Nonshock confinement duration and shock- and safebox similarity during escape training in rats

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Sixty female hooded rats received 70 shock-escape training trials with shock- and safeboxes similar or dissimilar to each other and nonshock (safebox) confinement durations of 5 sec or 20 sec. (Shockbox confinement duration prior to shock onset was 5 sec.) In each confinement condition performance under the similar shock/safe condition was reliably poorer than that under the dissimilar condition. Safebox confinement duration negligibly affected performance under the dissimilar condition, while in the similar condition increasing confinement duration reliably facilitated performance. Comparisons with control data suggest that facilitation of escape was due to the relative shock-safe confinement duration rather than to absolute safebox confinement.

The acquisition of avoidance (Knapp, 1965) and escape behavior (Franchina, Bush, Kash, Troen, & Young, 1973) is impaired when shock and safe compartments are similar rather than dissimilar to each other. An interpretation of these results within Denny's (1971) theory of avoidance/escape behavior (see Franchina et al., 1973) holds that under avoidance/escape procedures relaxation and/or relief responses develop in the temporal interval following the offset of aversive stimulation (Delprato & Denny, 1968; Denny & Weisman, 1964) and become established to environmental cues of the nonshock (safe) condition. Relaxation is conceived as a long-latency response whose onset in the safe situation occurs 25 to 40 sec following termination of shock or a warning signal (CS) and whose minimal optimal duration is about 150 sec (Denny, 1971, p. 289). Relief is regarded as a short-latency response which starts 5 sec after shock termination (only) and is complete 10 to 15 sec later. On the basis of stimulus similarity between safe and shock compartments relaxation/relief responses are presumed to generalize ("backchain") from safe- to shockbox stimuli and early in avoidance/escape training serve to mediate approach to the safe situation. However, increasing occurrences of "backchained" relaxation/relief in the shockbox presumably come to compete with the motivational basis of avoidance or escape behavior and, consequently, may impair acquisition (e.g., Franchina et al., 1973; Knapp, 1965) and facilitate extinction (e.g., Denny, Koons, & Mason, 1959).

According to this analysis the effects of nonshock confinement duration may be mitigated by the similarity between shock- and safeboxes during avoidance/escape

training. If relaxation/relief responses occur with increasing durations of safebox (nonshock) confinement, and if these responses generalize from safe- to shockbox cues on the basis of stimulus similarity, then, within the temporal intervals proposed by Denny (1971, p. 289), the longer the duration of safebox confinement the poorer the performance (e.g., in acquisition) should be when shock- and safeboxes are similar to each other. However, increasing safebox confinement duration may either facilitate performance or yield negligible effects when shock- and safeboxes are dissimilar to each other, depending on their relative degree of distinctiveness. For example, Denny and Weisman (1964) reported that in avoidance training with distinctive shock and safe areas (black versus white compartments) performance increased the longer the duration of nonshock (safebox) confinement. On the other hand, the facilitative effect of increasing nonshock confinement in the dissimilar shock/safe situation may become attenuated by the presumed "backchaining" of relaxation/relief responses to the shock situation and the resultant competition between these behaviors and avoidance/escape tendencies.

The purpose of the present experiment was to investigate the effects of nonshock confinement duration and shock- and safebox similarity during instrumental escape training (see Franchina et al., 1973). In support of the plausibility of an interaction between duration and similarity variables, data from Denny and Weisman (1964) show that increasing safebox confinement duration impaired avoidance performance when shock- and safeboxes were similar to each other (in extinction) and facilitated avoidance performance when shock- and safeboxes were dissimilar to each other (in acquisition). These investigators did not directly compare similar with dissimilar shock/safe conditions in either acquisition or extinction. They shifted from dissimilar to similar conditions in the shift from acquisition to extinction.

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Figure 1. Mean reciprocals of latency of hurdle jumping in blocks of 10 trials for groups trained with shock-safebox confinement durations of 5-5 sec, 5-20 sec, and 20-20 sec under similar (SIM) and dissimilar (DIS) shock- and safebox stimuli.

