PUNISHMENT OF AN EXTINGUISHING SHOCK-AVOIDANCE RESPONSE BY TIME-OUT FROM POSITIVE REINFORCEMENT¹

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Two experiments were conducted to determine the effects of punishment by time-out from positive reinforcement on the extinction of discriminated shock-avoidance responding. Subjects were trained initially to bar press for food on an intermittent schedule of reinforcement and, concurrently, to avoid shock at the onset of a warning signal. Experiment I compared avoidance extinction performance under no punishment and when avoidance responding resulted in a 30-sec TO from reinforced appetitive responding. In Exp II, the contingent use of TO punishment was compared with its random, or noncontingent use. The results of both experiments showed that in the absence of punishment, avoidance extinction was characterized by short latencies and nearly 100% avoidance responding. Avoidance responding in extinction was little affected by noncontingent TO punishment. When TO was made contingent upon avoidance responding, however, avoidance latencies immediately increased and the frequency of avoidance responses subsequently decreased to zero.

Punishment administered during extinction of discriminated shock-avoidance responding paradoxically increases resistance to avoidance extinction (Solomon, Kamin, and Wynne, 1953; Whiteis, 1956; Brush, 1957). Such punishment has, however, involved a noxious stimulus, such as shock, administered after an avoidance response. Shock and other noxious stimuli are not the only events which may be punishing. Conditions associated with the temporary withdrawal of positive reinforcement (*i.e.*, TO) are also effective as punishment. Time-out from positive reinforcement has been used, for example, to punish incorrect responses in matching-to-sample performance (Ferster and Appel, 1961; Zimmerman and Ferster, 1963; Zimmerman and Baydan, 1963) and to suppress such complex human behaviors as thumbsucking in children (Baer, 1962).

The present experiments sought to explore the effects of TO punishment on the extinction of discriminated shock-avoidance responding. Subjects were trained to bar press for food on an intermittent schedule of reinforcement and, concurrently, to avoid shock at the onset

of a warning stimulus. After concurrent appetitive-avoidance responding had stabilized, the shock contingency was removed and the resulting appetitive and avoidance-extinction performance served as a baseline from which to evaluate the effects of TO punishment. Experiment I was concerned with avoidance extinction performance when TO from reinforced appetitive responding resulted as a consequence of each avoidance response. In Exp II, the effects of the contingent use of TO punishment were compared with its random or noncontingent use.

EXPERIMENT I

Subjects

Four naive male albino rats of the Wistar strain (R-13, R-14, R-44, and R-46) between 100 and 130 days of age from the University of Maine Colony, were maintained on a 23-hr food deprivation schedule. Water was continuously available in the home cages and during all experimental sessions.

Apparatus

The response chamber consisted of a plywood box 13 in. by 8 in. by 9 in. high (inside dimensions) lined with aluminum. The chamber was enclosed in a sound-attenuating compartment (Scientific Prototype, Model SPC-300). The two manipulanda were an appetitive

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response bar and a shock-avoidance bar. The $\frac{1}{2}$ -in. by 2-in. food-rewarding bar was mounted on an end wall $1\frac{1}{4}$ in. above the floor. It extended $\frac{3}{4}$ in. from the wall and required 10 g of pressure to depress and activate it. Immediately to the right was a $\frac{1}{2}$ -in. by $1\frac{3}{4}$ -in. half-oval food cup into which 45 mg Noyes rat food pellets were dispensed. The shock-avoidance bar, with a $2\frac{1}{2}$ -in. cross bar, was located on the other end wall. A pressure of 15 g was required to actuate the microswitch associated with the shock bar. A $7\frac{1}{2}$ -w amber light, mounted in the cover of the response chamber, illuminated the enclosure and served as the S^D for reinforced appetitive responding. The floor consisted of $\frac{1}{8}$ -in. brass rods spaced $\frac{1}{2}$ in. apart. Shock was generated by an Applegate constant current stimulator (Model 228) with shock intensity set at 2 ma. When applied, shock was delivered through a device similar to that described by Hoffman and Fleshler (1962) which sequentially alternated the polarities of the shock across the grid floor, walls, and response levers. The shock-correlated stimulus (CS) was a pure tone of 670 cps delivered through a 3-in. speaker mounted against the outside back wall of the apparatus.

