Extinction and maintenance of avoidance behavior using response-independent shocks

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Response-independent shocks were delivered to six Ss previously trained to avoid shock. The response rate failed to recover when shocks were administered immediately following an avoidance-extinction procedure. The avoidance response rate was reinstated when shocks were presented 24 h after extinction. A second experiment involving six Ss demonstrated that when the avoidance session was immediately followed by response-independent shocks, the avoidance response rate was maintained.

Several investigators (Sidman, Herrnstein, & Conrad, 1959; Waller & Waller, 1963; Byrd, 1969) have demonstrated that shock avoidance behavior can be maintained by occasionally presenting shock independently of the S's behavior. Typically, the S is trained to respond under a continuous shock avoidance procedure (Sidman, 1953); the avoidance schedule is then suspended, and the E arranges for shocks to be occasionally given. It is possible that the effectiveness of these response-independent shocks (RIS) in maintaining responding depends on the *ongoing* behavior (specifically, rate of leverpressing) at the time RIS is delivered (see also Kelleher & Morse 1970). If the rate of leverpressing is high, the effect of RIS may be to maintain or enhance an ongoing response rate. If the S is primarily engaged otherwise, i.e., not leverpressing, RIS may suppress rather than enhance the leverpressing response.

The present experiment investigated this possibility. Following training under a free operant avoidance schedule, Ss were exposed to an extinction procedure. The effect of RIS was examined in terms of the time interval which was allowed to elapse between attainment of the extinction criterion and presentation of RIS. The question was, would RIS reinstate avoidance behavior if given immediately after extinction when the probability of the response was low? Further, would RIS reinstate avoidance behavior if given 24 h after extinction, at which time the occurrence of shock might be expected to facilitate the reinstatement of responding, i.e., a type of "warm-up" effect.

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EXPERIMENT 1

Subjects

Six adult female hooded rats served as Ss. The Ss had a history of 129 2-h free operant avoidance training sessions.

Apparatus

Three 23 x 24 cm chambers, each having a lever 5 cm wide protruding 2.5 cm into the chamber 5 cm above the grid floor, were used. A force of 10 N was need to depress the lever. The grids consisted of .25-cm brass rods spaced 1.3 cm apart, parallel to the lever. A constant current shock generator delivered shock via a mechanical scrambler to the grids, lever, and sides of the chamber. Each chamber was placed in a larger sound-insulated box with an exhaust fan to provide ventilation and mask noise (80 dB). All three boxes were housed inside a sound-attenuated man-sized cubicle. Automatic programming and recording equipment was placed outside this cubicle.

Procedure

Under the free operant avoidance schedule, shocks were given at 5-sec intervals unless a leverpress occurred, in which case shock was postponed for 20 sec. Following 129 2-h sessions of free operant avoidance training, the extinction procedure described by Roberts, Greenway, & Hurwitz (1970) was introduced: the shock source was disconnected and the only programmed consequence of a leverpress was a brief onset of houselights (Condition A). All Ss were run to a criterion of no responses over a consecutive 5-min period. When the extinction criterion was reached, 10 RISs of the same intensity and duration as those of the free operant avoidance schedule (.5 mA for 0.1 sec) were given at the rate of one shock every 2 min. This RIS frequency was approximately twice the minimum and equal to the maximum shock rate observed during free operant avoidance training. The avoidance schedule remained suspended over Conditions A, B, and A'; on the other hand, the feedback contingency was operative over all conditions.

The Ss were returned to the leverpressing chambers 24 h later for Condition B. The first RIS was given 20 sec after the session began, approximating the response-shock interval of 20 sec used in avoidance training, and 30 RISs were given in all, one every 2 min. Following Condition B, the extinction criterion of Condition A was reintroduced. When leverpressing had reached the extinction criterion, RIS was given again once every 2 min to all Ss (Condition A): Ss A, B, and C received 20 RISs and Ss D, E, and F received 10 RISs.

