BEHAVIORAL CONTRAST AS A FUNCTION OF THE DURATION OF AN IMMEDIATELY PRECEDING PERIOD OF EXTINCTION¹

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For four pigeons key-peck responding was reinforced on a variable-interval reinforcement schedule in the presence of a vertical white line. When response rates had stabilized a horizontal white line was introduced, in the presence of which reinforcement was not available (extinction). The horizontal line was presented once per session, immediately before the vertical line was presented. The duration of the horizontal line varied randomly from session to session, being either 0 sec (*i.e.*, no presentation), 10 sec, 30 sec, 2 min, 10 min, 40 min, or 120 min. When the horizontal line was present for more than 0 sec, behavioral contrast was obtained in the presence of the following vertical line. Contrast increased with increasing durations of the horizontal line, asymptoting when the horizontal line was present for 40 min.

If a pigeon is trained to respond on a schedule in which periods of a stimulus (S+), correlated with a variable-interval (VI) reinforcement schedule, alternate with periods of another stimulus (S-), correlated with non-reinforcement, then behavioral contrast may occur in S+ (Reynolds, 1961). That is, response rates may be higher than if only S+ is presented—without alternation of S-.

For schedules in which S+ and S- irregularly alternate, contrast is greater when S+ is immediately preceded by S- than when preceded by S+ (Bernheim and Williams, 1967; Boneau and Axelrod, 1962; Catania and Gill, 1964; Nevin and Shettleworth, 1966, Terrace, 1966). In the present experiment, the magnitude and duration of contrast in an S+ component was measured as a function of the duration of an immediately preceding period of S-. Previous studies of this type (*e.g.*, Bernheim and Williams, 1967) have either not adequately measured the duration of contrast in S+ and/or have not varied the duration of S- to any appreciable extent.

Contrast in S+ is increased when S- precedes S+, but it is also increased when S- consistently follows S+ (Wilton and Gay, 1969). In an attempt to eliminate this latter

contribution to any contrast effects in the present experiment only one S- presentation was employed per session, this coming, of course, before the S+ component.

METHOD

Subjects

Four adult homing pigeons, 3W, 24W, 18W, and 19W, locally obtained and experimentally naive, were maintained at about 80% of their free-feeding weights.

Apparatus

A sound insulated operant conditioning chamber contained a translucent response key of 19 mm (0.75 in.) diameter that could be illuminated from behind by either a homogeneous red light, a vertical bar of white light ($\frac{1}{8}$ in. width), or a horizontal bar of white light ($\frac{1}{8}$ in. width). A grain magazine was centered below the key. The reinforcer consisted of a 3 sec exposure to a grain mixture. Sessions were scheduled through relays and timers contained in an adjoining room.

Procedure

In the presence of the vertical line, the birds were trained to peck at the key by the auto keypeck training procedure used by Brown and Jenkins (1968). When pecking, each bird was gradually shifted to a VI 1-min schedule over the course of five days. Regular training sessions then began. A bird was placed in the

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chamber, and 5 min later the onset of the houselights initiated a session. For the first 10 min, intended as a warm-up period, the key was illuminated red. Responding was reinforced on a VI 1-min schedule (Fleshler and Hoffman, 1962). Following this the key was illuminated by a white vertical line, and the VI schedule ceased to operate until a first peck to the vertical line occurred. After this peck the VI schedule was again in operation, and remained so until the end of the session 20 min later. Sessions were conducted every day. When response rates were stable over at least 15 sessions the experimental procedure began. As before, the key was first illuminated red for 10 min. But this was followed by a horizontal white line (S-), in the presence of which reinforcement never occurred. The duration of S- varied from session to session according to the rules described below. After the assigned period of S-, the vertical line (S+) was presented. As before, the first peck initiated the final 20 min of the session, during which time responding was reinforced on the VI schedule.

For Birds 3W and 24W the duration of the S- period within any one session was either 0 sec (*i.e.*, S- was not presented at all), 10 sec, 30 sec, 2 min, 10 min, 40 min, or 120 min. Thirty-five sessions were conducted with each duration of S- occurring five times. Over the first seven sessions, each duration occurred once; after that the sessions were sequenced randomly. For Birds 18W and 19W, the S- durations were either 0 sec, 30 sec, 40 min, or 120 min. Twenty-eight sessions were conducted with each duration of S- occurring seven times. Over the first eight sessions, each duration occurred twice; after that the durations were arranged randomly.