Preliminary Training

The training procedures outlined below were designed to establish concurrent appetitive-avoidance responding.

Phase 1: Shock-avoidance acquisition. The shock-avoidance response was established during daily 30-min sessions. On Day 1, the subject was habituated to the CS and given 40

avoidance training trials, being shaped on the escape response as required. The intertrial interval (ITI) was 20 sec and the CS-UCS interval was 5 sec. For each session thereafter, the CS was presented at ITIs varying from 20 to 110 sec depending on whether the subject consecutively avoided or escaped the UCS. Each lever depression within the CS-UCS interval (*i.e.*, avoidance response) terminated the CS, prevented the subject from receiving shock and incrementally lengthened the ITI by 10 sec (to a maximum of 110 sec). A bar press occurring after the onset of shock terminated both the CS and shock and reset the ITI to 20 sec. If neither an escape nor avoidance response was emitted after 15 sec had elapsed, the CS and UCS were terminated and an ITI of 20 sec initiated. Intertrial responding had no effect upon these contingencies. These procedures were continued until the subject successfully avoided shock on 10 consecutive CS presentations. Table 1 (a) shows the total number of trials each subject required to reach the avoidance criterion.

Phase 2: Appetitive bar-press training. Avoidance trials were discontinued during appetitive bar-press training. The subject was magazine trained during the first session: the food dispenser automatically delivered one 45 mg Noyes food pellet into the food cup every 30 sec until a total of 30 pellets had been dispensed. After magazine training, food rewards were contingent upon performing the bar-press operant. During the initial sessions every response was reinforced (CRF). A TO from positive reinforcement implies that the

Table 1
Number of Experimental Sessions Devoted to Each Subject
During the Successive Phases of Preliminary Training

Subject Designation	(a) Trials to Avoidance Criterion	(b) Sessions to Discrimination	(c) Sessions to Appetitive Response Criterion	(d) Sessions to Concurrent Appetitive-Avoidance Stability
Experiment I				
R-13	310	6	(VR-6) 6	5
R-14	343	5	(FR-20) 9	6
R-44	319	7	(FR-20) 8	5
R-46	316	3	(VR-6) 5	4
Experiment II				
R-30	351	5	(FR-20) 9	3
R-40	319	7	(FR-20) 7	6

subject can discriminate between reinforcement and nonreinforcement conditions (*cf.* Holz, Azrin, and Ayllon, 1963). For this reason, periods of extinction were introduced into the CRF experimental sessions. The light in the response chamber was turned off and the pellet dispenser disconnected during the extinction periods. When reinforcement could occur, the light was turned on, and each response produced one reinforcement. The S^A periods were 1 min in duration and were presented at a mean interval of 2 min (range, 1 min to 3 min). These procedures were continued until less than 1% of the total responses emitted during a 50-min session were occurring under S^A conditions. (See Table 1, *b*).

After discrimination training, S^A periods were used to signal the beginning and end of each experimental session.

Next, a fixed ratio (FR) or variable ratio (VR) schedule of reinforcement was introduced. Responding was reinforced with food on an FR 20 or VR 6 schedule until the rate of responding had stabilized. The criteria for stability were (*a*) a uniform rate of responding within each session and (*b*) less than 15% change in the total number of responses between at least three consecutive sessions. All subjects met the above criteria within nine sessions (Table 1, *c*).

Phase 3: Concurrent appetitive-avoidance training. After these preliminary procedures had been completed, both the FR (or VR) and avoidance contingencies were scheduled concurrently. At the beginning of each session, the subject was permitted to bar press for food for 2 min before avoidance trials were introduced. Thereafter, the CS was presented at ITIs ranging from 80 to 120 sec ($\bar{X}$ = 100 sec). Thirty avoidance trials were programmed during each 50-min session. The subject was trained under these procedures until it successfully avoided 100% of the shocks programmed during each of two consecutive sessions (Table 1, *d*).

Punishment and Extinction

After Phase 3 had been completed, the shock contingency was removed and each subject was exposed to seven concurrent appetitive and avoidance-extinction sessions. Thirty avoidance trials were programmed during sessions 1-6 and 20 during session 7. The mean

ITI during avoidance extinction was 100 sec. The CS was presented as usual, but if the subject did not respond within the 5-sec CS-UCS interval, the tone was terminated. Each avoidance response that occurred, however, resulted in a 30-sec TO from reinforced appetitive responding for R-44 and R-46. No TOs were programmed for R-13 and R-14. The TOs consisted of the S^A periods which had been established during Phase 2 of training.

