Extinction of free-operant avoidance with and without feedback*

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Extinction of free-operant avoidance behavior of rats was studied under conditions in which a response either resulted in a response-contingent event (feedback) or had no scheduled consequence. Probes and the original conditions of training were alternated. The time to reach the criterion of extinction and the number of responses in extinction were greater when a feedback stimulus was available. Cyclic patterns of responding were observed during both free-operant avoidance and extinction.

It is well known that rats do not readily learn to avoid under a free-operant avoidance schedule (Anger, 1963; Stone, 1966; Hurwitz & Bounds, 1968; Herrnstein, 1969). Studies of the factors controlling the acquisition of free-operant avoidance have become available only recently (Leaf, 1966; Bolles & Grossen, 1969; Hurwitz, Harzem, & Kulig, 1970). Among the few factors so far identified is the availability of a feedback stimulus, that is, a stimulus that is contingent on a response. When such a stimulus is used, the development of a rate of response sufficient to preclude shocks is substantially improved.

When the feedback stimulus is withdrawn, after the response rate has stabilized and shocks are consistently avoided, both the response rate and the avoidance of shocks may be substantially affected (Roberts & Hurwitz, 1969). The functions of the feedback stimulus in a shock-avoidance experiment could also be studied by examining how such a stimulus would alter the course of experimental extinction. A similar procedure was used by Kelleher (1961) to determine the effect of a feedback stimulus on the extinction of a positively reinforced response. In the present study each S was used as its own control in a design analogous to Shnidman's (1968), in which probes and the original conditions of training were alternated.

SUBJECTS

Six adult female hooded rats served as Ss. They were purchased from Blue Spruce Farms, New Jersey, and were approximately 120 days old at the beginning of experimentation.

APPARATUS

Three 23 x 24 x 24 cm chambers were used, each having a 5-cm-wide lever protruding 2.5 cm into the chamber 5 cm above the grid floor. A weight of 10 g (0.01 N) was needed 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 scrambling device to the grids, lever, and sides of the chamber. Each chamber was placed in a larger sound-insulated box with an exhaust fan providing ventilation and a masking noise (80 dB). All three boxes were housed inside a sound-attenuated, man-sized cubicle. Automatic programming and recording equipment were placed outside this cubicle.

PROCEDURE

All Ss were given 129 2-h free-operant avoidance training sessions; a 0.1-sec 0.5-mA shock was given at 5-sec intervals unless a leverpress occurred, in which case shock was postponed for 20 sec. Brief onset of houselights served as a feedback stimulus (FS) and occurred coincident with each leverpress.

The avoidance schedule was in effect during the first 10 min of the experimental extinction session. Then the shock source was disconnected, and the Ss were run until they reached the extinction criterion of a 5-min period with no leverpresses. For three Ss the leverpress continued to produce the feedback stimulus (Condition FS); for the remaining three Ss the feedback stimulus was not available (Condition $\overline{FS}$). After reaching the extinction criterion, Ss were retrained in three 2-h free-operant avoidance sessions described above. On the fourth session, only 10 min were given under the free avoidance schedule before the extinction procedure was once more imposed. The feedback conditions of Extinction 1 were reversed for each S: Ss given feedback during Extinction 1 had feedback removed; Ss not given feedback during Extinction 1 had feedback available. After three additional 2-h retraining sessions, Ss were given a third extinction session with similar conditions and procedures as those for Extinction 1.

RESULTS

The number of responses made during the final 2-h training session ranged from 804 to 1,530 responses, with a median of 1,233 responses. Before the first extinction session, Ss were grouped so that each condition contained a S having a low response rate.

The number of minutes to reach the extinction criterion for each S under the three extinction procedures is presented in Fig. 1. Five of the six Ss required more time to reach the extinction criterion when the response produced a feedback stimulus. This result is consonant with extinction of a response conditioned under a positive reinforcement schedule; the availability of a feedback stimulus maintained responding

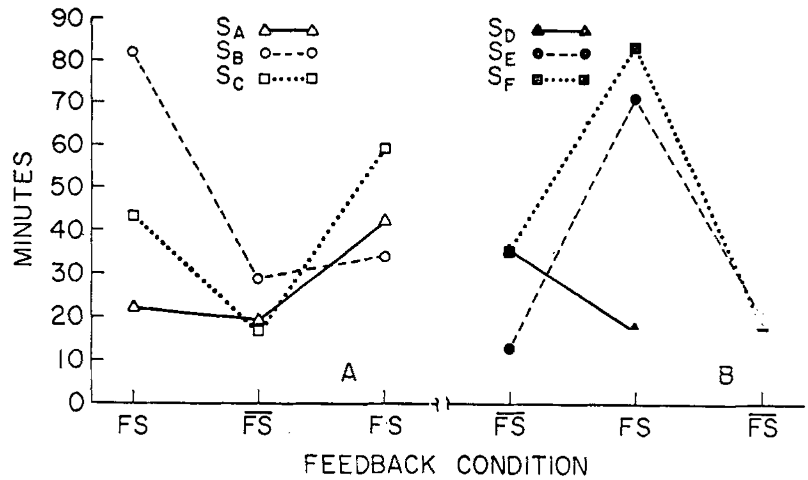

Fig. 1.