Results

Table 1 presents data from free operant avoidance training and Free-Shock Conditions A, B, and A'. Column BL presents mean responses per minute and, in parentheses, mean shocks per minute for each S over the final five free operant avoidance training sessions. These data were obtained when Ss were showing relatively stable performances. Over the RIS conditions, frequencies of response for each S were recorded every minute. Median responses per minute are presented for each condition, as stable behavior was not anticipated. Under Condition A, RIS was given immediately after extinction; under Condition B, RIS was given at the beginning of a session 24 h later; and under Condition A', RIS was given following extinction.

Table 1 shows that response rates remained *reduced* when RIS was given immediately after extinction (Condition A). Ss A and E showed some recovery of response rate, although responding was considerably less than under the free operant avoidance schedule of training. Condition A' replicated the procedure of Condition A and generally produced comparable results (Table 1,

Table 1

Mean response rates and, in parentheses, mean shocks per minute for each S as calculated over five free operant avoidance training sessions (Column BL). Median responses per minute under the conditions in which RIS was presented following an extinction procedure (Column A); RIS was presented at the beginning of a session (Column B) and RIS was presented following a second extinction session (Column A').

Ss	BL	A	B	A'
SA	7.24 (.38)	4	7	5
SB	13.10 (.23)	0	15	6
SC	6.70 (.50)	0	7	0
SD	7.34 (.55)	0	0	0
SE	11.57 (.42)	5	0	2
SF	9.66 (.45)	1	7	0