Results

Development of concurrent appetitive-avoidance responding. The transition from FR (or VR) performance to concurrent appetitive-avoidance responding markedly suppressed the rate of appetitive responding. This was followed by a gradual recovery within six sessions for all subjects. Figure 1 presents two representative records of these effects. The top tracing shows the overall decrease in rate of appetitive lever pressing when the avoidance contingency was introduced. Appetitive responding was particularly suppressed after the CS or UCS terminated. With continued avoidance trials, the subject returned to lever pressing on the food manipulandum almost immediately after terminating the CS. The bottom tracing in Fig. 1, taken for the final session of training for R-14, indicates that the fully recovered appetitive response rate was

Fig. 1. Cumulative response records for R-14. The displacement of the pen diagonally from the appetitive curve marks each avoidance response. A: Appetitive responding before avoidance trials. B: Suppression of appetitive responding. C: Recovery to stable concurrent appetitive-avoidance responding.

about the same as it had been before the avoidance contingency was introduced.

Effects of TO on rate of appetitive responding. The transition to avoidance extinction and avoidance contingent TO punishment was made without noticeable disruption in appetitive performance. The cumulative response records in Fig. 2 permit a comparison between the concurrent appetitive and avoidance-extinction performance observed under no TO (R-14) and under TO punishment (R-44). The curves reveal that appetitive response rates remained high and uniform under the punishment as well as under the no-punishment procedure. It should be noted, however, that appetitive lever pressing decreased to a near-zero rate during the 30-sec TO period following avoidance responding

for R-44. No comparable decrease in the rate of appetitive responding may be observed in the cumulative response records of subjects R-13 or R-14 which were not subjected to TO punishment.

Effects of TO punishment on avoidance extinction performance. Figure 3 plots avoidance extinction performance under no punishment and punishment by TO from positive reinforcement. For conciseness, the 200 extinction trials were divided into 20 blocks of 10 trials each. The effects of TO punishment may be seen by comparing the avoidance behavior of R-13 and R-14 with that of R-44 and R-46. In the absence of TO, nearly 100% avoidance was maintained over the entire 200 avoidance extinction trials. The data for R-44 and R-46 show, however, that avoidance latencies in-

Fig. 2. Cumulative response records for R-14 and R-44. The displacement of the recording pen diagonally from the appetitive curve marks each avoidance response. During the 30-sec TO following avoidance responding, S⁺ conditions (indicated by the near-zero rate of appetitive responding following each avoidance response) prevailed in the response chamber for R-44. No TOs were programmed during avoidance extinction for R-14.

Fig. 3. Effects of no punishment and avoidance contingent punishment by TO from positive reinforcement on the extinction of discriminated shock-avoidance responding.

creased steadily after relatively few TO punishments. Successive avoidance contingent TOs resulted, moreover, in a decrease to zero in the frequency of avoidance responses.

An example of the decline in frequency of avoidance responses under TO punishment is shown in Fig. 4, which reproduces the entire cumulative response records for R-44 during sessions 2 and 3 of avoidance extinction (from the point marked *a* in Fig. 3). In each

case, the arrows mark CS periods during which no avoidance response was emitted. Avoidance extinction was not abrupt, but several TO punishments were required to eliminate avoidance responding completely. The record for session 2 reveals, for example, that the subject frequently sustained lever pressing for food throughout two or three consecutive CS presentations. But these "runs" were typically followed by consistent avoidance responding to

the next 5 to 10 successive CS presentations. Avoidance responding was eventually eliminated, however, as shown in the records for the third session of avoidance extinction. Thereafter, a high and uniform rate of appetitive lever pressing was maintained throughout most CS presentations.

EXPERIMENT II

The results of Exp I demonstrate that punishment by TO from positive reinforcement sharply reduces the number of avoidance responses emitted in extinction. Experiment II sought to compare the effectiveness of the contingent use of TO with its random, or noncontingent, use. As in the previous experiment, performance under concurrent appetitive and avoidance-extinction was used as a baseline from which to evaluate the effects of TO punishment.