METHOD

Apparatus. The apparatus was that described by Franchina et al. (1973, Experiment 3). Briefly, a shockbox was separated from a safebox by a guillotine door and a hurdle. The boxes were made of wood and appeared highly similar to each other. In each box the walls were covered with white Plexiglas (0.16 cm thick) and the floors were grid rods. In the shockbox the grid floor was connected to a constant-voltage shock (dc) source. The current at the grids was 1.0 mA. The safebox floor was movable and could be depressed by the rat's weight to act as a switch.

Subjects. Subjects were 60 experimentally naive female hooded rats, 110 to 120 days old, from the local departmental colony. Throughout the experiment the rats were housed in pairs with food and water continually available.

Procedures and Design. On the first day of the experiment each rat was handled for 2 to 3 min and then was placed into shock and safe compartments for 3 min each. Illumination in each compartment was 110 ftc. Following placements the rats were randomly assigned to six groups and, starting on the next day, received a total of 70 escape-training trials, 10 trials/day. To start a training trial the rat was placed into the shockbox; shock- and safebox illumination was 110 ftc. Five sec later, the guillotine door was raised, simultaneously activating the shock and a timer, calibrated in .01 sec. If the rat jumped the hurdle within 40 sec the safebox floor was depressed, terminating the shock and the timer. For half of the rats ($n = 30$), depression of the safebox floor reduced safebox illumination from 110 ftc to 9-12 ftc (see Franchina et al., 1973). For the other half of the rats ($n = 30$), depression of the safebox floor did not alter safebox illumination. These conditions represented dissimilar (DIS) and similar (SIM) shock and safe situations, respectively. Following hurdle jumping 20 rats in each similarity/dissimilarity condition were confined in the safebox for 5 sec or for 20 sec ($n = 10$ each) and then were removed to an unpainted wooden holding box (30 cm x 30 cm x 30 cm) for the remainder of the

intertrial interval (ITI). The total ITI was 35 sec. This total consisted of the duration of safebox confinement, 5 sec or 20 sec, plus the complementary duration spent in the holding box, 30 sec and 15 sec, respectively (see Denny & Weisman, 1964).

However, it should be noted that after being placed into the shockbox, the rat was confined for 5 sec prior to the raising of the guillotine door and the activation of shock. Considering this confinement duration of 5 sec in combination with safebox confinement durations of 5 and 20 sec, respectively, it appears that the groups differ from each other in terms of *absolute* duration of safebox confinement (5 sec vs. 20 sec) and in *relative* confinement durations between shock- and safeboxes (5-5 vs. 5-20 sec of shock-safe confinement, respectively). Weisman, Denny, and Zerboli (1967) reported that avoidance responding is linearly related to relative confinement durations between nonshock (safe) and shock situations when these situations are highly distinctive from each other. Thus, to evaluate the effects of absolute vs. relative durations of nonshock (safebox) confinement for 5-5 and 5-20 groups this experiment included an additional group ($n = 10$ rats) in each similarity condition. For this group, 20-20, durations of confinement in the shockbox prior to shock onset and in the safebox after hurdle jumping were 20 sec. Thus, the design for this experiment combined two conditions of shock/safebox similarity¹ (SIM vs. DIS) and three confinement conditions (5-5 sec, 5-20 sec, and 20-20 sec for shock/safe compartments, respectively).

On all training trials escape performance was measured in terms of latency of hurdle jumping. If the rat failed to jump the hurdle within 40 sec, the guillotine door was lowered; shock remained on; and the rat was removed to the holding box for the ITI. A latency of 40 sec was recorded for such trials. All latency scores were converted to reciprocals for an index of escape speed.

RESULTS

Figure 1 presents mean reciprocals of latency of hurdle jumping for 5-5, 5-20, and 20-20 shock/safe confinement durations (sec) in SIM and in DIS conditions. Training under SIM yielded performance which was consistently inferior to that under DIS for all confinement durations. In the SIM condition the 5-20 group performed better than did the 5-5 and 20-20 groups, while the latter two groups did not differ appreciably from each other. In the DIS condition the confinement duration groups performed similarly to each other. Analysis of variance over all the data of Figure 1 yielded a reliable interaction between similarity conditions, confinement duration, and trial blocks ($F = 6.32$, $df = 12/324$, $p < .01$). Simple effects analysis for SIM and for DIS conditions separately showed that over Trial Blocks 5-7 the effect for confinement duration was reliable in the SIM condition ($F = 9.21$, $df = 2/54$, $p < .01$) but not in the DIS condition ($F = 1.01$). The effect of trial blocks was not reliable ($F_s < 1$) in either analysis, an indication that by the end of training a stable level of responding was attained. Scheffe comparisons for duration conditions in SIM showed that on Trial Blocks 5-7 the 5-20 group differed reliably from both 5-5 and 20-20 groups ($p_s < .01$). The latter groups did not differ reliably from each other. Comparisons between SIM and DIS conditions for each