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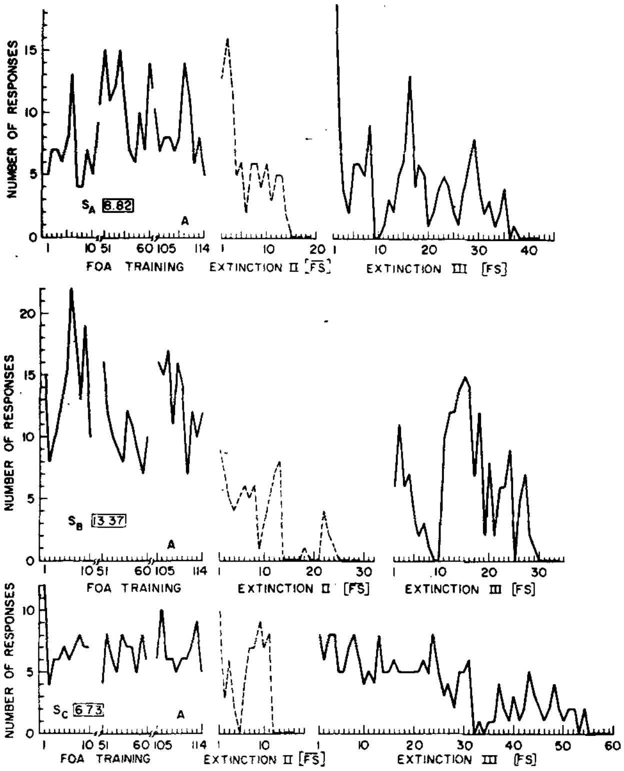

Fig. 2.

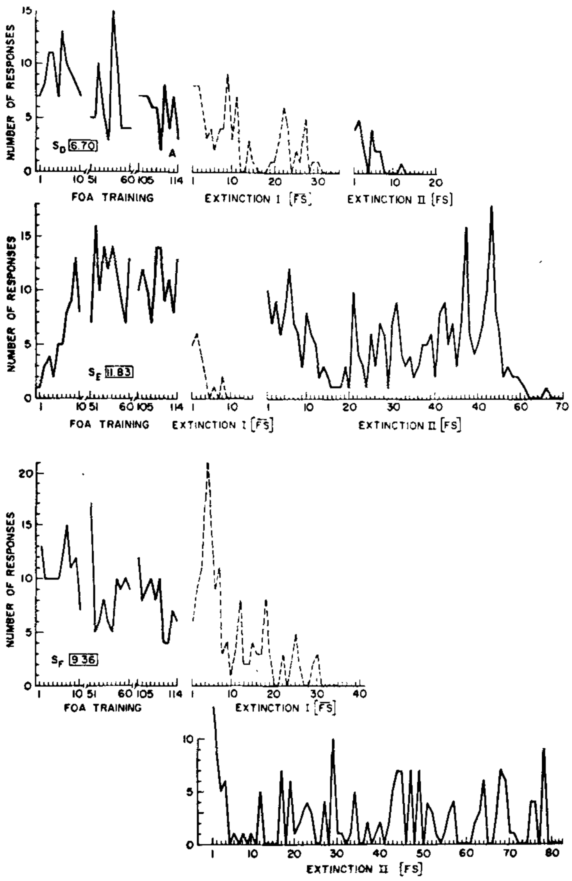

Fig. 3.

for longer periods than when a feedback stimulus was not available (cf. Wike, 1966).

Alternating the conditioning-extinction sessions did not seem to result in more rapid extinction in this experiment.

A detailed presentation of response rate during avoidance training and during subsequent extinction sessions for each S is presented in Figs. 2 and 3. Response frequencies over successive minutes for Ss under the FS-$\overline{FS}$-FS sequence is presented in Fig. 2 and for the $\overline{FS}$-FS-$\overline{FS}$ sequence in Fig. 3. The data is taken from three 10-min periods during a free-operant avoidance training session (labeled FOA on the figures) and during two entire extinction sessions. The responses per minute during the free-operant avoidance session is given in the box under the curve.

Figures 2 and 3 show the cyclic variability in responding during both training and extinction sessions for each S. That is, periods of relatively low responding were systematically followed by periods of high responding. A similar result has been reported for extinction of positively reinforced responses (Hurwitz, 1957).

DISCUSSION

The experiment produced two results. First, the time to reach the criterion of extinction was greater when a feedback stimulus used in training was available. Second, cyclic patterns of responding—periods of low response rates alternating with periods of high response rates—were observed during both free-operant avoidance training and extinction.