Subjects

Two naive, male albino rats (R-30 and R-40) were maintained on a 23-hr food deprivation schedule.

Apparatus and procedure

The apparatus and preliminary training procedures were the same as in Exp I. After preliminary training had been completed (see Table 1), the shock contingency was removed and each subject was exposed to 17 concurrent appetitive avoidance-extinction sessions. No punishment was programmed during sessions 1-3. Thirty avoidance trials occurred during each 50-min session. The CS was presented at ITIs varying from 90 to 120 sec ($\bar{X} = 100$ sec), but if no response occurred within the 5-sec CS-UCS interval, the CS was terminated. After these initial sessions, subjects were exposed to seven sessions in

Fig. 4. Cumulative response records for R-44 during the second and third sessions of concurrent appetitive and avoidance extinction. The pips indicate avoidance responses and the arrows CS periods during which no avoidance response was emitted.

which TO punishment had only a random contingency with avoidance responding. Each TO lasted 30 sec and was presented on a pre-arranged schedule with an average of one TO every 100 sec. Avoidance contingent TO punishment was then introduced for R-40 during sessions 11-17, while the contingencies for R-30 were returned to those in effect during sessions 1-3 (*i.e.*, no TO).

Results

The effects of TO punishment on avoidance extinction performance are summarized in Fig. 5. Separate curves show the mean latency and frequency of avoidance responses emitted by each subject during the consecutive phases of avoidance extinction. The left panels, for example, show avoidance extinction perform-

Fig. 5. Effects of no punishment, noncontingent punishment, and avoidance contingent punishment by TO from positive reinforcement on the extinction of discriminated shock-avoidance responding.

ance when no TO punishment was scheduled (sessions 1-3). As was observed in Exp I, short latencies and near 100% avoidance characterized performance in the absence of TO punishment.

The major findings of this experiment are presented in the remaining two panels in Fig. 5, which plot avoidance extinction performance under noncontingent and avoidance contingent TO punishment. Comparing the percent avoidance responses maintained under no punishment and noncontingent punishment, for example, reveals that noncontingent punishment had little effect upon the course of avoidance extinction. Avoidance latencies increased during the first few sessions of noncontingent punishment; after this initial suppression, they gradually decreased to their pre-punishment baselines. This effect is clearly illustrated in the data of both R-30 and R-40.

Time-out punishment was made a consequence of each avoidance response for R-40 during sessions 11-17. As the lower right panel in Fig. 5 shows, avoidance contingent TO had the same effects as were observed in Exp I. A steady increase in avoidance latencies resulted upon initial exposure to the punishment contingency. This was accompanied by a decrease to zero in the frequency of avoidance responses. These data should be contrasted with those for R-30 presented in the upper right panel of Fig. 5. For this subject, the punishment procedure was eliminated during sessions 11-17 of avoidance extinction. In this instance, however, avoidance latencies shortened and the frequency of avoidance responses remained at 96% for the remaining 200 avoidance extinction trials.

The results of this experiment confirm those of Exp I: that punishment by TO from positive reinforcement sharply decreases the frequency of avoidance responses emitted in extinction. The data from Exp II, moreover, make it clear that the mere presentation of TOs, irrespective of subjects' avoidance behavior, is not sufficient to affect the course of avoidance extinction.

The generality of these findings may be questioned by raising the possibility that they depend upon the particular conditions of the present experiment. Do the results depend, for example, upon the concurrent appetitive-avoidance schedule used to generate the base-

line performance? Consistent with this suggestion are some data reported by Sidman (1958) regarding the interdependence of behaviors when appetitive and avoidance schedules are programmed concurrently. Sidman has noted, for example, that when ratio reinforcement controls the appetitive response, the avoidance response might also come under the control of the food reinforcement. Such adventitious chaining of behaviors in the present experiment could have resulted from several possible factors. Although the appetitive and avoidance levers were located on opposite sides of the response chamber, the two responses were similar in topography. Thus, the frequent occurrence of an avoidance response followed by a food reinforcement after one or two presses on the appetitive lever might well have provided a mechanism whereby avoidance responding could have become linked to appetitive behavior. If this were the case, avoidance responding during extinction could have been maintained, at least in part, by an overlapping history of positive reinforcement. Following this same line of reasoning, it is conceivable that the performances depicted in Fig. 3 and 5 under TO punishment represent not extinction of shock-avoidance responding, but, rather, extinction of a superstitious appetitive lever press.

