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EXTINCTION OF SIDMAN AVOIDANCE BEHAVIOR[1]

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Extinction of Sidman avoidance behavior by eliminating the noxious stimulus was studied in Sprague-Dawley rats with bar-pressing as the response. Each of three subjects was trained and extinguished on each of the following schedules in a different order: nondiscriminated, response-shock interval = 20 sec, shock-shock interval = 5 sec; nondiscriminated, response-shock interval = 40 sec, shock-shock interval = 5 sec; discriminated, response-white noise interval = 15 sec, noise-shock interval = 5 sec, shock-shock interval = 5 sec. Less than one 4-hr session was required for extinction for all procedures. When a warning stimulus was present, resistance to extinction increased. Subjects did not, however, respond to avoid the signal. Only small differences in extinction were found after training on different schedules with no warning signal.

The maintenance of Sidman avoidance behavior when the negative reinforcer is permanently withdrawn has not been investigated. Sidman (1955) studied the extinction component of a mixed conditioning-extinction schedule. Thirty minutes of avoidance alternated with 15 min of extinction in which the shocks were withheld. The extinction periods were so short that the avoidance behavior was not modified by the extinction contingencies. Boren and Sidman (1957) and Boren, Sidman, and Herrnstein (1959) used a schedule of 3 hr of training followed by 3 hr of extinction in successive daily sessions. They did not, however, study the extinction of the behavior until responding ceased without retraining.

Sheffield and Temmer (1950) compared the relative resistance to extinction of a running response to escape or avoid shock. Based on their interpretation of their results, they theorized that greater resistance to extinction would result from avoidance training with longer delay intervals. They predicted this from the consideration that non-avoidance responses performed during long pauses after the avoidance response would be followed by shock. Since behaviors associated with long periods of not responding predominate in extinction, the punishment of these behaviors would result in a larger total number of avoidance responses in extinction in spite of lower rates. The Sidman avoidance procedure can provide a test of this hypothesis.

The extinction of Sidman avoidance behavior by eliminating the noxious stimulus was studied as a function of three different training conditions. The results using two delay intervals and the results with and without an exteroceptive warning stimulus were compared.

METHOD

Subjects

Three naive male Sprague-Dawley rats (Holtzman Co.), 60 days old at the start of the experiment, were maintained in individual cages with free access to food and water.

Apparatus

An operant conditioning chamber, 9.25 by 8.50 by 7.50 in., with a single bar at the center of one end, 3 in. from the floor, was en-

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closed in a sound-attenuated chamber. The grid floor and all other metal parts were wired into the shock circuit. The empty feeder operated whenever the bar was pressed, resulting in a loud click. A blower fan provided a masking noise of 57 db. When the white noise was added, the sound level was 81 db. A Grason-Stadler shock generator and scrambler was set at 1.3 ma for 0.2 sec.

Procedure

The three subjects were trained and extinguished on each of the three conditions in a different order. In the nondiscriminated procedure (Sidman, 1953), a 0.2-sec shock was administered at regular 5-sec intervals, the shock-shock or S-S interval, as long as there was no responding. When the subject pressed the bar, the next shock was delayed for a fixed amount of time from the response, the response-shock or R-S interval. In the discriminated Sidman avoidance procedure (Sidman, 1955), an exteroceptive stimulus preceding any impending shock was added to the procedure. White noise was used as the warning stimulus, S_1, which was presented before the shock, S_2. A response delayed both the warning stimulus and the shock. If no response occurred and the warning stimulus was initiated, a response during the warning stimulus terminated the stimulus, avoided the shock, and restarted the delay period. Otherwise, the shocks began and the subject could then terminate the warning stimulus and delay further shocks. In both procedures, every response restarted the delay period, so the subject could avoid all shocks by regularly responding within the R-S interval. The three training conditions employed were: nondiscriminated avoidance with response-shock interval (R-S) = 20 sec, shock-shock interval (S-S) = 5 sec; nondiscriminated avoidance with R-S = 40 sec, S-S = 5 sec; discriminated avoidance with response-noise interval = 15 sec, noise-shock interval = 5 sec, shock-shock interval = 5 sec.

Subject 10E was trained on the discriminated condition first, then R-S = 20 sec, then R-S = 40 sec. Subject 12E was trained on R-S = 20 sec first, then discriminated, then R-S = 40 sec. Subject 7E was trained on R-S = 20 sec first, then R-S = 40 sec, then discriminated.

