Suppression and recovery of a one-trial avoidance response after a single ECS¹

R. M. Cooper, ALBERT EINSTEIN COLLEGE OF MEDICINE
R. J. Koppenaal, NEW YORK UNIVERSITY

Abstract

Groups of rats were subjected to either a single ECS or no ECS within a few sec. after receiving 1 or 2 punishing shocks in a box in which they had been trained to drink from a water spout. ECS groups drank more (avoided less) than no ECS controls at both 1 and 24 hr. after the punishing shocks. Two shock ECS groups tested at 24 hr., however, drank less than 2 shock ECS groups tested at 1 hr. These results were considered in terms of the notion of memory consolidation.

Introduction

There is evidence that when memory-disturbing events are interpolated between learning and a retention test, the degree of disturbance varies with the length of the retention interval. Thus, it is well established that in the retention of two consecutively learned competing verbal habits the recency effect favoring retention of the second habit dissipates over time (e. g., Underwood, 1948; Koppenaal, 1963). Similarly, Brady and his collaborators (Brady, 1951; Hunt, Jernberg & Brady, 1952) found a conditioned fear response to be vestigial four days after the last of a series of ECSs but clearly present at 30 days.

The possibility that habit-loss is also somewhat temporary when a single ECS is administered immediately after a learning trial has important implications for the notion of memory consolidation. This notion implies that ECS brings about a permanent impairment in retention.

In the present study an avoidance response established in a single trial, and followed by one ECS, was examined at different intervals after the convulsive treatment.

Subjects

Seventy-four female, black-hooded, 200-gm rats, purchased from the Canadian Research Animal Farms, were used. The 30 Ss used in Experiment 1 had prior experience with food deprivation and foot-shock. The Ss used in Experiment 2 were experimentally naive.

Apparatus

A 12 x 12 x 10-in unpainted waxed pine box was fitted with a grid floor and a 1 x 1/2-in pedal. The pedal was located beneath a water spout on one wall. Slight pressure on the pedal closed a circuit initiating a recording device. The pedal had no control over water delivery but was so situated that when drinking from the spout S would almost always press it down. On test days E monitored the drinking response via a mirror suspended above the box. By manipulating a switch E delivered a 0.5-sec. punishing shock of 5 to 8 ma. to S on the grid or when S was in contact with the water spout or pedal (500 v, 40K resistance, delivered to the grid, spout and pedal). This punishing shock was sufficient to make the Ss attempt to jump out of the box when the lucite top was opened and bite E's gloved hand when picked up. ECS was induced by administering a current of 50 ma. for 0.2 sec., via saline-soaked, gauze-covered, alligator clips attached to S's ears (500 v, 0 resistance, delivered to the clips).

Procedure

The Ss were placed on a 23 1/2-hr. water deprivation schedule for three days prior to daily 10-min. adaptation-drinking sessions in

boxes similar to the one described above. Four or five days later the Ss were placed in the test box and drinking time was recorded for 3 min. on each of three successive days. By this time most Ss showed a stabilized drinking response. Experimental treatments were administered on the following day.

Throughout the experiment Ss were introduced into the box against the wall opposite that containing the pedal and water spout. On the final three days of pretraining and on the treatment day, a vertical lucite partition was lowered half-way between the above walls after S had approached the water spout. This prevented return to the starting point and localized all punishing shocks in the half of the box nearest the water spout and pedal.

One min. after S was placed in the box on the treatment day E closed the punishing shock switch if S was drinking or as soon as S did drink. Some Ss received a second punishing shock 5 sec. after the first. Immediately after the punishing shock, S was removed from the box and ECS or control procedures were carried out within 30 sec.

Experiment 1 consisted of seven groups, chosen in a semi-randomized fashion to ensure that no group was weighted with Ss that drank relatively infrequently. These groups were subjected to the various treatments indicated in Fig. 1. In Experiment 2, similar to the first, three groups were added making a total of 10. Figure 2 indicates the various treatments they received.

Ss that underwent 24-hr. retention tests were given access to water 1 to 2 hr. after ECS on a stand that was used during training. One-hr. retention groups did not receive water during the interval. The same number of hours of water deprivation preceded the 1-hr. and 24-hr. retention tests.

