Differential reward conditioning in the pigeon¹

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Pigeons trained in discrete trials to peck a red or a green key for 1 or 8 food pellets show stable negative contrast when the two colors are differentially rewarded. The contrast effect disappears when differential reward is discontinued and reappears when differential reward is resumed. Daily doses of pentobarbital sodium (5 mg/kg) do not prevent contrast. The magnitude of the effect increases within sessions and decreases between sessions, even in highly trained animals.

The negative results of a Crespi experiment with goldfish (Lowes & Bitterman, 1967) suggest that it may be instructive to examine the phyletic generality of the various contrast effects that are found in rats. In the present experiment with pigeons, we looked for evidence of negative contrast in differential reward conditioning. The experiment was patterned after those in which rats trained in different runways have been found to run less rapidly to small reward in one runway when reward in the other is large than when the reward in both runways is small (Bower, 1961; Ludvigson & Gay, 1967; Rossman & Homzie, 1967). What appears to be the same effect also has been found in the running times of rats on forced trials in choice situations (Davenport, 1962; Spear & Hill, 1965), and in the choice behavior of monkeys (Leary, 1958; Schrier, 1958).

Method

The Ss were 16 White Carneaux pigeons, which were housed individually in a temperature-controlled colony room and maintained at 85% of ad lib weight on a 24-h feeding schedule. The apparatus was a ventilated picnic chest with a panel containing a single pigeon key. Below the pigeon key was a Plexiglas food cup into which 1 or 8 98-mg Noyes pigeon pellets were discharged automatically by a Gerbrands feeder. The food cup was continuously illuminated by a white lamp (set behind it) that also provided some diffuse illumination of the animal's compartment. The key could be illuminated with red or green light.

Before the beginning of the present experiment, the Ss were trained to peck a red key on a CRF schedule, one group (N = 8) rewarded with 1 pellet and the other with 8 pellets. All the animals were extinguished, retrained, and then subjected to a series of further extinction sessions separated by retraining sessions. In the earlier retraining sessions, the CRF schedule was used; in later sessions, the schedule was changed to FR-10. In this initial phase of their training, which was patterned after previous work with rats and goldfish (Gonzalez, Holmes, & Bitterman, 1967), the pigeons performed in much the same way as rats.

In the experiment which is reported here, the Ss were trained in discrete trials with a 15-sec ITI and a 31-sec trial limit. Each trial began with illumination of the key. When the animal pecked the key 20 times, the key light turned off and the feeder discharged either 1 or 8 pellets into the food cup; if 20 pecks were not made in 31 sec, the trial ended without reinforcement. The measure of performance was time between the beginning and end of a trial. When the key light was red, the previous large reward group—now the 8-1 group—continued to receive 8 pellets as reward, and the previous small reward group—now the 1-1 group—continued to receive 1 pellet. When the key light was green, the reward for both groups was 1 pellet. The total number of pellets received by each group on each day was equated in postfeedings. There were 20 trials per day, 10 with red and 10 with green light. The two colors were presented in Gellermann orders except when the effect of

order was being studied. Other procedural variations are described in conjunction with the results.

Results

The development of negative contrast may be seen in the mean log response times of the 8-1 and 1-1 groups that are plotted in the first portion of Fig. 1 (Days 1-11). Both groups responded more slowly at first to the new color (green) than to the old, but as training continued the response of the 1-1 group to the new color became more rapid while that of the 8-1 group became even more slow. This divergence in the 1-pellet curves of the two groups is reflected in a significant interaction of groups by days ($F = 5.58$, $df = 10/140$, $p < .01$).

On Day 12, the 8-1 group was shifted to the 1-1 condition, and the difference in the response of the two groups to green gradually disappeared. As Fig. 1 shows, the principal effect of reducing the amount of reward given the 8-1 animals for response to the red key was to increase the readiness with which they responded to the green key. In their response to the red key after the change in conditions, the 8-1 animals gave little indication of successive contrast. On Day 46, the original conditions were restored, and, as may be seen in Fig. 1, the simultaneous contrast effect gradually reappeared; that is, the two green curves diverged once more ($F = 2.38$, $df = 19/266$, $p < .01$).

There followed a series of tests, prompted by the work of Rosen, Glass, & Ison (1957) on the Crespi effect in rats, in which the consequences of daily IM injections of pentobarbital sodium were studied. Doses of 10 mg/kg given 20-30 min before testing tended to slow the performance of the 1-1 animals. Doses of 5 mg/kg had no effect on the performance of the 1-1 animals, nor did they prevent the development of negative contrast when those animals were shifted to the 8-1 condition. (The old 8-1 animals, injected with saline, served as controls.)

Order effects then were studied in a combined group of 15 Ss (one animal was lost during the drug tests), all of which were trained under the 8-1 condition. It had been noted at the beginning of this experiment that the negative contrast first appeared within sessions and disappeared between sessions (cf., Hill, Erlebacher, & Spear, 1965). As training progressed, some effect was evident on the earliest trials of each session, but even highly trained animals continued to show within-sessions increases and between-sessions decreases in the magnitude of the effect. On Days 85-88, the animals were given either 10 red (8-pellet) trials followed by 10 green (1-pellet) trials, or 10 green trials followed

Fig. 1. Response to each stimulus, plotted in terms of mean log time per trial, in various stages of training. The training of the original 1-1 group continued unchanged from Day 1 through Day 65. After a period in which all animals received 8-1 training (ending on Day 92), they were divided into two new groups, of which one continued to receive 8-1 training and the other was shifted to 1-1.

Fig. 2. The increase in contrast within sessions. The curves are based on the pooled data of Days 89-92, when the two colors were presented in Gellermann orders. Trial 1 is the first trial on which a given color was presented, and so forth.

by 10 red trials in balanced orders over Ss and days. Mean log time per trial for response to red was independent of order (.66 for high-low and .67 for low-high), but the time for response to green was longer when green trials were preceded by red trials (.92 for high-low and .81 for low-high, $p < .01$ by Wilcoxon's test for paired replicates). Figure 2 shows the within-sessions increase in the magnitude of the effect for pooled Days 89-92, when the two colors were presented in Gellermann orders. Analysis of the difference scores yields a significant trials effect ($F = 2.66$, $df = 9/126$, $p < .01$).

In the final portion of the experiment, the animals were divided into two new groups, each comprised of half the original 8-1 Ss and half the original 1-1 Ss. The groups were matched on the basis of their performance on Day 92 (Fig. 1). On Day 93 and thereafter, the 8-1 Gellermann training was continued for one group, while the other was shifted to 1-1. As the final portion of Fig. 1 shows, the principal effect of reducing the amount of reward for response to red was, as before, an increase in the speed of response to green. Response to red was little affected by the change.

Discussion

The large and stable simultaneous negative contrast effect shown here in pigeons seems to be the same effect which is found in analogous experiments with rats. The results give us no reason to suspect, in any case, that reward functions differently in the instrumental learning of the two animals. To account for the contrast, it seems necessary to assume that the animals learn

somehow to anticipate given amounts of reward, although it remains to be determined how the anticipation produces the contrast. The conditioned-frustration analysis certainly finds little support in the present data. The stability of the contrast effect is difficult to account for in those terms, as is the fact that the principal consequence of shifting from 8-1 to 1-1 training is an increase in speed of response to the 1-pellet color. The within-sessions component of the effect revealed by the analysis over trials points to the operation of some short-term process, a further study of which may contribute to an explanation of the component that is stable over sessions.

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