Electroconvulsive shock, stress, and avoidance conditioning*

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Sixty-three rats were divided in equal numbers, such that one group received a series of 10 ECS treatments paired with a light CS, a second group received 10 unpaired ECS treatments, and a third received no ECS. Seven Ss in each group were then assigned to one of three CS conditions (light CS, tone CS, no CS) for purposes of avoidance conditioning. The results showed that ECS groups failed to show normal weight gain, while exhibiting greater amounts of urination and defecation during treatment. ECS-treated Ss also required a greater number of trials to reach criterion on the avoidance problem, an effect which was not related to specific CS pairings. It was concluded that the stressful effects of ECS were persistent and disruptive enough to restrict new learning in an aversive situation.

There is evidence that electroconvulsive shock (ECS), in addition to its retroactive effects, is capable of proactively influencing such behavior as maze learning (Leukel, 1957), active (Adams & Lewis, 1962; Vanderwolf, 1963) and passive (Poschel, 1957; Delprato, 1966) avoidance conditioning. Performance changes following ECS have frequently been explained in terms of competing response hypotheses, e.g., conditioned inhibition (Lewis & Maher, 1965), locomotor disinhibition (Vanderwolf, 1963), increased aversiveness (Aron, Glick, & Jarvik, 1969). These response patterns, however, have not been consistently observed, and, in a recent study which examined the disruptive nature of ECS and tested each of the above hypotheses, Winocur & Mills (1970) found a strong fear reaction to be the only clear effect.

In the present experiment, we confirm that ECS is a highly punishing stimulus and demonstrate that prolonged fear effects are capable of proactively interfering with the acquisition of a one-way active avoidance response.

METHOD

The Ss were 63 naive male Wistar rats, weighing between 250 and 310 g. All animals were housed individually in wire mesh cages, with food and water available on an ad lib basis.

At the beginning of the experiment, all animals were anesthetized under ether, and small aluminum ear tags (Wahmann Mfg. Co., Baltimore), which served as electrodes, were permanently attached to their ears. At that time, Ss were divided into three

groups of 21 rats each for purposes of administering ECS treatments. Group LECS was presented with a 25-W light CS for 10 sec, followed immediately by ECS; Group ECS received ECS alone; Group NECS received neither type of stimulation but, in all other respects, were treated the same as the other two groups. Full tonic-clonic seizures were produced in a 12 x 9 x 6 in. wood box by delivering a 45-mA current through wire leads connecting the electrodes to a 600-V transformer for 0.25 sec. During this part of the experiment, daily records were kept of the animals' body weights. In addition, counts were made of the number of boli and urinations in the treatment box.

After the last ECS treatment, each main group was divided randomly, for purposes of avoidance conditioning, into LCS, TCS, and NCS subgroups (all Ns = 7). LCS subgroups received avoidance testing with a 25-W light used as a CS, and, for the TCS subgroups, a 1,000-Hz 75-dB tone served as a CS in avoidance conditioning; there was no specific CS for the NCS subgroups.

The test apparatus consisted of an 18 x 12 x 6 in. chamber with wood walls and a grid floor. A manually operated Plexiglas door divided the chamber into a startbox painted black and a goalbox painted white. Two days after the last ECS treatment, Ss were given a 30-min habituation session in which they were allowed to explore freely both sides of the apparatus. Formal training was begun the next day. Each trial began with the animal being placed in the startbox with the Plexiglas door lowered. Five seconds later, the door was raised and the appropriate CS condition instituted. Movement to the goalbox within 10 sec constituted a correct avoidance response. If S failed to move to the goalbox within 10 sec, a 1.5-mA dc pulsating footshock came on and

Fig. 1. Mean weights for groups during treatment.

remained on until S escaped to the goalbox, at which time all stimuli were turned off, the door lowered, and the trial terminated. After 30 sec in the goalbox, S was returned to the startbox in preparation for the next trial. Fifteen such trials were administered daily until a criterion of nine avoidance responses on 10 successive trials was reached on a given day.

RESULTS

Figure 1 presents the average weight changes for all groups over the 10 treatment days. As can be seen from the graph, the nonshocked animals gained about 5 g/day, while both ECS groups failed to show any weight gain over the 10-day period. Analysis of variance applied to these data yielded significant Group by Day interaction ($F = 32.05$, $df = 18/540$, $p < .001$) and main ($F = 3.72$, $df = 2/60$, $p < .05$) effects. A Duncan multiple range test showed no significant differences between the ECS groups on any treatment day, but that the NECS group differed significantly from both ECS groups on Days 4-10, inclusive (all $ps < .05$).