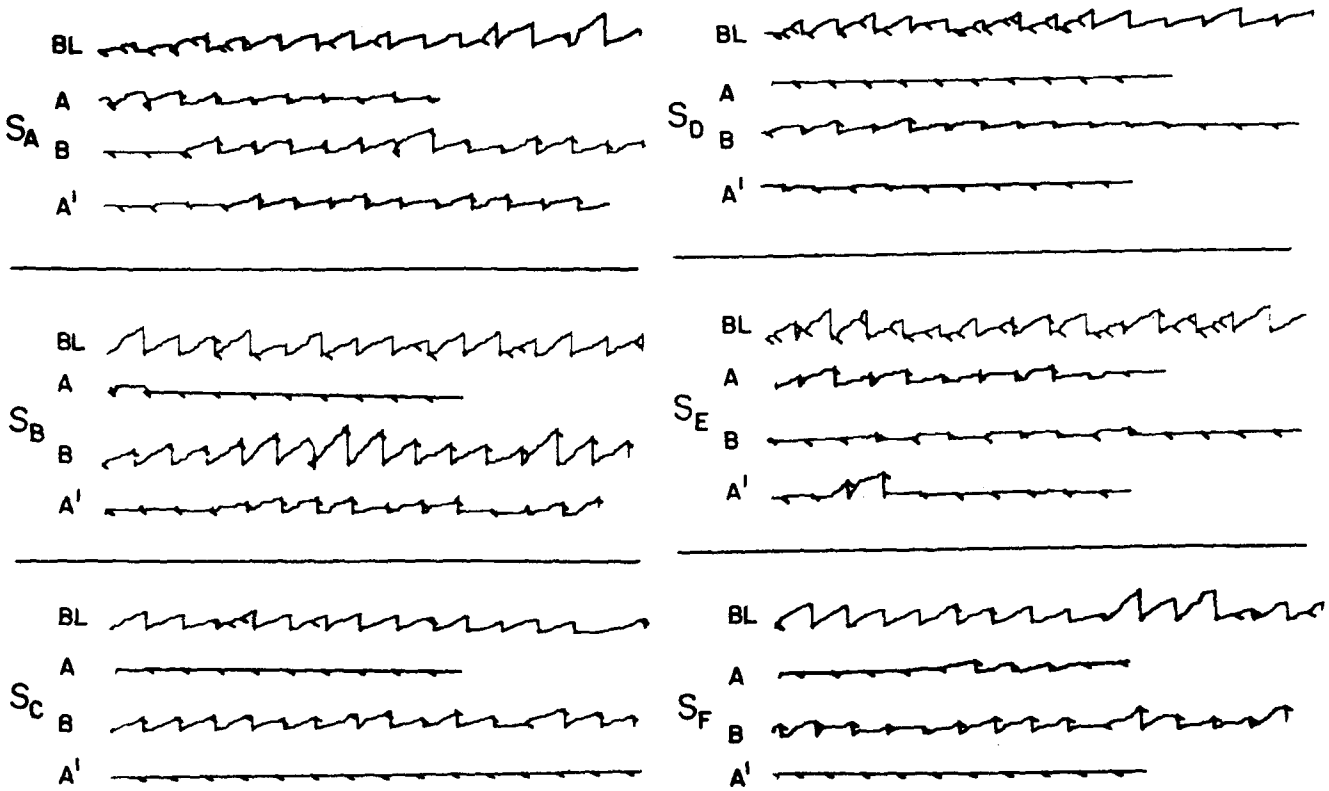

Fig. 1. Cumulative response records sampled at the beginning of each experimental condition for each S. Records BL were obtained from the final free operant training session, Records B were from the procedure of presenting RIS at the beginning of a session, and Records A' were from the procedure of presenting RIS following a second extinction session.

Column A' compared to A). The change in response rate of S B was only 45% of the rate observed under the free operant avoidance schedule.

When the avoidance schedule was replaced by RIS at the beginning of a session (Condition B), responding developed in five of six Ss and was subsequently maintained for the remainder of the session in four Ss (Table 1, Column B compared to BL). The responding of S E was restricted to shock-elicited responding.

Samples of cumulative response records taken from the beginning of each experimental condition for each S are shown in Fig. 1. Records BL show that responding under continuous avoidance was quite variable over the course of the session (see also Roberts, Greenway, & Hurwitz, 1970). Even though rates of response varied greatly, all Ss showed low shock rates (Table 1, Column BL). Records obtained for the four Ss who maintained responding over Condition B were similar to those obtained under the free operant avoidance schedule (Fig. 1, BL compared to B).

Discussion

The results presented in Table 1 and Fig. 1 harmonize with earlier studies in which Ss were alternately exposed to RIS and free operant avoidance schedules (cf. Sidman et al, 1957). The results suggest that the conditions under which RIS is given may determine whether or not the previously established avoidance rate will be maintained: RIS given immediately following extinction did not reinstate avoidance responding; RIS presented at the beginning of a session maintained responding in four of six Ss. Thus, the effectiveness of RIS in maintaining an operant avoidance response rate may be attenuated by an interpolated extinction procedure. To strengthen this conclusion, we need to demonstrate that RIS will maintain avoidance responding when given immediately after free operant avoidance training. This procedure was used in Experiment 2.

EXPERIMENT 2

Subjects

Six adult female hooded rats having a history of 100 2-h free operant avoidance training sessions were used as Ss. Ss were approximately 120 days old when purchased from the Blue Spruce Farms, N.Y., and had never been exposed to an extinction procedure.

Apparatus

The leverpressing apparatus and programming equipment were the same as described in Experiment 1.

Procedure

All Ss were run under the free operant avoidance schedule described in Experiment 1. One hour after the session had begun, the free operant avoidance schedule was suspended, and 30 RISs of the same intensity and duration as the free operant avoidance shocks (.8 mA for Ss 1, 2, and 3 and 2.0 mA for Ss 4, 5, and 6) were then given, one every 2 min (Condition C).

Results

Table 2 presents mean responses per minute (mean shocks per minute in parentheses) for the Ss over the 1-h avoidance session and the median responses per minute during Condition C (Columns BL and C, respectively). S 3 failed to reach the avoidance criterion of receiving less

Table 2

Responses per minute for each S as calculated over a 1-h free operant avoidance session (Column B) and median responses per minute under the condition of presenting RIS immediately following an avoidance session (Column C).