confinement duration on Trial Blocks 5-7 yielded reliable effects ($ps < .01$) in all cases. (It should be noted that evaluation of the data of Trial Blocks 5-7 by means of a 2×2 factorial analysis of variance which combined SIM vs. DIS and 5-5 vs. 5-20 groups, on one hand, and then SIM vs. DIS and 5-20 vs. 20-20, on the other, in each case also yielded a reliable interaction between similarity conditions and confinement durations ($ps < .05$).

DISCUSSION

Escape performance under the similar shock/safe condition was reliably poorer than that under the dissimilar condition for each confinement duration. However, the effect of confinement duration was differential for the similarity conditions; escape performance in the DIS condition was negligibly affected by safebox confinement duration, while performance in the SIM condition was reliably facilitated by relative safebox confinement durations. The 5-20 SIM group performed reliably better than did 5-5 and 20-20 SIM groups, which performed similarly to each other.

Finding a reliable SIM-DIS difference is consistent with Franchina et al. (1973) and with the relief portions of Denny's (1971) theory. (Present results seem more amenable to a relief rather than to a relaxation interpretation because relatively brief postshock confinement durations, 5 sec and 20 sec, were used.) In the SIM condition relief presumably occurred in the safebox postshock and generalized ("backchained") to similar stimuli in the shockbox. Eventually, relief occurrences in the shockbox came to impair escape performance. The basis for this impairment, at least in the avoidance situation (see Denny, 1971), is presumably response competition between relief (or relaxation) in the shockbox and fear conditioned to shockbox stimuli by prior shock presentations. In the present shock-escape situation the basis for response impairment seems less clearcut. If, in fact, Denny's (1971) theory is applicable to the shock-escape situation, then the sequence of events should be comparable to that in the avoidance situation (i.e., relief occurrences in the safebox, "backchaining," etc.). Thus, the impairment of shock-escape behavior should be due to response competition between backchained relief and fear. However, it is uncertain whether relief competes with conditioned fear elicited by shockbox cues alone (i.e., prior to shock onset) or with pain and/or fear produced following shock onset. If relief competes with conditioned fear, then possibly the duration of shockbox confinement prior to shock onset may be a salient variable. The present data do show reliably poorer performance for the 20-20 SIM group than for the 5-20 SIM group. However, because of their paucity, these data are at best suggestive; additional confinement durations and controls should be investigated.

The results for safebox confinement duration were both consistent and inconsistent with expectations. Specifically, the finding of a reliable effect of safebox confinement duration (albeit only in SIM condition) is in itself consistent with Denny's (1971) theory and with previous data from Delprato and Denny (1968) and Weisman et al. (1967). Delprato and Denny (1968) showed that under "vicious circle" procedures (Brown, Martin, & Morrow, 1964) the longer the duration of postshock confinement (up to 30 sec in the safebox) following punishment of avoidance behavior in extinction, the greater the resistance to extinction. These data provided original evidence for postshock duration effects and relief behavior. Presumably, increasing postshock confinement durations occasioned relief, a positive factor, which mediated approach to the nonshock (safe) situation and thereby served to maintain avoidance responding (Delprato & Denny, 1968, p.463). While Delprato and Denny (1968) showed duration effects in the maintenance of instrumental avoidance responding, the present study provides additional (and, perhaps, new) information on duration effects and relief behavior by showing that postshock confinement duration influences the establishment of instrumental (shock-escape) behavior. Further, in the present study escape responding was facilitated by relative rather than by absolute conditions of safebox confinement. If these data are interpretable in terms of short-latency relief, then, they parallel the effects for relative confinement duration which Weisman et al. (1967) reported for shuttle-avoidance training and, presumably, long-latency relaxation.