The elimination measures recorded during the treatment sessions also illustrate the stressful effects of ECS (see Table 1). While the ECS and LECS groups did not differ from each other, both groups defecated and urinated significantly more often than the NECS group ($p < .001$, chi-square analysis).

In avoidance conditioning, the performance of the ECS-treated animals was consistently worse than

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Table 1
Median Urination and Defecation Scores During Treatment

	LECS	ECS	NECS
Urination	1.60	1.60	0.29
Defecation	4.30	3.20	0.30

that of the nonshocked animals, but once again there was no differential effect of pairing the ECS with a light stimulus. Accordingly, Table 2 shows the mean trials to criterion of the combined ECS and NECS groups in the three test conditions. T-test comparisons showed that the ECS-treated animals required significantly more trials to reach criterion than did control animals in each CS condition (all p s < .05). There were no significant differences within the ECS groups or within the NECS group across the CS conditions, indicating that the tasks were of comparable difficulty under the three conditions.

DISCUSSION

The major findings of the treatment phase of the experiment were that a series of electroconvulsive shocks restricted normal gain in body weight and contributed to relatively high defecation and urination rates in the treatment box. These results are in accord with previous reports (Pryor & Otis, 1970; Winocur & Mills, 1970) and, taken together, generally support the hypothesis, originally proposed by Coons & Miller (1960), that ECS is a stress-inducing agent capable of generating considerable fear in the S.

Previous attempts to study the proactive effects of ECS on one-way active avoidance conditioning have produced contradictory results. Some investigators have reported proactive interference of such learning (Adams & Lewis, 1962; Pryor & Otis, 1970) following a series of ECS treatments, while others (Vanderwolf, 1963; Delprato, 1966) found no effect at all. Our results clearly support those of the former investigators. However, while confirming the findings of Adams & Lewis (1962), it is difficult to accept the conditioned inhibition interpretation developed by Lewis and his colleagues (Lewis & Maher, 1965). Upon being placed in the test apparatus, the ECS-treated animals in the present experiment proceeded to freeze, remaining immobile until after the first shock, when they responded very quickly by escaping to the goalbox. Elimination rates in the apparatus were comparable between the ECS and NECS animals, and, in general, the behavior of all Ss during the early stages of testing was very similar. The basic difficulty of the ECS-treated animals appeared to be their inability to inhibit incompatible freezing behavior without the added stimulus of footshock. Thus, the results of this study suggest that, rather than reducing arousal levels (Lewis & Maher, 1965), ECS produces quite the opposite effect and that proactive interference of avoidance conditioning is more likely related to an uncontrolled fear reaction.

Table 2
Mean Number of Trials to Criterion
on Avoidance Testing

LCS		TCS		NCS	
ECS	NECS	ECS	NECS	ECS	NECS
55.8	33.9	57.1	30.1	40.6	22.1

The failure of the ECS Ss to channel constructive use of their fear in the avoidance test may reflect, in part, the generalized nature of the fear state. It is noteworthy that, while ECS interfered with subsequent avoidance conditioning, this effect was in no way related to similarities between the treatment and test conditions. If this had been the case, one might have expected to find the greatest learning deficit in the LECS Ss when they were tested in the light CS avoidance condition, i.e., that combination where treatment and test conditions were the most similar. Winocur & Mills (1970) also reported that, while ECS generated a discrete fear response which became conditioned to a specific CS, there was evidence that the fear effects were more general and extended beyond the highly specific conditions in which the CS was present.

Effects of chronic and acute morphine administration on one-way avoidance training*

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In a 2 by 2 design, chronically morphinized or nonmorphinized rats received either 7 mg/kg of morphine sulphate or physiological saline before training in a one-way avoidance apparatus. During the acquisition stage, the acute administration of morphine increased the number of shocks received by the nonmorphinized Ss but had no effect on the escape latencies of any of the groups. During the criterion run of 10 consecutive avoidances, chronic morphinization decreased avoidance latencies, while acute morphine administration had no effect.

A number of psychoactive substances (e.g., reserpine, chlorpromazine, morphine) have the property of selectively suppressing a conditioned avoidance response (CAR), while leaving escape behavior relatively intact (Cook & Weidley, 1957; Verhave, Owen, & Robbins, 1959). Compared with other drugs, the acute administration of morphine sulphate has been found to be the most specific inhibitor of an

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established CAR (Maffii, 1959; Herz, 1960).

The present study was designed to extend these findings by examining the effects of chronic, as well as acute, morphine administration on the acquisition and maintenance stages of CAR learning. We define the acquisition stage as beginning with the first and ending with the last escape trial and the maintenance stage as the criterion run of 10 consecutive avoidances.

METHOD

The conditioning apparatus consisted of two compartments