Two analyses should be considered in discussing our results. The first analysis focuses on the notion that a response-contingent effect, like the feedback stimulus in the present study, acquires the properties of a conditioned positive reinforcer because it is consistently associated with periods free from shock (Denny & Ratner, 1970; Weissman & Litner, 1969). That periods free from shock are the primary reinforcing events which account for avoidance learning has previously been suggested by Sidman (1962) and Herrnstein (1969). One could extend this argument and claim that responses which insure a high rate of such feedback stimuli would be highly probable.

The second analysis is based on the discrimination hypothesis (cf. Wike, 1966), which asserts that the rate of extinction is a function of stimulus differences between conditioning and extinction. The greater the stimulus difference, the faster the response decrement when reinforcement is withdrawn. By removing the feedback contingency during extinction, as was done in the present experiment, the extinction condition is clearly differentiated from avoidance training. Thus, the rapid response decrement observed during the $\overline{FS}$ condition could be accounted for by the Ss discriminating the two experimental conditions.

Figures 2 and 3 present rates of response during extinction. Certain similarities between these data and the extinction of food-reinforced responding are apparent. Notterman (1959) demonstrated that during extinction the response force exerted on a lever far exceeded the fluctuations in the magnitude of the response force observed during conditioning; that is, cyclic patterns of responding were observed. More relevant to the data presented in Figs. 2 and 3 was his finding that response force during extinction frequently dropped below the minimum required by the conditioning procedure until response force decreased and the criterion for extinction was met. Millenson & Hurwitz (1961) showed that during the extinction of sucrose-reinforced responding, high rates of response alternated with increasingly longer periods of no responding. We similarly observed, during avoidance extinction, an exaggeration of the fluctuations in the rate of leverpressing. Extinction of the free-operant avoidance response rate followed a pattern of response "bursts" alternating with increasingly longer periods of no responding (cf. Fig. 3 S_F). Note that response rates frequently dropped below the rate necessary to prevent shock during avoidance training (about four responses per minute) and then increased. The effect of the feedback stimulus seemed to prolong this cyclic pattern.

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Acquisition measures in avoidance learning*

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Rats were trained to different criteria on a one-way avoidance task in order to examine the comparability of these various measures of acquisition. On two measures of relearning, it was found that Ss trained to a criterion of 10 consecutive avoidances performed better and were significantly less variable than yoked animals that had either been given the same number of trials or trained to the same number of avoidances. No difference were found in extinction.

In comparative studies of learning, various scores have been used as measures of acquisition. The three main approaches have been (1) responses required to reach a specified criterion level; (2) the administration of a set number of training trials; and (3) the number of correct responses made.

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In the acquisition of discrimination-learning sets, Miles (1965) concluded that the first two of these procedures were indistinguishable. With single-problem learning, however, this conclusion may not necessarily apply. For example, in studies of age effects on avoidance learning, Kirby (1963), equating avoidance responses within a set number of trials, concluded that age did not influence the acquisition of this type of task but that younger animals were inferior on retention. Thompson, Koenigsburg, & Tennison (1965), on the other hand, using a criterion of 10 successive avoidances, found that younger animals took longer to acquire the response, but once criterion was reached performed as well as adult animals on retention.

More recently Porter & Thompson (1967) and Riccio, Rorbaugh, & Hodges (1968), using similar but less stringent measures than Thompson et al, claimed support for the Kirby view. However, these two studies are not incompatible with that of Thompson et al as both sets of results show trends in this direction, and in fact Riccio et al do report one significant result. Lack of significance for the other results could well be accounted for by the comparatively small numbers of Ss and large within-group variances evident in these studies. It appears then that the measures of learning used in many of these studies are not necessarily comparable. An equal number of avoidances made by two animals within a preset number of trials may not represent equivalent learning, whereas training both animals to criterion may.

To examine this hypothesis three groups of rats were tested, namely, (1) animals trained to a criterion of 10 successive avoidances, (2) animals yoked to the number of trials given to individuals in Group 1. and (3) animals yoked to the number of avoidances made by each animal in Group 1.

SUBJECTS

Ss were three groups of 10 male albino rats. All were aged from 120 to 140 days.

APPARATUS

The shuttlebox consisted of two compartments, one white and one black, separated by a 2.5 x 8 in. guillotine door.

A steel grid floor through which shock could be delivered ran the length of the floor. Electric timers and appropriate relay circuitry controlled the CS-UCS interval. Response latency was recorded from a photocell set into the walls of the box 0.5 in. from the door on the goalbox side.

CS consisted of door opening plus a 700-Hz tone from a speaker set into the side of the box.

PROCEDURE

Each S was given 5 min to explore the apparatus before being placed in the black start compartment and testing begun. ITIs averaged 75 sec and trials were signaled by the door opening and onset of tone. If S failed to cross (avoid) to the opposite chamber within 5 sec of this, a 2.0-mA shock was delivered until S escaped by crossing to the opposite chamber.