It should be noted, however, that the duration effects reported by Weisman et al. (1967) occurred in training with distinctive shock and safe situations (black vs. white compartments). In the present experiment duration effects were reliable in the SIM condition and were negligible in the distinctive shock/safe condition (i.e., DIS). This inconsistency between present results for DIS and those of Weisman et al. (1967) may reflect either: (a) task differences (a shuttle-avoidance task for Weisman et al. (1967) vs. a one-way escape task in this study), (b) manipulation of shock- and safebox similarity response contingently in this study as compared to the maintenance of constant conditions of shock/safe dissimilarity in Weisman et al. (1967), or (c) use of a relatively small difference in relative confinement duration between shock- and safeboxes in the present study (15 sec) vs. a minimum of 30 sec and an upper limit of 190 sec in Weisman et al. (1967). The choice among these alternatives is currently moot.

Finally, while reliable duration effects were obtained in the SIM condition in this experiment, the direction of these differences is opposite to those originally expected from Denny's (1971) theory. Presumably, the longer the duration of safebox confinement, the greater the availability of relief for "backchaining" to shockbox cues in the SIM condition, and thereby the greater the

impairment of escape performance. Consequently, performance of the 5-20 and 20-20 SIM groups should be poorer than that of the 5-5 SIM group. These expectations were contradicted by the present results: 5-20 SIM reliably outperformed 20-20 and 5-5 SIM groups, which performed like each other. To accommodate these data within Denny's (1971) theory, it might be assumed that in the SIM condition generalization of relief from safe- to shockbox cues was mitigated by the relative distinctiveness accorded to these boxes by their differential confinement durations. If formation of a temporal discrimination occurred between shock- and safeboxes for the 5-20 SIM group, and if this discrimination curtailed generalization of relief to shockbox cues, then escape behavior may have been less impaired and relief-mediated approach to the safebox may have been enhanced for 5-20 SIM over that for 5-5 and 20-20 SIM groups. This assumption of a temporal discrimination between shock and safe situations is tentative, but it seems reasonable because Denny and his co-workers have previously ascribed discriminative cue properties to differential confinement durations. For example, Weisman et al. (1967) reported that when differential confinement periods occurred in distinctive (black vs. white) compartments of a shuttlebox, shuttle-avoidance performance was facilitated toward the longer of the two confinement conditions. When confinement duration was held constant between the compartments performance was not differentially affected by distinctive compartmental cues (Weisman et al., 1967, p. 35). Since the occurrence of shock in either compartment in shuttle-avoidance training may have made the compartments comparably aversive, the latter results suggest that the influence of distinctive external compartmental stimuli (black vs. white) was negligible when confinement durations were nondifferential. Considering this, it appears that differential confinement durations served as discriminative cues which demarcated the shuttle compartments.

In the present study shock- and safebox stimuli in the similar condition were certainly not highly distinctive from each other. Thus, it is difficult to specify a mechanism for temporal discrimination in this situation until data from other confinement conditions (e.g., a 20-5 SIM group) are available. However, if a case can be made for temporal discrimination between otherwise similar shock and safe areas, then manipulation of shock- and safebox similarity, at least within Denny's (1971) theory, might consider generalization based on similarity of temporal components as well as similarity of situational stimuli.

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NOTE

1. In this experiment the results of shock- and safebox similarity are reported for responding from a bright (white) shockbox to a darker safebox in the DIS condition. Some investigators (e.g., Allison, Larson, & Jensen, 1967) have reported a preference in rats for responding from a light to a dark situation. Thus, it is possible that differences in performance between DIS and SIM conditions may reflect effects of a preferential direction of responding rather than effects of a similarity variable per se. However, prior data from this laboratory (Franchina et al., 1973, Control studies A and B) and considerable evidence from related studies which employed similar equipment (e.g., Denny & Weisman, 1964; Weisman, Denny, Platt, & Zerbolio, 1966; Zerbolio, 1968) indicate that the direction of responding (light to dark and vice versa) does not yield reliable differential effects on performance. Considering this previous information, this study investigated the effect of shock/safebox similarity using a light to dark direction of responding. However, to evaluate the effects of responding from dark to light, a brief replication ($n = 4$ rats per group) of groups 5-20 SIM, 5-20 DIS, and 20-20 DIS was performed using a dark to light direction of responding for DIS and dark to dark for SIM. Results were essentially like those obtained for training from light to dark.

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