

ELIMINATING BEHAVIOR WITH REINFORCEMENT¹

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Responding produced food according to a fixed-ratio schedule while the prevailing key-color alternated between red and blue. Stimulus durations were varied until a period was found that maintained equal rates of responding in the presence of both colors. Then, food presentation was discontinued in the presence of one stimulus and made dependent on not responding in the presence of the other. Food presentation dependent on not responding reduced the rate of responding faster than did extinction. Spontaneous recovery occurred only during the stimulus correlated with extinction.

Recent years have seen rapid advances in the development of reliable prescriptions for acquiring and maintaining behavior, but, except in the case of punishment (Azrin and Holz, 1966), knowledge of how to eliminate behavior remains primitive. Because this problem is of concern both in laboratory and applied settings, there is a need to evaluate techniques for decreasing the probability of a response. Uhl and Garcia (1969) and Uhl and Sherman (1971) compared the effectiveness of presenting food only if a response did not occur for a specified time period (a differential-reinforcement-of-other, or DRO schedule) with a schedule in which food was simply withheld (extinction). They found that DRO decreased responding more slowly than did extinction. When Uhl and Sherman combined punishment with either DRO or extinction, they found that the combination of DRO and punishment had the more permanent effect in eliminating behavior. The present experiment provided another comparison of DRO and extinction but with emphasis on the behavior of individual organisms. Since both the Uhl and Garcia and the Uhl and Sherman experiments involved between-group comparisons, information is not available about the way in which DRO and extinction operate in individuals.

To study the effects of DRO and extinction in individual subjects, a procedure was de-

rived from that used by Hearst (1961). Hearst was able to conduct parametric analyses of resistance to extinction in individual pigeons by correlating each level of the independent variable (number or intermittency of food presentations) with a distinctive discriminative stimulus. After first giving differential treatment with respect to the stimuli, Hearst correlated each with extinction and observed the persistence of responding in the presence of each stimulus. In the present study, the treatments correlated with each stimulus were identical initially, but then the subsequent conditions were varied. Pigeons first were trained to respond equally in the presence of two stimuli by correlating the same reinforcement schedule with each, and then DRO was correlated with one stimulus and extinction with the other.

METHOD

Subjects

Three adult pigeons were maintained at 80% of their free-feeding weights. The birds had not served in other experiments.

Apparatus

The experimental chamber was a standard single-key unit (Ferster and Skinner, 1957). The 0.8-in. (20-mm) diameter response key (R. Gerbrands Co.), operated by a minimum force of 12 g (0.12 N) was transilluminated by either red, blue, or white pilot lamps. A 2-in. (5 cm) square aperture centered 3 in. (8 cm) below the key provided occasional access to

¹Supported by National Science Foundation Grant GB-25959. Reprints may be obtained from the author, Department of Psychology, Emory University, Atlanta, Georgia 30322.

Purina Pigeon Checkers, the food used as the standard diet. During the 4-sec feeder cycles, a 1.1-w white lamp illuminated the aperture, and the keylights went off. A houselight provided dim general illumination, and continuously present white noise masked extraneous sounds.

Procedure

One of the three birds was auto-shaped to peck a white key (Brown and Jenkins, 1968). The other two failed to auto-shape and were trained to peck by successive approximations. In the presence of the white key, food presentations followed every fixed number of pecks (fixed-ratio schedule). Initially, each response resulted in food presentation, and then the fixed ratio (FR) was gradually increased to FR 120 for Bird 110, FR 60 for Bird 111, and FR 30 for Bird 113. They were then exposed to an alternating sequence of the red and blue key colors. The ratio began anew with each food delivery and did not reset when the color changed. Thus, the schedule bore no relation to which color was present on the key. The ratio value differed for each bird in order to study the generality of the observed effects.

The colors alternated and appeared for the following durations according to the following order. They changed every 180 sec for 28 sessions, every 60 sec for 22 sessions, every 30 sec for 23 sessions, every 300 sec for 15 sessions, every 30 sec for 20 sessions, and finally every 300 sec for 22 sessions. Stimulus durations were manipulated in order to obtain an equal rate of responding in the presence of the two stimuli. This manipulation resulted in a parametric analysis of the effects of stimulus durations on response rates when stimuli changed, but the availability of food was controlled by responses alone without reference to prevailing stimuli.

Stimulus durations then were held constant at 300 sec, but the schedule correlated with the two stimuli was changed so that pecks did not produce food. Instead, during one color, food appeared whenever 30 sec passed without a peck (DRO 30-sec). The 30-sec period began anew with the onset of the stimulus. During the other color there were no food presentations and key pecks had no scheduled consequences (extinction). Whether red or blue was correlated with the DRO schedule varied among the three birds. This multiple DRO

extinction schedule was maintained for 12 sessions.

Sessions were conducted five days per week and lasted until each bird obtained 30 food presentations.

