BEHAVIORAL EFFECTS OF PAIRING AN S^D WITH A DECREASING LIMITED-HOLD REINFORCEMENT SCHEDULE

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Four pigeons were trained on a multiple reinforcement schedule consisting of two limited-hold schedules, one in which a discriminative stimulus (S^D) accompanied the periodic reinforcement contingency, and one in which the discriminative stimulus was omitted. The duration of the limited-hold in each component of the multiple schedule was reduced in parallel steps. It was shown that behavioral differences between the two schedules were attenuated by this manipulation of temporal parameters. When S^D was reduced in duration, three out of four pigeons responded with extremely high S^A rates, despite the regular pairing of S^D with the reinforcement contingency. These high rates qualitatively resembled the rapid rates emitted on the analogous no- S^D component.

Schoenfeld, Cumming and Hearst (1956) demonstrated that rapid ratio-like key-pecking behavior can be produced in pigeons by limited-hold (Ferster and Skinner, 1957) reinforcement schedules. The method they used was the progressive decrease of a periodic limited-hold (t^D). Their findings have since been confirmed (see review by Schoenfeld and Cumming, 1960) and the substance of their findings has been extended to avoidance behavior (Hurwitz and Millenson, 1961).

Work reported from this laboratory (Weissman, 1961) supported the findings of Schoenfeld *et al.*, (1956) and further extended their method into the area of stimulus discrimination. A discriminative stimulus (S^D) was associated with a t^D presented every 90 sec. When the duration of t^D exceeded 1 sec, key pecking during S^D was consistent, but very low key-pecking rates arose in the absence of S^D . When the duration of t^D and the accompanying S^D was reduced to 1.0 or 0.5 sec, extinction developed. Subsequently an analogous experiment was performed with the same subjects but S^D was omitted; in essence the limited-hold contingency corresponded to that reported by Schoenfeld *et al.*, (1956). This time rapid ratio-like response rates were emitted and reinforcements were obtained at the same t^D durations which previously produced extinction when paired with an S^D . It

was concluded that an S^D correlated with a reinforcement contingency can impair performance when the contingency is a t^D of brief duration. Further work revealed that if the initial stimulus discrimination was poor, rapid key pecking in the absence of S^D would occur when t^D was decreased, despite the fact that stimulus discrimination conditions were in effect. Thus, behavior under a stimulus discrimination and under a corresponding "pure" reinforcement schedule could be partially reconciled.

The study reported here makes use of the multiple schedule technique (Ferster and Skinner, 1957) to show the effect on behavior of simultaneous reductions in t^D duration under the two types of limited-hold contingencies, one in which the reinforcement contingency is accompanied by an S^D , and one in which no S^D is presented.

METHOD

Subjects

Four White Carneaux hen pigeons, two years old when obtained, were fed *ad lib* for several months. They were then deprived to 80% of their free-feeding weight levels, and subsequently were maintained at this weight by a combination of food reinforcements plus supplemental feeding.

Apparatus

A commercial Skinner box (Foringer and Co., Rockville, Md.) was used. Its important

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working parts were two identical Gerbrands pigeon keys which could be illuminated white or green, and a solenoid-operated reinforcement magazine. External circuitry automatically programmed stimulus conditions and recorded key pecks.

Procedure

The subjects (Ss) were first trained by conventional procedures (Ferster, 1953) to peck at a green key for reinforcement (3-sec access to a mixture of grains). The experiment proper, consisting of a long series of daily sessions on different values of a multiple reinforcement schedule, then began. Outside of reinforcements earned during sessions, the only food allowed Ss was enough supplemental grain, given in home cages immediately after each session, to bring their body weights to 80% of their free-feeding levels.

Each session began with the right key illuminated white (S^A). Every 90 sec it became green (S^D). The first key peck during S^D produced a reinforcement and reinstated S^A . Key pecks were not reinforced until the key was again green. This stimulus discrimination procedure continued for 15 min (10 presentations of green) during which time the left key was not illuminated. After the 15 min elapsed, the right key was darkened and the left key was illuminated green. Every 90 sec S became eligible for reinforcement in the same way as on the right key, except that the key was continuously green; no discriminable stimulus denoting reinforcement-eligibility was presented. The limited-hold period on the left key was termed t^D , and that of noneligibility was termed t^A , in accordance with the system outlined by Schoenfeld *et al.*, (1956). After 15 min on this program, the right key was illuminated as before. In this way, the two analogous schedules, stimulus discrimination on the right key and intermittent reinforcement on the left key, were programmed alternately until four periods of 15 min duration each had been assigned to each of the keys and 2 hr of total session time had elapsed.

When Ss were first exposed to this program, the maximum duration of S^D and t^D periods were set at 30 sec. Consequently, if S failed to peck within 30 sec from the onset of reinforcement eligibility, a possible reinforcement would be missed.

The duration of both t^D and S^D was the independent variable of this study. It was reduced every 30 sessions from 30 sec to 3, 1, .3, and .1 sec; durations of both t^D and S^D were reduced simultaneously, and as a result they equaled one another in all sessions.

