DIFFERENTIAL REINFORCEMENT OF OTHER BEHAVIOR (DRO): A YOKED-CONTROL COMPARISON¹

JENNIFER DAVIS AND M. E. BITTERMAN

UNIVERSITY OF SOUTH FLORIDA

After training to press a lever on a variable-interval 30-sec schedule, one group of rats was shifted to a differential-reinforcement-of-other-behavior 10-sec schedule, while a second group was shifted to a noncontingent yoked-control schedule that provided the same frequency and distribution of reinforcement. Then, both groups were extensively retrained on the variable-interval schedule, after which the first group was shifted to a series of differential-reinforcement-of-other-behavior 30-sec sessions alternating daily with variable-interval 30-sec sessions, while the second group was treated like the first on variable-interval days and yoked with the first as before on differential-reinforcement-of-other-behavior days. In both phases, response-decrement was more rapid and more marked in the differential-reinforcement-of-other-behavior animals than in the controls. The difference was due, at least in large measure, to sustainment of response in the control animals by adventitious reinforcement. All the differential-reinforcement-of-other-behavior animals developed "other" behavior—the same distinctive pattern of waiting at the foodcup—but there was no direct evidence that it contributed in any way to the decrement in lever pressing.

When a response postpones a reinforcer, the schedule has been referred to as differential reinforcement of other behavior (DRO). The familiar outcome of such training is a decrement in the rate of response (Reynolds, 1961). But little is known about what produces the decrement. Although the name of the schedule suggests that the animal stops responding in part at least because "other" (presumably incompatible) behavior is reinforced, there is no conclusive evidence for that assumption. The possibility must be considered that the animal stops responding simply because the response is not reinforced.

The only indication that response decrement in DRO is not due entirely to the lack of reinforcement may be found in an experiment by Nevin (1968) on discrimination in pigeons, which showed somewhat less response to the negative stimulus (S—) in DRO than in extinction. Unfortunately, however, Nevin's principal concern was with other matters, and he reported individual data for only the last three of 10 sessions during which responding was differentially reinforced. A

subsequent experiment described in the same paper showed no difference between DRO and extinction. In two experiments with rats trained on a variable-interval (VI) schedule, and then shifted either to DRO or to extinction, there actually was more responding in DRO than in extinction (Rescorla and Skucy, 1969; Uhl and Garcia, 1969). This unexpected outcome perhaps may be explained in terms of a tendency, evident in the data, for reinforcement to elicit the previously reinforced response, but we are left nevertheless with very little evidence for the efficacy of the DRO contingency.

The comparison of DRO with simple extinction does not, of course, control for any effects of reinforcement that are independent of the contingency. A better procedure might be to compare the performance of DRO animals with the performance of yoked animals undergoing extinction with reinforcers delivered independently of their behavior whenever a reinforcer is produced by the DRO animals. No such yoked-control experiment appears in the literature, although there is a close approximation that fails again to provide evidence for the effectiveness of the DRO contingency. Rescorla and Skucy (1969) found no reliable difference in the performance of rats trained on a VI schedule and then extin-

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guished either with free reinforcement delivered on a VI schedule or with a brief (5 sec) response-contingent delay of free reinforcement on the same schedule. Presented here are the results of a true yoked-control experiment in which responses of the DRO animals postponed reinforcement for somewhat longer periods of time.

METHOD

The subjects, 10 experimentally naive, 140-day-old hooded rats reduced to 85% of their free-feeding weights on a 24-hr feeding schedule, were trained to press a lever for 45-mg pellets on a VI 30-sec schedule in two identical Gerbrands chambers. Each chamber contained a single centered lever, with a foodcup below and to the left of the lever. A houselight, which was turned on at the start of each such session and turned off at the end of the session, dimmed sharply as each reinforcer was delivered. After responding had stabilized, the animals were paired on the basis of response rate to form two groups, DRO and yoked control.

In the first phase of the experiment, one member of each pair was shifted to a DRO 10-sec schedule (reinforcers provided by a 10-sec recycling timer that was reset by response), while the other member of each pair received reinforcers independently of its own behavior whenever the DRO animal waited at least 10 sec. There were 10 sessions, with five retraining sessions on VI 30-sec interpolated between the fifth and sixth. Each session was terminated after 30 reinforcements.

In the second phase, after extensive retraining of all animals on VI 30-sec, 21 sessions of DRO 30-sec and yoked-control training (odd days) regularly alternated with 21 sessions on the VI 30-sec schedule (even days). The purpose of this procedure was to study discrimination between the two schedules.

RESULTS

Two measures of performance were taken from the cumulative records in the first phase of the experiment, number of responses made in each session, and length of the session. The two measures were, of course, highly correlated. As the number of responses made by any given DRO animal declined, the sessions (which terminated after 30 reinforcements) became shorter, and the opportunity for response

afforded its yoked-control animal was reduced correspondingly. The performance of the DRO and control groups is compared in terms of the number of responses, since the length of session was, of course, the same for both. As Fig. 1 shows, the mean number of responses made by the DRO animals declined sharply over the first five sessions, recovered after the interpolated VI training, and then declined sharply once more. In Sessions 3 to 5 and 7 to 10, the DRO animals made almost no responses at all, waiting at the foodcup, typically with head in the cup, and displaying considerable resistance to being removed from that location at the end of the session. Every control animal made more responses in every session than did the DRO animal with which it was yoked, and the cumulative records of four of the controls continued to show long segments of what might easily be mistaken for VI behavior. The only control animal that failed to make a great many more responses than the DRO animal with which it was yoked came early to show an easily recognizable pattern of posturing over the lever.