RESULTS

Response Rate with the Fixed-Ratio Schedule

The single fixed-ratio schedule continued regardless of the prevailing key color, so that responses emitted in the presence of either stimulus counted equally in meeting the ratio requirement. Nevertheless, after two or three sessions of responding at equal rates (within 0.1 responses per second) during each stimulus, the birds began to respond unequally. These differences, measured by the average response rate over the entire session, were the outcome of the duration of post-reinforcement pauses; once responding began, the rates were similar. When the stimulus controlling the lower rate appeared just after a food presentation, the birds often paused for the entire stimulus duration. If responding began in the color controlling the higher rate and the ratio was not completed when the other color appeared, the birds continued to respond until food was presented and then often paused for the remainder of the stimulus period.

Stimulus durations were manipulated in an attempt to obtain equal rates. Decreasing the durations from 180 sec to 60 sec and then to 30 sec either maintained or increased the inequalities in rate of responding; rate differences were as high as 1.5 responses per second. As post-food pausing increased during one stimulus, the birds obtained as many as 28 of the 30 daily food presentations during the other. Throughout, Bird 110 alternated between equal rates during both stimuli and decreased rates during one, and Bird 111 had either equal rates during both stimuli or lower rates when the key was blue. Bird 113 had developed equal rates during both stimuli in the last 12 sessions of the 180-sec duration condition. With the 60-sec duration, it alternated between equal rates during both and decreased rates during one, and with the 30-sec stimulus duration it revealed consistent rate differentials favoring red.

The 300-sec stimulus durations resulted in equal rates during the two stimuli for the

three birds, because pauses became equal. When the 30-sec duration was reinstated, however, differences reappeared. Reimposition of 300-sec durations again eliminated the differential. In summary, although there was not an orderly functional relation between stimulus durations and rate differences, the durations did determine whether or not differences were maintained. Rate differences occurred with durations of 30 sec with all of the birds and occurred at least temporarily with durations of 180 sec and briefer. The 300-sec durations, in contrast, produced the nearly identical rates shown as "FR" in Fig. 1.

Multiple DRO Extinction Schedule

Figure 1 shows the response rate in the 12 sessions with the DRO and extinction schedules. Responding declined from its previous level in both conditions and showed no relation to the size of the preceding fixed ratio. The DRO schedule could not begin to exert its effects until the birds paused long enough to receive the first food presentation; this took

from 3 to 8 min of exposure to the DRO schedule. As a consequence, the two schedules at first showed the same reduction in responding. From the first few reinforcements on, however, the advantage of DRO became evident. In every session, the DRO schedule controlled at least as low and usually a lower rate than extinction. By the second or third session and thereafter, the rate during the DRO schedule was less than 0.05 responses per second for Birds 111 and 113 and less than 0.12 responses per second for Bird 110. Behavior during the extinction component was more erratic with declines in rate broken by abrupt increases. Eventually, there were sessions with few or no responses during the stimulus correlated with extinction, but the birds were still pecking at the disk in the twelfth session. Six or fewer responses occurred in the DRO component in the last three sessions, while there were over 100 responses for all birds in Session 11 and more than 25 in Sessions 10 and 12 during the extinction component.

Sessions 6 and 11 took place 72 hr after the preceding one, whereas the others were separated by 24 hr. All of the birds increased their response rate during the extinction component in the sixth and eleventh sessions and then declined in Sessions 7 to 10 and in session 12. These increases and decreases generated the appearance of three separate extinction curves, one beginning in Session 1, a second beginning in Session 6, and the third beginning in Session 11. The increases following the long inter-session intervals are instances of spontaneous recovery, a phenomenon found under extinction conditions in both operant and Pavlovian conditioning situations. The DRO schedule, though, which reduced responding even more rapidly than did extinction, did not reveal spontaneous recovery.

Observations during the twelfth session suggested another difference between the two schedules. In the presence of the DRO stimulus, the birds stood relatively quietly except when food was delivered and they ate from the hopper. They were more agitated in the presence of the extinction stimulus in that they often turned away when that stimulus appeared and retreated to the rear of the chamber, occasionally advancing to peck at the disk.

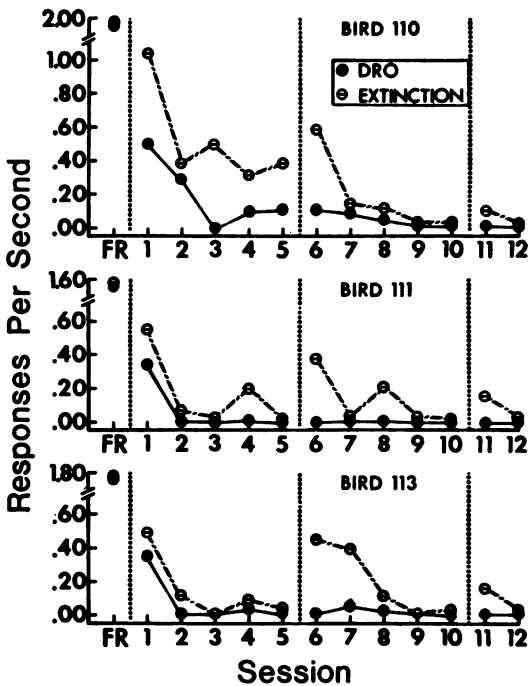


Fig. 1. Response rate on the last day of the fixed-ratio phase (FR) and in each of the 12 sessions with the DRO and extinction schedules. Birds had been trained as follows. Bird 110: FR 120; Bird 111: FR 60; Bird 113: FR 30. The vertical dashed lines appear between sessions separated by 72 hr; other sessions were separated by 24 hr.

