inclusion of the appropriate control groups in ECS experiments.

The observed aversiveness of a single ECS is to be logically expected given the generally accepted aversiveness of multiple ECS (Hudspeth, McGaugh, & Thomson, 1964). If the sole effect of ECS was amnesic, after each convulsion the S should appear naive. That aversiveness results from repeated ECSs strongly suggests that fear of ECS-associated cues is cumulative starting with the first ECS.

The theoretical point of this study is that, at least in situations to which the S has been extensively exposed, ECS fails to prevent the formation of a memory of itself. As the temporal interval between onset of the aversive stimulus (ECS in this case) and ECS is obviously nil, the conclusion must be drawn that "memories" that have had no time at all to consolidate can survive ECS. This is equivalent to saying that unconsolidated memories are not necessarily rendered unavailable by ECS. Lewis, Miller, & Misanin (1969) reported that after pretraining familiarization with the apparatus, ECS could not interfere with a 0.5-sec-old memory. They accepted the conventional view that ECS acts selectively upon unconsolidated memories and concluded that consolidation could reach an initial first stage of completion in less than 0.5 sec. The present data suggest that ECS is an inadequate probe to separate recently received information from consolidated memories.

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The effects of shock intensity and intertrial interval duration on the operant level of a shuttle-avoidance response

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The factorial assessment of the effects of shock intensity and ITI on the unreinforced occurrence of shuttle responses showed that these variables affect initial response rate in the same way as they have been shown to affect shuttle-avoidance acquisition. It was also shown that CS introduction uniformly enhanced operant-avoidance rates. It was concluded that CS introduction, long ITIs, and low shock intensities each enhance response probability and, consequently, increase the likelihood of response reinforcement.

In a first attempt to discover factors determining the probability of unreinforced responses in a shuttle-avoidance situation, the intensity of the UCS and the duration of the intertrial interval (ITI) were selected for study. Moyer & Korn (1964), Levine (1966), and Cicala & Kremer (1969) have uniformly shown that shuttle-avoidance learning is inversely related to shock intensity. While Murphy & Miller (1956) and Levine & England (1960) have shown that shuttle-avoidance learning improves with increases in ITI duration, Brush (1962), in a complete assessment of this parameter, found improvement up to 5 min.

Since the acquisition of a shuttle response must depend upon the initial probability of occurrence of that response, it is reasonable to assume that if different shock intensities and different ITIs produce differences in unreinforced response rate, these differences may account, either wholly or in part, for the results of parametric studies of shuttle-avoidance learning. The present study was done to test this hypothesis.

SUBJECTS

Thirty-two male Wistar rats, 90-110 days old, were used.

APPARATUS

A test cage constructed entirely of stainless steel grids spaced ½ in. apart in a Plexiglas frame, 9 x 7½ x 6½ in. was used. All of the grids were wired for shock. A speaker directed at the test cage was mounted in the top of a sound-attenuating chamber enclosing the test cage. A variable-output 150-K-ohm fixed-impedance shock source (Campbell & Masterson, 1969) provided the shock stimuli. Interruptions of a photocell beam bounced across the width of the test cage recorded crossings.

PROCEDURE

Ss were divided into four groups and were assigned to a 2 by 2 factorial matrix varying shock intensity, 120 V vs 300 V, and ITI, 35 sec vs 5 min. Each S was placed in the test cage and, after 2 min, was presented with 50 inescapable, unavoidable presentations of a 12-sec, 80-dB, white-noise CS, the last 2 sec of which was paired with an overlapping 2-sec electric shock.

Crossings measured by photocell interruptions served as the index of unreinforced avoidance responding. This measure was taken during the 10-sec period prior to CS onset (pre-CS) and during the initial 10 sec of the CS period (CS).

Fig. 1. Mean crossings per trial as a function of pre-CS and CS conditions for shock intensity and ITI duration. Since these are interaction figures, the scores on all Ss are included in both graphs.

