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NOTES ON FIXED-RATIO AND FIXED-INTERVAL ESCAPE RESPONDING IN THE PIGEON[1, 2]

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After learning to peck a key when each peck removed a slowly increasing series of electric shocks, pigeons were placed on fixed-ratio and fixed-interval escape schedules. The resulting behavior was comparable to that of other species on ratio and interval escape schedules. Thus, while the pigeon apparently requires special techniques for the initial shaping of a key-peck response with negative reinforcement, this response, once obtained, can be subjected to intermittent schedules of negative reinforcement with no great difficulty.

Negative reinforcement, the strengthening of responses by removal of aversive stimuli, has produced, in some situations, effects similar to those of positive reinforcement. A notable example is that reported by Kelleher and Morse (1964) in which virtually identical performances were set up with schedules of negative and positive reinforcement, with subsequent demonstration that drugs affected these performances in very similar ways. Comparability of responding on ratio schedules of negative reinforcement to behavior maintained by ratio schedules of positive reinforcement has been demonstrated also by Morse and Kelleher (1966), Azrin, Holz, Hake, and Ayllon (1963), and Winograd (1965). However, all of these demonstrations used either monkeys or rats, which are readily trained with conventional escape-conditioning techniques.

The pigeon, while a common subject for schedules of positive reinforcement, has required special treatment to produce responding with negative reinforcement, even when every response is reinforced. This special treatment has involved either choice of a particularly convenient response (Hoffman and Fleshler, 1959; Macphail, 1968) or a modification of standard shock-presentation procedures (Rachlin and Hineline, 1967). The apparent recalcitrance of pigeons on escape contingencies was pointed out by Dinsmoor (1967) in a comprehensive review of escape conditioning.

The present report demonstrates that while the pigeon apparently requires special techniques for the initial shaping of a key-peck response, this response, once under control of negative reinforcement, can be subjected to intermittent scheduling of negative reinforcement with no great difficulty.

METHOD

Subjects

Three White Carneaux pigeons were used; they had previously been shaped to peck a key. Reinforcement for pecking had been escape from a train of shocks of gradually increasing intensity (Rachlin and Hineline, 1967). The birds, numbered 270, 319, and 499, were housed in individual home cages with food and water freely available. Gold electrodes were implanted under the birds' pubis bones for the delivery of shock (Azrin, 1959).

Apparatus

The conditioning was accomplished in a standard pigeon chamber (Ferster and Skinner, 1957) coated with an insulating spray, and equipped with a response key, a diffuse houselight, and a Gerbrands mercury swivel. Pulsing shock was scheduled through a relay that controlled the primary of a variable transformer whose output was stepped up and then applied across a 10 K ohm resistor in series with the electrodes implanted in the bird. The variable transformer was driven by motor and

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gear changer. The result was a stream of 35-msec pulses, delivered at a rate of 2 per sec, with the intensity of each pulse being slightly greater than that of the preceding one.

Procedure I. Fixed-Ratio (FR) Escape

The birds' pecks had been previously conditioned by means of negative reinforcement (Rachlin and Hineline, 1967). Pecks had resulted in a 5-sec blackout and reset of the train of slowly increasing shocks. For the present procedure, the rate of shock increase was held at 0.748 ma/min as before, but to reset the shock to 0 and produce a 5-sec timeout, the birds had to emit more than the single peck that had hitherto been required. On the first day, shock reduction and blackout (negative reinforcement) occurred at each second peck. The next day it occurred at each third peck, and so on. This ratio requirement was increased by one each day (with a few exceptions to permit assessment of stability) until the bird stopped responding or until a ratio of 21 was reached. Sessions were held constant at 90 min.

Results

Bird 319 responded, but only up to the ratio of 12; Bird 499 showed similar patterns of responding, but continued to respond until the ratio reached 21; Bird 270 showed no signs of stopping at a ratio of 21, but the ratio was not increased further. On the occasions when the ratio was held constant for two or more sessions, no substantial changes in performance were observed. Figure 1 shows tracings of cumulative records that characterize the responding of Bird 270 at various ratios. Each response stepped the pen upward; downward deflections indicate reinforcements. The patterns in these records closely resemble those produced by fixed-ratio schedules of positive reinforcement: rapid responding is interrupted by post-reinforcement pauses that become longer as the ratio is increased. Of course, some post-reinforcement pause is built into this particular schedule, for the intensity of shock was very low immediately after reinforcement, thus providing very little reinforcement for pecking. But as shown by the responding on FR 1 (CRF), this bird, unlike most other subjects, tended to keep the shock at very low intensity; hence the spacing of responses at higher ratios may be attributed mostly to the increase in ratio, and not to the low shock intensity after reinforcement.

