on that day must reflect some factor due to the drug treatment during the training trial. However, since the active test data show good performance, one cannot conclude memory was affected. As suggested by several authors (Carlton, 1963; Calhoun et al, 1967), scopolamine modifies the exploratory behavior of rodents and decreases the rate of habituation, which may well be critical factors in the type of task used here. There is a large number of published studies in which effects of various treatments were found for passive avoidance, e.g., ECS interferes with retest performance, but such findings are not complete if the treatment differentially affects the two retention measures, as we have shown for scopolamine. A more complete analysis should be conducted before we reach general conclusions about treatment effects on memory.

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