In the second phase, the performance of all the animals stabilized rapidly during retraining on the VI schedule and remained relatively constant in the subsequent VI sessions. In the DRO and yoked-control sessions, the rate of responding in every DRO animal declined progressively to a level lower than that of its

Fig. 1. Mean number of responses per session made by DRO 10-sec (O) and yoked-control animals (C) in the first phase of the experiment.

control, although the performance of the control animals varied markedly. Figure 2 shows the results for three pairs of animals selected to illustrate three different control outcomes, either a progressive decrease in rate over sessions, which was found in three cases (lower pair); no substantial change (middle pair), or a progressive increase in rate (upper pair). The progressive increase in rate provides an unusually clear illustration of the efficacy of adventitious reinforcement. The curves of Fig. 2 are plotted in terms of the number of responses made in the 15 min following the first reinforcement delivered in each session. The first reinforcement was taken as the point of reference because it defined for the DRO animals

Fig. 2. Number of responses in 15 min following the first reinforcement of each session made by selected pairs of DRO 30-sec (O) and yoked-control (C) animals in the second phase of the experiment.

whether the schedule in effect during the session was DRO or VI, while a fixed time of 15 min was chosen because that was the minimal duration of a DRO session after the first reinforcer. (Here, again, it should be remembered that the sessions declined in length for both members of each pair as the number of responses made by the DRO animal declined.)

The behavior of the animals in the second phase of the experiment is illustrated by some representative records for two of the pairs in the first, sixth, and sixteenth DRO and yoked-control sessions, which are reproduced in Fig. 3. A residual tendency for a reinforcer to initiate a period of responding on the lever may be seen in the first-session records of the DRO animals (6 and 9). That tendency disappeared rapidly in subsequent sessions, and waiting at the foodcup became the dominant response to free reinforcement. Some DRO animals (e.g., 6) would begin each session with lever pressing, pause only after a period of unreinforced responding (which tended to decrease in length from session to session), and then remain at the foodcup after taking the first pellet. Other DRO animals (e.g., 9) would wait near the foodcup at the start of each session and (on VI days) begin to press the lever only after a period of unreinforced waiting. The control records (3 and 5) illustrate a characteristic initial tendency in the control animals (which persisted in 5 but not in 3) to continue to press the lever while the DRO animals were receiving pellets for not pressing it. Three of the controls learned eventually to wait at the foodcup while the postponement contingency was in effect for the DRO animals, but much more slowly than the DRO animals with which they were yoked.

DISCUSSION

This experiment clearly demonstrates greater response decrement in DRO animals than in animals undergoing extinction but given the same number of free reinforcers as are received by DRO animals with which they are yoked. The failure of Rescorla and Skucy (1969) to find such a difference in a similar study perhaps may be attributed either to their use of a shorter response-postponement interval or to the fact that their procedure did not exactly control the distribution of reinforce-

Fig. 3. Cumulative records for two DRO 30-sec animals (6 and 9) and their yoked controls (5 and 3) in the first (left), sixth (center), and sixteenth (right) sessions of the second phase of the experiment. Vertical lines separate the records for the three sessions, whose length was, of course, always the same for both members of each pair. Rates may be estimated from the fact that the pen reset after 180 responses and that the duration of the sixteenth session for the lower pair was about 15 min.

ment. The present results do not, however, require the conclusion that the reinforcement of "other" behavior contributes to response-decrement in DRO, because the difference obtained may have been due entirely to sustenance of response in the control animals by adventitious reinforcement. The early per-

formance of the control animals certainly was much like the performance of animals whose lever pressing is reinforced, although—as has been reported by other investigators (Appel and Hiss, 1962; Boren, 1969; Edwards, West, and Jackson, 1968; Zeiler, 1968)—there were some substantial decrements in responding

with further opportunity to discriminate between contingent and noncontingent reinforcement. It is conceivable, then, that the DRO animals responded less than the controls only because the DRO contingency prevented the adventitious reinforcement of lever pressing.

The performance of the DRO animals was not, of course, simply that of animals undergoing extinction. All of them developed "other" behavior—the same, seemingly adaptive pattern of waiting at the foodcup—as an alternative to lever pressing, shifting precipitously from one mode of reaction to the second with changes in the prevailing schedule from VI to DRO, which were discriminated, apparently, in terms of the circumstances under which reinforcement was received. That well-defined "other" behavior did, in fact, appear does not necessarily mean, however, that it contributed significantly to the observed decrement in lever pressing, any more than the occurrence of collateral behavior in DRL means necessarily that it has a timing function (Zuriff, 1969). It is not unlikely that waiting at the foodcup could develop only as lever pressing extinguished, and that the extinction of lever pressing progressed independently of the behavior in which the animals engaged when they were not pressing. Recent work by Leitenberg, Rawson, and Bath (1970) suggests that the extinction of one response may indeed be hastened by the reinforcement of an incompatible response, but experiments of a different design than the present one will be required to

determine whether some such process is operating in DRO.

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