This hypothesis was evaluated by placing both responses on extinction. If avoidance responding were in some way controlled by the appetitive contingency, a decrease in the frequency of avoidance responses should accompany the extinction of appetitive responding (*cf.* Sidman, 1958). After the last session of avoidance extinction, therefore, R-30 was exposed to an additional session in which the pellet dispenser was disconnected and appetitive extinction begun. Figure 6 reproduces the entire cumulative response record for that session. It shows that appetitive extinction followed a course typical of extinction after training on an FR schedule of reinforcement: rapid bursts of responding alternated with periods in which the subject did not bar press at all. Throughout this session, however, the subject emitted an avoidance response during 29 of the 30 CS presentations. The only occasion on which it failed to avoid is indicated by the arrow. These observations do not support the suggestion that an adventitious correlation with the appetitive contingency

Fig. 6. Cumulative response record for R-30 during concurrent appetitive-avoidance extinction. Appetitive extinction was begun at *b*. The displacement of the recording pen from the lower curve marks the onset of each CS, while those from the appetitive curve mark the occurrence of each avoidance response.

was responsible for sustained avoidance responding in extinction.

DISCUSSION

Previous research concerning the extinction of discriminated shock avoidance responding indicates that punishment not only fails to accelerate avoidance extinction, but, instead, functions to prolong extinction. On the basis of these findings, Solomon (1964) concluded that punishments "... may be ineffective in eliminating the avoidance responses they are supposed to eliminate" (p. 243). It seems clear from the results of the present study, however, that punishment by TO from positive reinforcement may be used effectively to decrease the frequency of avoidance responses emitted in extinction. Several general implications are indicated by this finding.

Church (1963) has suggested that one of the major factors determining the effects of punishment on the extinction of avoidance behavior may be the similarity between the noxious stimulus used for avoidance training and that used for punishment. An increased resistance to extinction, according to this hypothesis, is most likely to occur when punishment consists of the same aversive stimulus previously used to establish avoidance responding. However, if punishment is discriminatively different from the aversive stimulus used in

training, punishment would accelerate avoidance extinction. A comparison of the results obtained in previous experiments in which the training and punishing stimuli were similar and those obtained in the present study, in which these stimuli differed, appears to support this hypothesis. When shock is used to establish avoidance responding and subsequently to punish that same response, an increased resistance to avoidance extinction typically results (e.g., Solomon *et al.*, 1953; Whiteis, 1956; Brush, 1957). It would appear that the termination of punishment in this case is equivalent to what was previously reinforcing in the training situation, *i.e.*, shock reduction. Under these conditions, it is reasonable to assume that avoidance responding would be maintained. In the present experiments, on the other hand, punishment (*i.e.*, TO) was discriminatively different from the aversive stimulus used to establish avoidance responding. In this case, punishment functioned to accelerate avoidance extinction. Thus, while there are numerous procedural differences which might account for these contrasting findings, the results of the present study make it highly probable that the paradoxical effects of punishment on avoidance extinction previously observed resulted principally from using the same aversive stimulus for punishment as was used to establish avoidance responding.

A second implication is that punishment by TO apparently can be extended to the control of behavior maintained by negative reinforcement. In an experiment somewhat similar to the present study, Ferster (1958, Exp III) used a procedure in which a TO from positive reinforcement could be avoided if the rate of responding dropped to some specified minimum value during an interval signaled by a pre-TO stimulus. Under these conditions, responding fell to zero during the pre-TO stimulus interval. During the extinction phase of the present study, the CS served a function similar to the pre-TO stimulus in the experiment reported by Ferster: responding during the CS resulted in a TO, whereas nonresponding permitted the CS to terminate without a TO. Although TO was used by Ferster to punish appetitive responding and in the present study to punish avoidance responding, similar results were obtained. Avoidance contingent TO punishment decreased to zero the frequency of avoidance responses emitted in extinction, as did the frequency of responding during the pre-TO interval in the experiment reported by Ferster. The results of both experiments demonstrate, therefore, that if responding during a particular stimulus results in a TO from positive reinforcement, the future probability of responding during that stimulus is decreased.

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