RESULTS AND DISCUSSION

The data from each bird are summarized in Fig. 1. Data shown are from the terminal day on each t^D and S^D value. Figure 2 illustrates a continuous 30-min output of behavior on these days from pigeon C-1.

Key-pecking response rates during the t^D - t^A (intermittent reinforcement) component of the multiple schedule increased sharply when the duration of t^D was reduced below 1 sec. At the lowest two or three values of t^D , some reinforcements were missed. The combined effect of increased response rates and decreased reinforcements led to a large increase in mean responses-per-reinforcement and a qualitative change, evident in t^D - t^A cumulative response records, from "fixed-interval" to "ratio-like" behavior. Figure 2 (right side) illustrates this effect in bird C-1. In general, the results from this component are similar to those reported by Hearst (1958).

Overall response rates emitted by the four Ss during the S^D - S^A (stimulus discrimination) component of the multiple schedule were very low at long S^D durations. In three of the four birds, the stepped reduction of S^D from 1.0 to .3 and .1 sec led to marked increases in response rates. The number of reinforcements received by these three birds during the stimulus discrimination component declined considerably at low S^D values, but were still substantial. The exceptional pigeon (C-2) failed to emit appropriate rapid response rates at low S^D values. For the most part, the S^A responding that C-2 emitted at these values, especially at .1 sec, consisted of brief bursts of responding after S^D was presented. This bird received no reinforcements at all at the lowest S^D duration.

Decreases in the duration of t^D can therefore produce increased response rates in t^A whether or not t^D is accompanied by a discriminative stimulus. One might suspect that the behavioral control exerted by S^D at longer S^D durations, as reflected by the very low S^A response rates, would carry over to short S^D

Fig. 1. Responses-per-minute as a function of t^D and S^D value. Plotted points for the four birds were calculated from the last of 30 sessions on each t^D and S^D value. Numbers above the points are total reinforcements received (out of a possible 40) at each value of t^D or S^D .

durations, and disallow the development of rapid response rates, as previously reported (Weissman, 1961); in three out of four pigeons, however, this was clearly not the case. However, the consistent failure of pigeon C-2 to emit substantial S^A responding at the three highest S^D values was probably instrumental in precluding rapid rates from developing in this S when S^D was reduced.

The three birds which did emit high S^D - S^A response rates at low S^D values nevertheless emitted still higher t^D - t^A rates. One reason for this difference is apparent in Fig. 2, c, d, e, f and i; after a missed reinforcement at low S^D values, birds C-1, C-3 and C-4 usually (but not always, e.g., Fig. 2, h) paused, indicating

that considerable control over key-pecking behavior was still exerted by S^D . In the t^D - t^A component such pauses were usually absent (Fig. 2, b, g and j). In addition, consistently fewer reinforcements were received during the S^D - S^A component than during the t^D - t^A component, suggesting that terminal response rates, just before the reinforcement contingency, were higher on the t^D - t^A component. This would appear to support further the previous conclusion (Weissman, 1961) that an S^D can impair performance, as measured by reinforcements received.

The left side of Fig. 2 illustrates qualitative changes in stimulus discrimination behavior for pigeon C-1. At the highest two S^D values

Fig. 2. Segments of representative cumulative response curves from pigeon C-1. Each pair of segments shown is a continuous 30-min record extracted from the final session on each t^D and S^D value; overall data from these sessions are plotted in Fig. 1. Reinforcements are shown as pen deflections on the curve. Reference letters are explained in the text.

overall response rates were very low compared to rates on the other component. The temporal distributions of S^A responses in some respects resembled those on certain fixed-interval schedules in that "scalping" was often evident (Fig. 2, a). When S^D equaled 1.0 sec S^A rates reached even lower levels. Further reduction of S^D to .3 and .1 sec resulted in rapid overall response rates which resembled the characteristic ratio-like behavior emitted by this pigeon on corresponding t^D - t^A schedules. Qualitative differences between "stimulus discrimination" behavior and "intermittent reinforcement" behavior are therefore seen in Fig. 2 to have dissipated dramatically when t^D and S^D were reduced concomitantly.

REFERENCES

- Ferster, C. B. The use of the free operant in the analysis of behavior. *Psychol. Bull.*, 1953, **50**, 263-274.
- Ferster, C. B., and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Hurwitz, H. M. B., and Millenson, J. R. Maintenance of avoidance behavior under temporally defined contingencies. *Science*, 1961, **133**, 284-285.
- Hearst, E. The behavioral effects of some temporally defined schedules of reinforcement. *J. exp. Anal. Behav.*, 1958, **1**, 191-202.
- Schoenfeld, W. N., and Cumming, W. W. Studies in a temporal classification of reinforcement schedules: Summary and projection. *Proc. Nat. Acad. Sci.*, 1960, **46**, 753-758.
- Schoenfeld, W. N., Cumming, W. W., and Hearst, E. On the classification of reinforcement schedules. *Proc. Nat. Acad. Sci.*, 1956, **42**, 563-570.
- Weissman, A. Impairment of performance when a discriminative stimulus is correlated with a reinforcement contingency. *J. exp. Anal. Behav.*, 1961, **4**, 365-369.

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