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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REFERENCES

- ADAMS, H. E., & LEWIS, D. J. Electroconvulsive shock, retrograde amnesia, and competing responses. *Journal of Comparative & Physiological Psychology*, 1962, 55, 299-301.
- ARON, C., GLICK, S. D., & JARVIK, M. E. Long-lasting proactive effects of a single ECS. *Physiology & Behavior*, 1969, 4, 785-789.
- COONS, E. E., & MILLER, N. E. Conflict versus consolidation of memory traces to explain "retrograde amnesia" produced by ECS. *Journal of Comparative & Physiological Psychology*, 1960, 53, 524-531.
- DELPRATO, D. J. Effect of electroconvulsive shock on inhibition of an active avoidance response. *Psychonomic Science*, 1966, 4, 15-16.
- LEUKEL, F. A. Comparison of the effects of ECS and anaesthesia on acquisition of the maze habit. *Journal of Comparative & Physiological Psychology*, 1957, 50, 300-306.
- LEWIS, D. J., & MAHER, B. A. Neural consolidation and electroconvulsive shock. *Psychological Review*, 1965, 72, 225-239.
- POSCHER, P. B. H. Proactive and retroactive effects of electroconvulsive shock on approach-avoidance conflicts. *Journal of Comparative & Physiological Psychology*, 1957, 50, 392-396.
- PRYOR, G. T., & OTIS, L. S. Persisting effects of chronic electroshock seizures on brain and behavior in two strains of rats. *Physiology & Behavior*, 1970, 5, 1053-1055.
- VANDERWOLF, C. H. Improved shuttle-box performance following electroconvulsive shock. *Journal of Comparative & Physiological Psychology*, 1963, 56, 983-986.
- WINOCUR, G., & MILLS, J. A. Aversive consequences of electroconvulsive shock. *Physiology & Behavior*, 1970, 5, 631-634.

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

Table 1
Means of Escape Latencies, Shocks Received, Precriterion Avoidance Latencies, and
Criterion Avoidance Latencies as a Function of Treatment Condition.
 Latencies are measured in seconds.

	M	M+	S	S+
Escape latencies	6.816	6.339	6.463	7.213
Shocks received	5.43	4.57	3.64	12.14
Precriterion avoidance latencies	2.663	2.572	2.823	2.367
Criterion avoidance latencies	1.336	1.169	1.935	1.772

separated by a manually operated guillotine door (cf. Theios & Brelsford, 1966). The shock chamber was painted black and had a stainless steel grid floor, through which 1.5 mA of constant-current high-voltage shock was delivered by a relay-sequencing grid scrambler (Hoffman & Fleshler, 1962). The white nonshock chamber had a wood floor.

The conditioned stimulus (CS) was composed of the simultaneous raising of the guillotine door, offset of the 15-W lamp in the end wall of the shock chamber, and the onset of a 98-dB intermittent tone (1,500 Hz, 5 pulses/sec) through a speaker set into the shock chamber roof. Ambient noise level was 65 dB and was measured on the C scale of a Scott sound pressure level meter. Response latencies were read from a Standard Electric Timer in 100ths of a second.

At 50 days of age, 21 male Wistar rats were paired by weight with littermates (seven litters of 6 rats/litter). One member of a pair was assigned randomly to either a morphine (M) or saline (S) group, and the other member was assigned to the other group. Each litter was housed together in a large group cage. The M group received IP injections of morphine sulphate (30 mg/ml) every 12 h, starting with a 20 mg/kg dose. The dosage was increased each day by 5 mg/kg to a level of 30 mg/kg. Thereafter, daily increments were calculated on the basis of 10% of the previous day's dose. The Ss were stabilized at a level of 100 mg/kg every 12 h for 4 days before training began. The S group received the same relative volume (by weight) of 0.9% saline solution, IP.

Five and one-half hours after the last morning injection, seven Ss from each of the M and S groups received 7 mg/kg of morphine sulphate, IP (the M+ and S+ groups, respectively), and the remaining 28 rats received an equivalent volume of saline solution. It has been found that 7 mg/kg has no effect on the spontaneous motor activity of pharmacologically naive rats (Collins, 1965).