Bird 499 was more typical on FR 1, giving performances similar to those of 319 and the

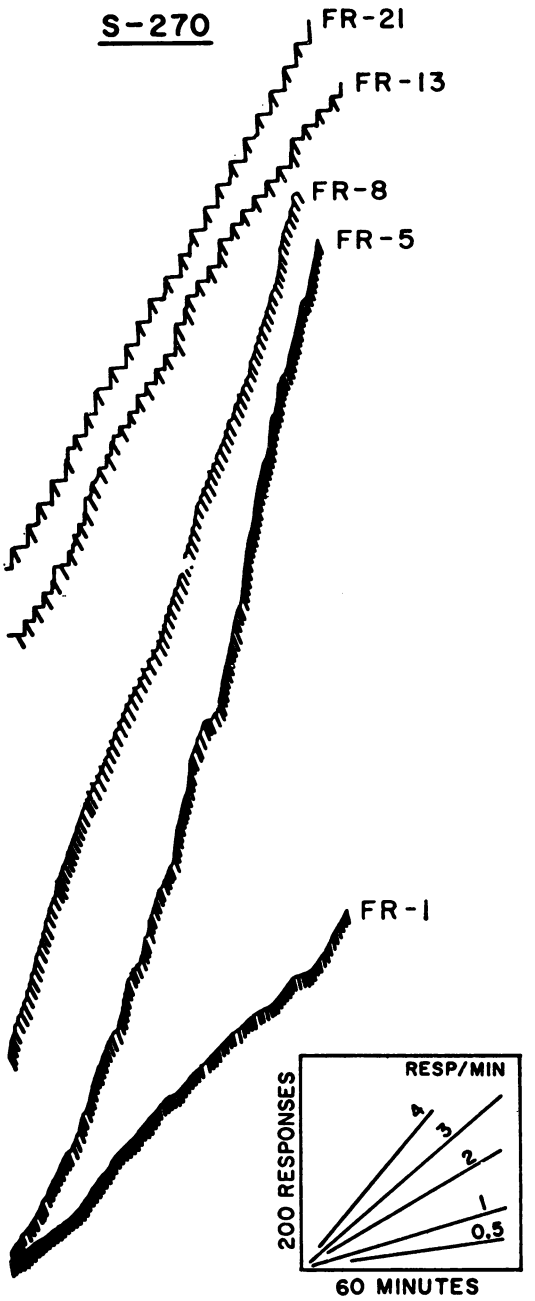

Fig. 1. Cumulative records for pigeon 270 on various fixed-ratio escape schedules. Each cumulative response curve is taken from a session of responding on the ratio indicated to its right. Diagonal marks indicate reinforcements (5-sec blackout with 0 shock intensity), during which movement on the time axis was interrupted.

other birds run at continuous reinforcement. As shown in Fig. 2, Bird 499 did not respond at low shock intensities. While pausing occurred at FR 1, increased ratio requirements produced even greater pauses between reinforcement and subsequent response. The pauses for FR 17, for instance, are twice as long as those for FR 1.

The time from first to last response of a ratio represented only a very small part of the interreinforcement interval. Thus, just as in ratio schedules of positive reinforcement, once the bird began to respond, pauses between responses were very unlikely except after a reinforcement. Pauses within the ratio occasionally occurred on ratios very close to that where the bird ceased responding. Also, post-reinforcement pausing tended to increase within sessions, decreasing between sessions.

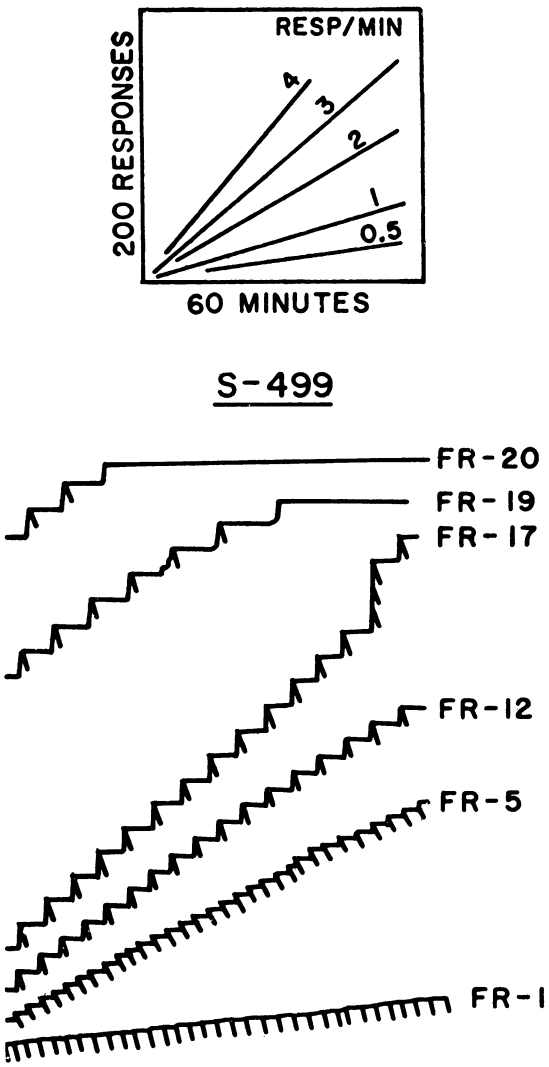

Fig. 2. Cumulative records for Pigeon 499 on various fixed-ratio escape schedules. Each cumulative response curve is taken from a session of responding on the ratio indicated at the right of the figure. Diagonal marks indicate reinforcements, during which movement on the time axis was interrupted.