Results

Figure 1, depicting the results of Experiment 1, shows that ECS Ss drank more than no-ECS Ss. It also indicates that 2-shock ECS Ss tested at 24 hr. drank less than 2-shock ECS Ss tested at 1 hr. ($U=1$; $p<.006$). The difference between the 1-shock ECS groups tested at 1 and 24 hr. is not significant ($U=7$; $p=.7$).

Fig. 1. Mean drinking times during 180-sec. period for groups: 1-E-1 (1 shock, ECS, retention test at 1 hr.), 2-E-1 (2 shocks, ECS, retention test at 1 hr.), 1-E-24 (1 shock, ECS, retention test at 24 hr.), 2-E-24 (2 shocks, ECS, retention test at 24 hr.), 1-NE-1 (1 shock, no ECS, retention test at 1 hr.), 1-NE-24 (1 shock, no ECS, retention test at 24 hr.), 2-NE-24 (2 shocks, no ECS, retention test at 24 hr.) and 0-0-0 (the mean drinking time of Ss on the last day of preliminary training).

Fig. 2. See legend under Fig. 1. The last 2 groups (0-E-1 and 0-E-24) shown on the right side of the figure designate Ss receiving ECS-only and subsequent drinking tests at 1 and 24 hr. respectively.

The results of Experiment 2, shown in Fig. 2, are similar to the first: ECS groups drank more than no-ECS groups; the 2-shock ECS Ss tested at 1 hr. drank more than 2-shock ECS Ss tested at 24 hr. ($U=6.5$; $p<.05$, one-tail); and there was no significant difference between the 1-shock 1- and 24-hr. ECS groups ($U=16.5$; $p=.82$). Figure 2 also indicates that ECS by itself does not seem to disrupt subsequent drinking at 1 and 24 hr.

While half of the no-ECS Ss had clips applied to their ears and half did not, these subgroups were combined in the figures since there were no indications of differences.

Discussion

The increase in avoidance behavior from 1 to 24 hr. by 2-shock, ECS animals may indicate that ECS does not impair the formation of a memory trace, but somehow interferes with its expression in behavior. That this suppression effect is not simply attributable to a temporary, postictal, general confusional state is indicated by several observations: loss of retention was signified by an active drinking response; there was no difference between 1-shock ECS 1-hr. and 24-hr. retention groups; and ECS-only Ss drank normally at 1 hr. The lack of recovery of the avoidance response in the 1-shock, ECS 24-hr. retention groups is not clearly contradictory since it is possible that a weaker habit would be suppressed by ECS for a longer duration. Unfortunately we could not establish an avoidance response in one trial that showed stability over longer periods of time.

While there is significant similarity between the results of the present work and those of Brady (1951) and Hunt et al. (1952), they seem to differ in one respect. Their studies showed that paralleling the return of the fear response in the ECS rats there was a similar though lesser gain in no-ECS animals. Possibly the slight but insignificant tendency for all four 24-hr. shocked groups to show greater avoidance than respective 1-hr. groups in Experiment 2 reflects a similar effect. If a fear "incubation" process (Kamin, 1957, 1963) was occurring

in our animals, then it is possible that the one 24 hr. difference reflects a growth in strength of the avoidance habit in addition to recovery from ECS suppression.

The best evidence for the consolidation interpretation of ECS effects is the general finding that the longer the interval between habit acquisition and ECS, the less the effect of the convulsions on memory (Glickman, 1961; Heriot & Coleman, 1962). It is difficult to reconcile the consolidation interpretation, however, with the fact that Brady (1952) found the same effect over intervals (60-90 days) which seem outside the bounds of a neural perseveration process. If fear incubation is a general phenomenon, these findings may be compatible with a suppression interpretation. With longer intervals between acquisition and ECS an incubated fear response, with greater habit strength, would be less subject to suppression by the convulsions.

Whether the foregoing speculations prove useful or not the present study, as well as those of Hunt et al., do not support two current interpretations of the effects of ECS on retention. The competition of response hypotheses of Coons & Miller (1960) and Lewis & Adams (1963) are not supported because loss of retention was demonstrated by an active approach response. Since the consolidation hypothesis (Glickman, 1961) implies permanent impairment of the trace the demonstration that ECS may only temporarily suppress retention is conflicting evidence for that interpretation.

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Note

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