

The effects of time-out duration during fixed-ratio reinforcement

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Pigeon's keypecking was reinforced on a multiple fixed-ratio (FR) schedule. All three components were maintained at a FR 50 response requirement with two components containing time-outs. A 2.5-sec time-out appeared regularly after the 30th response in one of these components, while a 10-sec time-out appeared after the 30th response in the second time-out component. Pauses following reinforcement were shortest in the non-time-out component, while longest duration pausing accompanied the 10-sec time-out component. The 2.5-sec time-out generated intermediate duration pauses. In time-out components, response rate was low preceding the time-out, and high immediately following it. The total time from response initiation to subsequent reinforcement was highly predictive of pause duration.

The fixed-ratio (FR) schedule requires the emission of n responses with reinforcement contingent upon completion of the specified ratio. The frequency of reinforcement is, therefore, a function of the ratio length, concomitant with the rate at which the organism emits responses in the ratio (Ferster & Skinner, 1957). Following delivery of the reinforcer, the probability of a response on the operandum is typically zero. This period of time, during which no responses are made on the operandum, has been termed the postreinforcement pause (prp), preresponse pause (prp), pause after reinforcement (par), or ratio break, and its duration has been reported to be a function of the length of ratio (Boren, 1953; Felton & Lyon, 1966; Ferster & Skinner, 1957; Powell, 1968). In studies employing multiple FR schedules, where the impending contingency is exteroceptively cued, the ratio pause appears to be a function of both the ratio just completed and the present ratio (Griffiths & Thompson, 1972; Mintz, Mourer, & Gofseyeff, 1967) or forthcoming ratios (Mintz, 1976).

With inclusion of delays of reinforcement, a temporal parameter has been added to the contingency for reinforcement (Azzi, Fix, Keller, & Rocha Silva, 1964; Morgan, 1972). With such delays imposed prior to the delivery of reinforcement, the pause accompanying the FR sequence tends to increase. The pause no longer appears to correlate solely with the number of responses

emitted, but rather incorporates certain temporal components. This has also been demonstrated by Killeen (1969), Neuringer and Schneider (1968), and Zeiler (1970, 1972), where the duration of the pause was a function of the interval between successive reinforcements, rather than exclusively the number of responses emitted.

The present experiment incorporates a time-out (TO) in the manipulation of temporal constraints on the availability of the reinforcer during FR training. This period of darkened key and ineffective keypecking was provided in the context of a multiple schedule. The key color was reliably correlated with the TO duration. TOs, when included, were invariably produced by the 30th response of the FR 50. In this manner the procedure shared some properties of chained schedules or correlated block counters. The analysis is largely concerned with the contribution of response rate variations and other temporal factors in the determination of pausing in ratio behavior.

METHOD

Subjects

The subjects were three male White Carneaux pigeons, maintained at 80% of their ad-lib weight. These birds were between 2 and 3 years old and were experimentally naive at the start of the study.

Apparatus

A Lehigh Valley Electronics standard two-key operant chamber for pigeons was employed. For purposes of the study only, the key to the left of the grain hopper was in operation, and a force of approximately .2 N was required to operate the key microswitch. A grain mixture of 50% kaffir, 40% vetch, and 10% hemp was used for the reinforcer.

Temporal data were recorded by two Pressin Printing

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Table 1
Median Pause Duration in FR 50 Related to the Schedule in Effect and the Immediately Preceding Schedule

Preceding Schedule	P 8655			P 1578			P 3716		
	Present Schedule			Present Schedule			Present Schedule		
	No-TO	TO (2.5)	TO (10)	No-TO	TO (2.5)	TO (10)	No-TO	TO (2.5)	TO (10)
No-TO	1.9	4.4	19.8	3.2	7.0	50.6	2.6	15.8	33.2
TO (2.5)	2.6	2.8	20.6	3.6	5.3	31.1	3.5	3.7	35.1
TO (10)	2.4	4.9	9.2	3.4	7.0	18.0	2.2	11.4	13.2
Overall	2.3	4.0	16.5	3.4	6.4	33.2	2.8	10.3	27.2

counters pulsed by a Scientific Prototype reed clock at 10 Hz, and responses during TOs were counted by two electro-mechanical counters, but did not contribute to the ratio count.

Procedure

After the three birds were trained to peck the key with the key color switching after each reinforcement from red to green to white, further training involved systematic increases in the number of responses required for reinforcement until responding on FR 50 in the presence of all three key colors stabilized.

During subsequent training on the multiple schedule, key color was programmed in a quasirandom sequence of 124 steps, each color being presented with approximately equal frequency and juxtaposition to the other colors. However, there were no more than two successive presentations of the same color.