S	BL	C
S1	6.12 (.40)	7
S2	12.84 (.27)	16
S4	7.30 (.62)	13
S5	11.10 (.11)	17
S6	6.10 (.82)	8

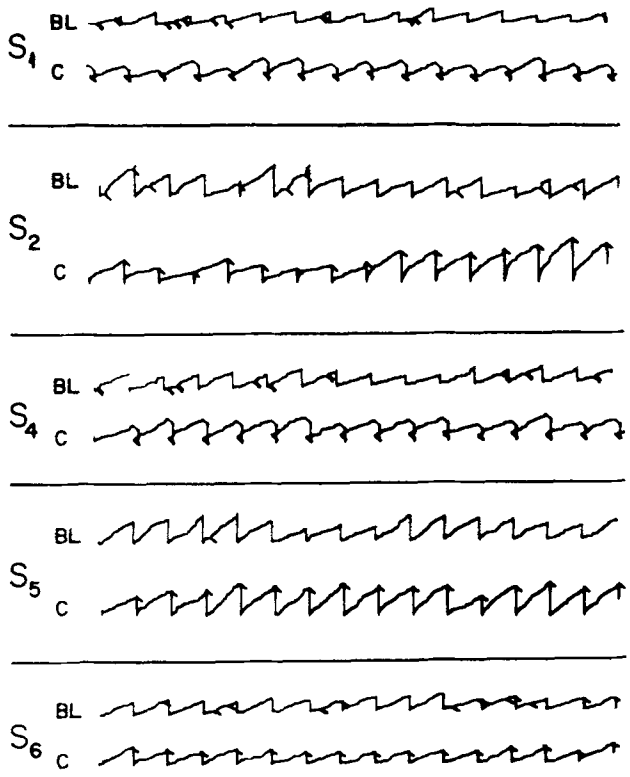

Fig. 2. Cumulative responses for each S during the final 30 min under a free operant avoidance schedule (BL) and the first 30 min of the condition in which RIS presentations replaced the avoidance schedule (C). Recorder pens were reset every 2 min, and pen deflections indicate the occurrence of shock.

than one shock per minute and was dropped from the experiment. (The response rates for Ss 4, 5, and 6 were estimated from cumulative records because of an apparatus failure affecting the response counters.) Fig. 2 presents cumulative response records for each S sampled from the final 30 min of free operant avoidance training (BL) and the first 30 min under Condition C.

Inspection of Table 2 and Fig. 2 indicates that Condition C maintained, or even enhanced, responding in each S, relative to free operant avoidance training. Although only samples of the records are presented, responding was maintained unabated throughout Condition C. In fact, 30 additional RISs were given to S 1 and S 2, with no indication of reduced responding. No evidence for differential response rate attributable to intensity of shock used was found.

These data demonstrate that avoidance responding was unimpaired when an RIS procedure replaced the free operant avoidance schedule; in fact, response rates for four of five Ss were *increased* under this RIS procedure.

GENERAL DISCUSSION

The results of the two experiments showed that the conditions under which RIS replaced the free operant avoidance schedule determined whether avoidance responding was maintained. Response rates were maintained under two conditions: first, when the extinction and RIS procedures were separated by 24 h (Condition B); second, when the RIS procedure immediately followed free operant avoidance training (Condition C). When free shock closely followed extinction, i.e., when leverpressing was minimal (Conditions A and A'), response rates failed to be maintained. These data suggest that the nature of the ongoing behavior as well as the immediate conditioning history play significant roles in determining the effect of RIS in maintaining avoidance responding. If the responding is reduced, RIS may result in further reductions; if responding is relatively high, RIS may maintain or even increase the rate. It should be noted that the frequency of RIS might also be a determining factor (cf. Jones, 1969).

Our results harmonize with experiments that demonstrate that responding originally learned under a continuous avoidance schedule can be maintained solely by the presentation of response-contingent shock (McKearney, 1968, 1969; Byrd, 1969). Both McKearney (1968, 1969) and Byrd (1969) presented response-contingent shock while their Ss were responding under the continuous avoidance schedule. Such a "concurrent" schedule would insure that a relatively high response rate was present when the avoidance schedule was replaced by the response-contingent shock procedure (see also, Kelleher & Morse, 1970). Condition C, in which RIS was given immediately after free operant avoidance training, similarly maintained (and even increased) responding. Another method of favoring a relatively high response rate would be to minimize the effect of extinction by interpolating between extinction and the RIS procedure a sufficiently long period of time (Condition B).

The results of this experiment and other previously noted experiments may seem to be contrary to the view that response rates closely followed by a noxious stimulus are suppressed, i.e., the punishment hypothesis. But the procedures employed by this and other experiments indicate, as Kelleher and Morse (1970) have pointed out, that a S's immediate experimental history, his ongoing behavior, and the schedule under which an event is presented will determine whether the effect of that event is reinforcing or punishing.

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