The subjects were adapted in the operant chamber for 30 min without shock. Then the schedule was allowed to operate with shocks administered at S-S intervals until the appropriate response occurred. There was no shaping. In the discriminated avoidance condition, the warning stimulus was introduced after the nondiscriminated behavior was established. Conditioning was conducted on alternate days in 4-hr sessions.

Extinction was begun when the behavior had stabilized for the last 2 hr of two consecutive days. A minimum of four sessions of training, comprising at least 15 hr, preceded every extinction. The extinction session began with 3 hr on the training schedule to eliminate the initial warm-up. Then the shock apparatus was disconnected. In the discriminated condition, if the subjects responded, the signal presentation was delayed for 15 sec. Otherwise, the signal was activated every 15 sec for 5 sec. If a response was made during the warning signal, the signal terminated immediately and was presented again 15 sec later. This extinction procedure was chosen because of its similarity to the procedure used in classical avoidance studies (Kamin, Brimer, and Black, 1963). Extinction was conducted in a single session to a criterion of a block of 15 min with no responses. Two days later another training procedure was instituted.

RESULTS

The pre-extinction and extinction results are shown in Table 1. The pre-extinction responses and shocks represent the mean frequencies of responses and shocks for 4 hr. The data from the third and fourth hours of each of the last two sessions preceding extinction on each condition were averaged. The pre-extinction rates obtained are comparable to those reported in the literature (Sidman, 1953). The maximum variability of the hourly rates of each subject about the subject's mean rate was ±10%. In the discriminated condition, 96% of the responses of Subject 10E, 80% of the responses of Subject 12E, and 87% of the responses of Subject 7E occurred in the signal period in the last hour of conditioning before extinction.

All subjects extinguished to the criterion. The training conditions had a differential effect on the number of responses in extinction (Friedman Two-Way Analysis of Variance, $\chi^2 = 6.0$, $p = 0.028$). The Spearman rank cor-