RESULTS AND DISCUSSION

A four-way analysis of variance on the mean crossing scores for blocks of five trials assessed Shock Intensity by ITI by Stimulus Condition (pre-CS vs CS) by 10 Trial Blocks. This analysis showed that crossings were inversely related to intensity ($F = 7.64$; $df = 1/28$, $p < .01$), and that crossings during the CS were reliably greater than during pre-CS ($F = 42.69$, $df = 1/28$, $p < .01$). It also showed crossings to diminish over blocks of trials ($F = 13.54$, $df = 9/252$, $p < .01$). While the main effects of ITI were not significant, ITI interacted significantly with stimulus condition ($F = 12.52$, $df = 1/28$, $p < .01$). No other interaction was significant.

These results are illustrated in Fig. 1. The top graph shows the Intensity by Stimulus Condition interaction, and the bottom graph shows the ITI by Stimulus Condition interaction. It is clear from the top graph that crossing scores for the two intensities of shock are parallel, with more crossings under 120 V than under 300 V. This graph also shows that less crossing occurred during the pre-CS condition than during the CS condition. The bottom graph shows that the increase in the crossing scores from the pre-CS to the CS condition is greater with the 5-min than with the 35-sec ITI. Trials were not presented since

they did not interact with any of the three factors described.

Assuming that the crossing scores obtained reflect the initial probability of unreinforced responding in a shuttle-avoidance situation, the data bear a suggestive similarity to the results of parametric studies of shuttle-avoidance learning. First, where avoidance learning has been consistently shown to vary inversely with UCS intensity, the present experiment shows that the unreinforced response rate varies inversely with shock intensity. Further, where avoidance learning has been shown to increase with ITI up to 5 min, the present results show that initial response rate varies directly with ITIs within this range. It may be safely concluded that the results of these parametric studies of avoidance learning may be caused by differences in initial response rate, which results in the differential probability of response reinforcement.

It is, of course, questionable to use the total number of responses that occur in the presence of a CS as an indicator of the initial rate of responding in an avoidance-learning situation where characteristically only the first response during the CS is measured. An index of initial response rate which is more analogous to frequency of avoidance responding, the total number of trials on which at least one crossing occurred during the CS, was obtained and analyzed. An Intensity by ITI analysis of variance showed that as intensity increased crossings decreased ($F = 4.57$, $df = 1/28$, $p < .05$), and as ITI increased crossings increased ($F = 6.99$, $df = 1/28$, $p < .05$). These measures did not interact. It thus appears that the previous conclusions also apply to this measure.

The results of the present study suggest that a CS increases initial response rate over the rate preceding its introduction, and, as Fig. 1 shows, this is the case for both ITIs used. The number of crossings during the CS period was greater than the pre-CS period for the 35-sec ITI ($t = 3.04$, $df = 15$, $p < .01$) and for the 5-min ITI ($t = 5.93$, $df = 15$, $p < .001$). The facilitative effects of CS introduction are clearly inconsistent with views of the CS as an elicitor of freezing responses in either a fear-conditioning (Bindra & Palfai, 1967) or an avoidance-learning situation (Weiss, Krickhaus, & Conte, 1968), but suggest conversely that the CS introduction reduces freezing responses, possibly in the manner suggested by Blanchard & Blanchard (1969), increasing initial response rate and thus increasing the probability of adaptive responding.

The interaction between stimulus

condition and ITI poses an interpretive problem. Brush (1962) has proposed that while CS fear extinguishes equally with both long and short ITIs, situational fear is extinguished more with long ITIs. The relative amount of fear reduction produced by CS termination for long ITIs is greater, and this greater reinforcement leads to faster avoidance learning. In the present study, the occasional reinforcement of crossings occurring coincidentally with CS and UCS termination should be equal, and thus the rate of crossings during the CS periods might be assumed to be equal. An interpretation of the ITI by Stimulus Condition interaction consonant with Brush's reasoning, then, might postulate differential rates of crossings during the pre-CS periods. The virtual identity of the pre-CS crossing rates with differing ITIs argues against this interpretation. As indicated in Fig. 1, pre-CS crossing rates do not differ with ITI ($t < 1$). Crossings during the CS period, however, are greater with 5-min than with 35-sec ITIs ($t = 2.55$, $df = 30$, $p < .02$). A preferred interpretation of this interaction is that the CS is a stimulus which increases crossing rate, and that with longer ITIs greater facilitation occurs because the CS is more readily discriminated.

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