Training began for all groups 30 min after the acute injection. Each S was allowed to explore the shock chamber for 1 min, following which adaptation trials were presented, during which no

shock was delivered. The criterion for the initiation of training was four consecutive trials in which the S remained in the shock chamber for 11 sec after CS onset without the shock being presented. Each acquisition trial was defined as the period from CS onset until the rat entered the nonshock chamber. The CS-shock interval and the intertrial interval were 5 and 30 sec, respectively. An avoidance response was defined as entering the nonshock chamber within 5 sec of CS onset. During avoidance training, the S was left in the nonshock side for 15 sec and then returned to the shock side for the remainder of the intertrial interval. Training continued to a criterion of 10 consecutive avoidances.

RESULTS

Separate 2 by 2 analyses of variance were performed on the means of escape latencies, number of shocks received, precriterion avoidance latencies, and criterion avoidance latencies. The means of these variables are shown in Table 1. The absence of significant differences between mean escape latencies on either the acute or chronic morphine dimension or their interaction suggests that the differences in avoidance behavior reported below were not a consequence of analgesia or locomotor impairment.

Although the acute administration of morphine did not influence any dimension of avoidance behavior in chronically morphinized rats, suppression of acquisition in pharmacologically naive rats was demonstrated by the significantly greater number of shocks received by the S+ group ($F = 11.44$, $df = 1,38$, $p < .005$). The significant interaction ($F = 17.20$, $df = 1,38$, $p < .005$) was also due to the greater number of shocks received by the S+ group.

Rats receiving chronic morphine injections had significantly shorter criterion avoidance latencies than nonmorphinized Ss ($F = 11.70$, $df = 1,38$, $p < .005$). Neither the acute morphine dimension nor the interaction was significant.

Finally, the analysis of precriterion avoidance latencies revealed no differences between any of the groups due to either drug treatment or their interaction.

DISCUSSION

The results of this experiment are consistent with other findings of the differential effect of morphine sulphate on an established CAR (Cook & Weidley, 1957; Verhave et al, 1959). The present study demonstrated a similar specific morphine-induced inhibition of CAR acquisition, as well as a facilitatory effect on CAR maintenance attributable to chronic morphine administration.

The acute administration of morphine sulphate (7 mg/kg) inhibited acquisition, as evidenced by the greater number of shocks received by the nonmorphinized, as compared to chronically morphinized, rats. Chronic morphinization was prepotent during the maintenance phase, as seen in the significantly shorter criterion avoidance latencies exhibited by the chronic group. Neither acute nor chronic morphine administration had any effect on escape or precriterion avoidance latencies.

The marked difference between the acute morphine groups (M+ and S+) in the number of shocks received is probably a reflection of the development of tolerance in the chronic Ss. Although we did not make any direct measurement of tolerance, there is evidence that rats receiving 100 mg/kg morphine sulphate every 12 h are tolerant to the effects of the drug and are in a state of partial withdrawal 6 h after the last morphine injection (Martin, Wikler, Eades, & Pescor, 1963).

REFERENCES

- COLLINS, L. G. Effect of morphine sulphate on spontaneous activity level of the albino rat. *Psychological Reports*, 1965, 16, 693-696.
- COOK, L., & WEIDLEY, E. Behavioral effects of some pharmacological agents. *Annals of the New York Academy of Sciences*, 1957, 66, 740-752.
- HERZ, A. Drugs and the conditioned avoidance response. In C. C. Pfeiffer and J. R. Smythies (Eds.), *International review of neurobiology*. New York: Academic Press, 1960.
- HOFFMAN, H. S., & FLESHLER, M. A relay sequencing device for scrambling grid shock. *Journal of the Experimental Analysis of Behavior*, 1962, 5, 329-330.
- MAFFII, G. The secondary conditioned response of rats and the effects of some psychopharmacological agents. *Journal of Pharmacy & Pharmacology*, 1959, 11, 129-139.
- MARTIN, W. R., WIKLER, A., EADES, C., G., & PESCOR, F. T. Tolerance to and physical dependence on morphine in rats. *Psychopharmacologia*, 1963, 4, 247-260.
- THEIOS, J., & BRELSFORD, J. W. Theoretical interpretations of a Markov model for avoidance conditioning. *Journal of Mathematical Psychology*, 1966, 3, 140-162.
- VERHAVE, T., OWEN, J. E., & ROBBINS, E. B. The effect of morphine sulphate on avoidance and escape behavior. *Journal of Pharmacology & Experimental Therapeutics*, 1959, 125, 248-251.