Fixed ratio schedule of reinforcement as a determinant of successive discrimination reversal learning in the pigeon*

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Pigeons, trained on a series of blue-green discrimination reversals and then on a series of red-yellow discrimination reversals, were required to emit either 1 or 15 pecks per trial. Those pigeons with the FR 15 requirement improved more rapidly across successive reversals for both problems, with the magnitude of the effect being larger for the more difficult discrimination problem.

Successive discrimination reversal learning (SDR) has been increasingly used as a tool of the comparative psychology of learning. Considerably less research has been devoted to a functional analysis of SDR behavior for any particular species. Without such analysis, species differences revealed by the SDR procedure remain potentially interpretable as products of confounded variables correlated with species differences. A prerequisite for interpreting any species difference in the SDR procedure, therefore, is a specification of the determinants of SDR behavior in general.

One variable of potential significance for SDR behavior is the response requirement. In previous experiments (Williams, 1971a, b) examining the acquisition of a different complex learning problem (nonspatial delayed alternation), the author has found that pigeons required to emit 10-15 pecks per trial learned to alternate between two colors, even with delays as long as 45 sec between trials, whereas pigeons required to emit 1-5 pecks per trial showed no learning. The present study extends the analysis of the FR variable to the SDR procedure in order to determine whether or not response requirement affects other types of complex discrimination learning.

SUBJECTS

Twelve White Carneaux pigeons were maintained at 80% of their free-feeding body weight. Six Ss were experimentally naive; three had been trained previously on an auditory generalization task using variable-interval schedules of reinforcement; and three had been trained on a red-green discrimination reversal procedure 18 months prior to the start of this experiment.

*This experiment was conducted when the author was a NSF graduate fellow and was supported by Research Grants NIMH 15494 and NIH-GM-15258 to Harvard University. Reprints can be obtained from the author, The Colorado College, Colorado Springs, Colo. 80903.

when a food magazine was activated. The relay programming for the chamber was located in an adjoining room.

PROCEDURE

After shaping the birds to peck the left key while illuminated with white light, training on a red-yellow discrimination problem was presented. Yellow was the correct stimulus for Day 1, red on Day 2, yellow on Day 3, etc., with this continuing for a total of 10 sessions. Within a daily problem, each color was present on each trial. When the correct color was pecked, the lights were extinguished and the S was rewarded with 2.8-sec access to the food magazine, followed by 1.2 sec of complete darkness before the start of the next trial. When the incorrect color was pecked, the lights were extinguished for the entire 4.0-sec interval between trials. With the exceptions of Days 1 and 2, when a noncorrection procedure was used, the positions of the colors changed randomly after a correct trial but did not change after an incorrect trial. Training within a session continued until the bird reached the criterion of 20 consecutively correct trials.

For Sessions 1 and 2, all Ss were trained using only one peck per trial (FR 1). Thereafter, one-half of the Ss were required to emit at least 15 pecks per trial (FR 15). With this procedure, correct and incorrect pecks were counted separately so that whichever first reached the FR 15 requirement determined whether the trial was

APPARATUS

The apparatus was an operant conditioning chamber converted from an aluminum picnic cooler. The bird's chamber was a 30.5-cm cube, equipped with an overhead houselight and constant white noise input to mask outside noise. On the front panel, two Gerbrands pigeon keys, 1.9 cm in diam, were mounted 10 cm apart, center to center, and 23 cm above the floor. Each key required a force of at least 0.15 N for operation. Behind each key were two 7.5-W Christmas tree light bulbs, one of which was illuminated on each trial. Each peck on either key produced a click resulting from the activation of a relay located behind the panel. Directly between and 13 cm below the keys was a 5.0 x 4.5 cm aperture through which the birds were fed

Fig. 1. Mean number of errors per session (trials completed on incorrect stimulus) on the red-yellow and blue-green reversal problems.

correct or incorrect.

After 10 sessions of red-yellow training (R-Y), the blue-green problem (B-G) was introduced, with no other changes being made in the daily procedure. During B-G training, occasional single-stimulus pretraining was presented to four Ss in each FR group. This pretraining in no way affected the FR comparisons, however, and its effects are not presented here. Training on the B-G problem was continued for 56 reversals.

After completion of B-G training, the colors were returned to the original R-Y problem. This training continued for 20 reversals.

RESULTS

The data from each of the three phases of training are presented in Fig. 1. The first four sessions of the initial R-Y training are not shown because of the shaping required for the FR 15 behavior to become stable. Figure 1 reveals that both groups of Ss gradually learned reversals with increasing proficiency but that FR 15 Ss required fewer errors per reversal. To test this observation statistically, Ss from the two FR groups were paired according to their training history with difference scores then computed for their respective mean errors per problem. The mean difference was subjected to a *t* test and was found to be significant for both B-G training [probability, one-tailed, $t(5) = 2.10 < .05$] and the second

phase of R-Y training [probability, one-tailed, $t(5) = 3.71 < .01$].

In addition to the overall FR effect, Fig. 1 suggests an interaction between FR value and difficulty of the discrimination. For all FR 1 Ss, many more errors were emitted during R-Y training than during B-G training, hence indicating that R-Y was the more difficult problem. Much less difference was apparent, however, for the FR 15 Ss. To test for this interaction, difference scores for the second R-Y training were compared with difference scores for the first 20 sessions of B-G training, with a *t* test then performed on the differences of the differences. The mean difference of the differences was 9.9 errors per reversal and was statistically significant [probability, two-tailed, $t(5) = 3.12 < .05$]. Thus, the more difficult the discrimination problem, the more important the FR variable becomes.

DISCUSSION

The immediate question raised by the FR requirement's considerable effect on SDR learning proficiency is its mechanism. Since several different response parameters were correlated with the ratio requirement (e.g., effortfulness, duration), some further analysis of the actual mechanism of the facilitative effect would seem desirable. One observation pertinent to this question, from a previous experiment, was the distribution of pecks within a trial. Although the

overall accuracy for individual responses was only slightly less than overall accuracy for trials, Williams (1971a) found a persistent tendency for the initial pecks of a trial to be less accurate than later pecks in the trial. The inaccuracy of the initial pecks was not the result of random behavior, however, but instead was specifiable as the result of perseverative errors (the problem was delayed alternation learning). The larger FR requirements allowed such perseverative errors to be overcome within a trial. Whether a similar explanation accounts for the present results with a different learning problem, where sources for perseverative errors are less obvious, is not answerable by the available data.

A second question regarding the FR effect, regardless of its mechanism, is its generality across species. For example, can SDR learning in fish be facilitated by a FR requirement? Although no data are available on this question, it is noteworthy that qualitative differences in learning proficiency in other complex learning problems have previously been shown with pigeons (Williams, 1971a).

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