DISCUSSION

The results confirmed Uhl and Sherman's (1971) observation that DRO more permanently reduced behavior than did extinction, although the two experiments showed this in different ways. Uhl and Sherman found that the DRO schedule retarded reacquisition of the response relative to extinction, and the present study showed relative permanence in terms of the presence of spontaneous recovery with extinction but not with DRO. Differences between the two schedules in spontaneous recovery have not been reported previously, perhaps because the three sessions of extinction and DRO used by Uhl and Sherman (1971) and Uhl and Garcia (1969) may have been insufficient to reveal spontaneous recovery or because all of their sessions were separated by equal time intervals. In the present study, which involved 12 sessions, spontaneous recovery occurred during the extinction stimulus whenever sessions were separated by 72 hr.

Although DRO eliminated the response more rapidly than did extinction in the present experiment, Uhl and Garcia (1969) and Uhl and Sherman (1971) found that DRO operated more slowly than did extinction. This difference might stem from the use of within-subject comparisons here as opposed to between-group comparisons in the other studies. Other variables such as species (pigeons *versus* rats), and preliminary reinforcement schedule (fixed ratio *versus* variable interval) also could be responsible.

Research on multiple schedules does not suggest that the loss of behavior during DRO should be facilitated relative to extinction by virtue of its combination with extinction; in fact, there is some indication (Nevin, 1968) that a DRO schedule providing food presentations at a high frequency reduces response rate in the other component of a multiple schedule. In addition, extinction usually increases the rate in another schedule in which food presentations occur (*e.g.*, Reynolds, 1961). Such interactions would seem likely to minimize rather than maximize the advantage of DRO over extinction in reducing response rates when they are combined in a multiple schedule. However, to the extent that DRO establishes some behavior other than key pecking, extinction may enhance that other be-

havior. In that case, DRO combined with extinction could eliminate key pecking faster than would DRO in isolation.

The similarity in behavior among the three birds during both phases of the experiment indicates that the size of the fixed ratio used in training was not critical. Given this degree of generality, it is necessary to note that the experiment did not manipulate DRO value. To what extent the differences are between DRO and extinction in general or between DRO 30-sec and extinction is not known.

Since extinction and DRO differed in the speed of reducing behavior, in the occurrence of spontaneous recovery, and in generating effects that might be described as emotional, different processes appear responsible for the decrements in behavior under the two conditions. The behavior with DRO is attributable to the power of reinforcement to stereotype behavior that precedes it. Under a DRO schedule, this behavior has been shown to be some particular form of not emitting the specified response (Zeiler, 1970). Reinforcement acts to make this particular competing behavior predominate, thereby resulting in the rapid decrease in the frequency of emission of the original response. Behavior loss in extinction, in contrast, may reflect the power of nonreinforcement either to weaken the original response without simultaneously developing some other competing behavior, or to develop competing behavior less directly. In short, it may be that DRO operates by building in a competing response, while extinction weakens the existing behavior by no longer following it with a reinforcing stimulus. If so, the DRO schedule represents the more straightforward instance of the conditioning of a competing response hypothesized by Guthrie (1952) to underlie all losses of behavior.

The development of unequal rates of responding in the first phase of the experiment, when both stimuli were correlated with the same fixed-ratio schedule, was an instance of a superstitious discrimination. Such differential responding with respect to stimuli in the absence of scheduled differential reinforcement was initially reported by Morse and Skinner (1957) who used a variable-interval schedule and unequal durations of the two stimuli. The present data show that differential responding also occurs with fixed-ratio

schedules and when stimulus durations are equal, so long as they are sufficiently short. Based on Morse and Skinner's observation that superstitious discriminations do appear with long but unequal stimulus durations, it seems that both parameters—relative duration and absolute duration—are important. The role of reinforcement in establishing superstitious discriminations is equivocal. In Morse and Skinner's and in the present study, differential responding was correlated with the differential frequency of reinforcement that followed from the behavior. A circular relation between reinforcement and rate would seem plausible: adventitious differential reinforcement could produce rate differences which then would accentuate differential reinforcement and thereby produce further rate differences, *etc.* Lander's (1968) report of differential responding when two stimuli were correlated with extinction, however, shows that superstitious discriminations can arise in the absence of reinforcement.

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Received: 21 April 1971.

(Final Acceptance: 21 June 1971.)