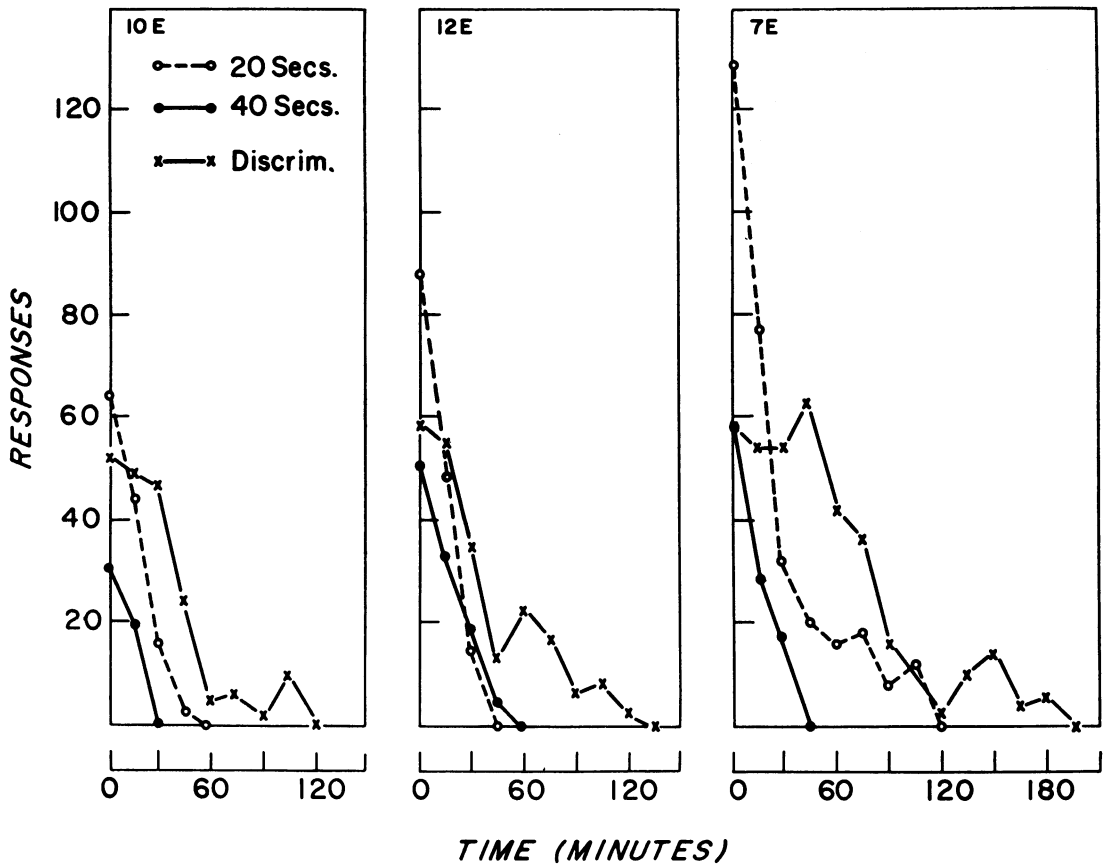

Fig. 1. Extinction curves for each subject on each condition to a criterion of a block of 15 min with no responses. The time required to reach the criterion of extinction on each condition is shown on the abscissa. The points at zero time represent the number of responses during the last 15 min of conditioning preceding extinction. Each data point represents the sum of responses during the preceding 15-min period.

Table 1
Pre-extinction and extinction performance of each subject on each condition.

Subjects	*Conditions* R-S = 20	R-S = 40	*Discriminated*
	Pre-extinction Responses per Hour		
#10E	260	125	210
#12E	350	205	230
#7E	516	230	230
	Pre-extinction Shocks per Hour		
#10E	38	14	20
#12E	22	15	40
#7E	32	20	5
	Total Responses in Extinction		
#10E	59	19	143
#12E	64	56	157
#7E	183	43	311

relation between number of responses in extinction with pre-extinction response rate per hour was $r_s = +0.50$ ($p > 0.05$, one-tailed test); with pre-extinction shocks, $r_s = +0.20$ ($p > 0.05$, one-tailed test). Figure 1 shows the extinction curves for each subject. The largest number of responses and the longest time to reach the criterion of extinction were found for the discriminated avoidance behavior for all subjects. The R-S = 40 sec condition required fewer responses to extinguish than the R-S = 20 sec condition for all subjects. The difference is very small for #12E, however, and this subject required more time to extinguish to criterion on the R-S = 40 sec condition.

Extinction was also considered after the first and second pause for a period of time longer than the $R\text{-}S_2$ interval. If extinction operations were not in effect, a shock would have then been administered. When the data are evaluated from these pauses to the criterion of extinction, the ranking of the three con-

ditions in resistance to extinction remains the same for each subject.

DISCUSSION

The pre-extinction response rate in the discriminated Sidman avoidance was lower than in the non-discriminated R-S = 20 sec condition in which the temporal contingencies were the same. Although according to the two-factor theory of avoidance behavior (Solomon and Wynne, 1954) the signal stimulus itself becomes aversive as a function of its pairing with shock, subjects rarely responded to delay signal onset. They waited and responded in the signal period. This finding is in accord with the results of Ulrich, Holz, and Azrin (1964).

Sidman avoidance behavior was maintained longer with the noxious stimulus withheld when an exteroceptive stimulus was present than in the nondiscriminated conditions. This difference cannot be attributed to rate or temporal contingencies alone. The rate in the discriminated condition was equivalent to the R-S = 40 sec condition, and the temporal variables to the R-S = 20 sec condition. The presence of the warning stimulus, of course, may change considerably the functional role of other variables. There is also the question of whether the warning noise might have been mildly aversive. Though not enough to maintain an escape response, this aversive property in combination with the training procedures might have prolonged the extinction with the discriminated avoidance procedure. Presenting the white noise continuously after extinction, a response producing a period of silence, did not result in a resumption of responding. The same stimulus was also used in a study of the conditioned emotional response, and there was no evidence to indicate that the stimulus itself was aversive. Nevertheless, comparing the results using a reduced intensity of noise with the results obtained here would be valuable.

The prediction of Sheffield and Temmer (1950) regarding the nondiscriminated conditions was not substantiated by the data. They suggested that longer intervals would result in a greater number of responses in extinction. It is clear that avoidance behavior trained using the longer delay interval does not result in more responses in extinction. The R-S = 40 sec condition extinguished with fewer responses than the R-S = 20 sec condition for all the subjects, although the difference for one subject was small. With regard to time also, two of the three subjects extinguished more quickly after training with the longer R-S interval. One subject extinguished more slowly after training on the R-S = 40 sec schedule, but the difference was small.

Withholding the noxious stimulus is not the only procedure to effect extinction of avoidance behavior. Another possible procedure to eliminate the reinforcing consequences of responding would be to make the noxious stimulus unavoidable. The shocks would be presented on an independent schedule which could not be affected by the subject's responding. It would be interesting to compare the effects on Sidman avoidance behavior of making the shocks unavoidable with the effects obtained when the shocks are withheld.

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