RESULTS

Two points can be noted before response rates are analyzed. First, data from the first few experimental sessions (seven sessions for Birds 3W and 24W and eight sessions for Birds 18W and 19W) were discarded. At the end of these sessions each bird had formed a partial S+, S- discrimination, response rates to S- being less than 60% of the baseline rates to S+. Second, response rates in S+ (vertical line) were calculated on the basis of

time elapsed since the first peck to S+. It was anticipated that some very long latencies might occur for the first peck to S+ after a 40-min or 120-min exposure to S- (although the houselights were on throughout). This did not happen; most latencies were shorter than 5 sec, and only two were greater than 30 sec (one after a 30-sec exposure to S-, the other one after a 120-min exposure). Furthermore, as measured to the nearest second, no systematic variations in these latencies occurred, and therefore they are not reported.

Figure 1 shows a series of panels for each bird. For each bird, the first panel on the left represents that part of the session in which the red stimulus was present. Succeeding panels represent successive portions of the S+ (vertical) component: 0 to 3 min, 3 to 6 min, 6 to 10 min, and 10 to 20 min. Within each panel the data point furthest to the left represents the mean response rate over the last 15 baseline sessions (B). The remaining points show the mean response rates in the experimental sessions, plotted as a function of the duration of the preceding S-. Using contrast to refer to any increase in rate over the baseline rate, panel 0 to 3 min shows that in the first few minutes of the S+ component, contrast is greater the longer the exposure to S-. In later minutes, this effect declines (panels 3 to 6, 6 to 10 and, 10 to 20 min). Also, the effect seems to reach asymptote when S- lasts for 40 min. In no panel is the rate following an exposure to S- for 120 min consistently higher than that following an exposure for 40 min.

The response rates occurring after a 0 sec exposure to S- are of particular interest. As S- failed to occur in these sessions, a comparison of response rates in S+ with the baseline rates gives some idea of the contrast that resulted from exposures to S- in preceding sessions (days). Panel 0 to 3 min suggests the occurrence of some contrast in the 0-sec condition, since birds 3W, 18W, and 19W then respond faster than in baseline sessions. However, the effect is small, is not replicated in Bird 24W, and is not obtained at all consistently in any subsequent panel (*e.g.*, 3 to 6 min). Moreover, response rates in the red component (first panel) are no higher than the baseline rates. Thus, there seems to be little contribution to contrast from the S- presentations in previous sessions.

Fig. 1. Mean response rates in the red and S+ components plotted as a function of S- duration. Durations of S- are plotted on a logarithmic scale, except for the duration of 0 sec, which is given as a value appropriate to 1 sec (avoiding a plot of $-\infty$). B indicates the mean rate obtained over 15 baseline sessions.

DISCUSSION

Bernheim and Williams (1967) showed that a transition from a schedule of high reinforcement frequency to one of low reinforcement

frequency produced a negative contrast effect, the magnitude of which was proportional to the duration of the high reinforcement schedule. In the same study, a transition from a schedule of low reinforcement frequency

quency to one of high reinforcement frequency produced positive contrast in two of the four subjects. But unlike negative contrast, positive contrast showed no relationship to the duration of the immediately preceding schedule. In part, this finding led Bernheim and Williams to suggest that positive and negative contrast effects are not "complementary aspects of a single underlying mechanism." The present results show that positive contrast increases with increasing durations of the preceding S— component, and therefore reduce the basis for the rejection of the above hypothesis. Moreover, the present results appear not to be in conflict with those of Bernheim and Williams. They are perfectly compatible with the suggestion that the durations of the low reinforcement schedule used in their study (1 to 5 min) were of insufficient range to demonstrate the effect.

The present results suggest that the increase in contrast with S— duration reaches asymptote when S— lasts for 40 min or less. However, in the absence of data collected with very long durations of S— it is impossible to preclude the possibility of a non-monotonic function relating contrast to S— duration. Contrast might decline with S— durations much greater than 40 min.

It is of interest that there was little evidence of contrast in those sessions when S— did not occur (0-sec duration). This suggests that exposures to S— on preceding days did not directly produce contrast on succeeding days. In a study by Bloomfield (1967), where S+ and S— alternated from day to day, contrast did occur in S+. Thus, exposure to S— on one day produced contrast on a succeeding day. This may not have happened in the present study because of the intervening S+ component that immediately followed S—. On the other hand, in unpublished work, we have

been unable to obtain contrast under conditions similar to Bloomfield's, suggesting that the effect is not easily obtained even outside the present procedure (*cf.* Amsel, *in press*).

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