Procedure II. Fixed-Interval (FI) Escape

After exposure to the ratio schedules described above, Birds 270 and 499 were placed on a fixed-interval schedule of escape reinforcement. At the beginning of a session, or after a peck, the 5-sec blackout was in turn followed by gradual shock increase with houselight and keylight illuminated. For the first 300 sec, pecks were recorded, but had no other effect. The first peck after 300 sec produced the blackout and 0 shock intensity. This procedure was run for 29 sessions of 90 min each.

Results

As shown in the cumulative records of Fig. 3, Bird 499 showed pause-and-run behavior from the very first session on this procedure, which is understandable in light of this bird's previous performance on FR schedules. A progression within sessions persisted through even the last session on this procedure. Early in sessions there was more responding early in each interreinforcement interval; toward the end of the session there was usually only a single response, made after the interval had elapsed. Consistent with previous performance, Bird 270 showed much less spacing of responses when first placed on this schedule. By the fifteenth session, typical FI pause-and-run responding had begun to occur. As with Bird 499, a progression within sessions persisted through even the last session. Post-reinforcement pauses became more pronounced as time increased within sessions. This produced the slightly concave downward cumulative records of Fig. 3.

DISCUSSION

Performances of the pigeons on FR schedules were similar to those on ratio schedules of positive reinforcement. The main difference was that two of the three birds stopped responding, and all birds showed extensive post-reinforcement pausing, at ratios smaller than those producing comparable results with pos-

itive reinforcement, and in amounts exceeding that observed on CRF escape. However, the ratio sizes were comparable to those maintained with negative reinforcement in other species (Winograd, 1965; Dinsmoor, 1967). One significant factor that opposes persistent responding on intermittent escape schedules is the fact that unreinforced responses are not simply responses with no consequence; rather they are responses frequently followed by punishment, albeit adventitiously arranged. The importance of this feature of schedules of escape from primary aversive stimuli has been questioned (Dinsmoor, 1967; Winograd, 1965) but the fact remains that escape responding has not been maintained on the high ratios that are easily used with positive reinforcement. Experiments by Kelleher and Morse (1964) suggest that higher ratios can be maintained by escape from a stimulus paired with intermittent shock than by escape from continuous shock.

Some of the post-reinforcement pausing on the present procedures is attributable to the low shock intensities in effect immediately after reinforcement. Low shock intensities provided for less shock-reduction (and presumably, reduced reinforcement) after pecks. Further, the increasing sequences of shocks provided additional "time cues" that could have enhanced differential responding with respect to time. Effectively, the shock sequences converted the present escape procedures to FI and FR with added clock. In the case of FI, the use of an added clock—stimulus changing systematically with post-reinforcement time—produces more marked post-reinforcement pausing (Ferster and Skinner). The effects of an added clock on a FR schedule are not so well documented, but the cueing function of shock for the post-reinforcement pause in FR responding has been proposed with respect to escape from constant-intensity shock (Winograd, 1965), and should be even more important here. Nevertheless, the performance of Bird 270 in the present experiment was certainly under control of the interval contingencies, for responding changed systematically when the FI schedule was introduced.

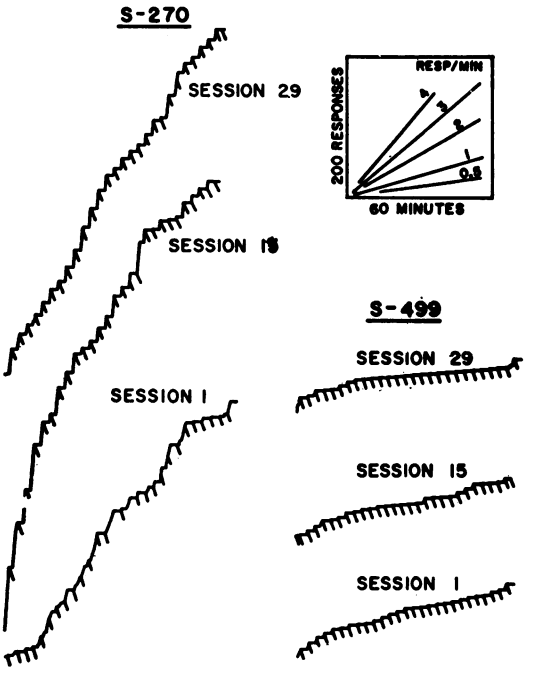

Fig. 3. Cumulative records for Pigeons 270 and 499 during their first, fifteenth, and twenty-ninth sessions of exposure to a 5-min fixed-interval schedule of escape reinforcement. Reinforcements are indicated by diagonal marks. Movement on the horizontal axis was interrupted during reinforcement (5-sec blackout with 0 shock intensity).

The main point to be made concerning the present data is that, once under control of escape contingencies, the pigeon's key-peck appears comparable to a rat or monkey's lever-press under similar contingencies. Work not yet published suggests that this comparability may be made complete by fading in a sudden shock onset that would eliminate the gradually increasing shock of the present procedure, the feature that most complicates interpretation. The gradual onset, however, appears necessary for initial production of the response.

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