In the three-ply multiple FR 50 schedule, the components were: FR 50; FR 50 with a 2.5-sec TO at R 30 (designated as short); and FR 50 with a 10-sec TO at R 30 (designated as long). Any response during the TOs recycled the timers so that a minimum of 2.5 sec had to elapse with no responding for the short TO condition and a minimum of 10 sec had to elapse with no responding for the long TO condition. Any responses during TOs did not count toward satisfying reinforcement requirements. The TO was signaled by the unilluminated response key; the house light remained illuminated throughout the session. Key-color correlations with the schedule components were counterbalanced across birds to control for possible effects of color preference.

Reinforcement was 3.0-sec access to the grain. The key light was darkened during reinforcement. Water was continuously available in the test chamber and home cage. Thirty daily sessions were run, with each session ending after either 62 reinforcements or 2.5 h, whichever occurred first. Data were recorded daily, and analyzed for the last 10 days, which served as criterion sessions.

RESULTS

Record was kept of the duration of pausing, defined as the time from the end of the food-hopper availability until the emission of the first response of the next FR cycle. The time subsumed by each successive block of 10 responses of the FR 50 was also recorded.

Pausing data are summarized in Table 1, based on the last 10 days' performance. The two-way contingency table identifies the populations of pauses by the schedule component in which the pause was observed and by the component immediately preceding it. Overall medians reflect all pauses in a component, regardless of the predecessor in the multiple schedule. There was a clear and substantial increase in pause duration with the increase in TO duration. There was also a within-

components effect, showing the shortest pausing for a component when that same component immediately preceded itself. The single exception was the no-TO data for P 3716, which showed shortest pausing following the 10-sec TO component.

A characterization of the rate variations during the ratio run is provided in Figure 1. This figure contains the median rate of response for each successive block of 10 responses in the three components of the schedule. In general, the lowest rate was shown during the first 10 responses. The final 10 responses of the FRs showed small differences among the schedule components, an observation generally true of the other post-TO block (31-40). Preceding the TO, there was a reliable hierarchy of rates, the longer the TO, the lower the

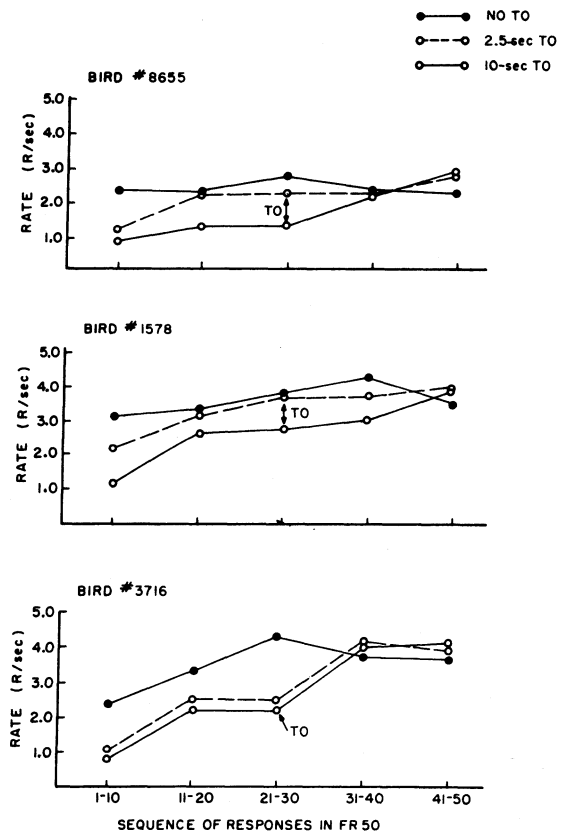


Figure 1. Median response rate during successive 10-response segments of the fixed-ratio cycle. The locus of the TO is indicated.

rate. P 3716 showed a sharp increase in rate following TO, evidenced to a lesser degree for the other birds, and greater for them with the 10-sec TO than the 2.5-sec TO. No-TO provided the smallest within-cycles changes for all birds.

In general, the introduction of a within-ratio TO affected both the pausing before responding and the cohesiveness of the pre-TO response sequence.

We have termed the time from the first response of a cycle until the reinforcer is obtained the "time of involvement" (TOI). It includes the TO duration. Figures 2, 3, and 4 provide scattergrams of TOI and pause duration. The plotted points were obtained separately from each of the 10 criterion days for each component. Least-squares best-fit regression lines are plotted and the regression equations are shown. Visual inspection suggests that the linear function described the relation between TOI and log pause reasonably well. Although the regression lines largely relate three separate clusters of points, in several instances the variations within clusters shows some conformity to the overall regression line. The general form and parameters of the equation are relatively similar among the birds.

DISCUSSION

Although no additional responses were required of the organism to receive reinforcement, the addition of a period of nonresponse time (TO) to two components of the multiple FR schedule resulted in increased pausing prior to initiating the ratio response sequence. The pause before responding appeared to be more a function of the time the organism was involved in responding on the ratio sequence (TOI) than the number of responses emitted. Similar effects have been observed

by Zeiler (1970, 1972) where the ratio requirement was held constant, while the time necessary to complete the ratio was varied. Further, Barowsky (1973) and Barowsky and Mintz (1975) have reported that varying the location of the TO within

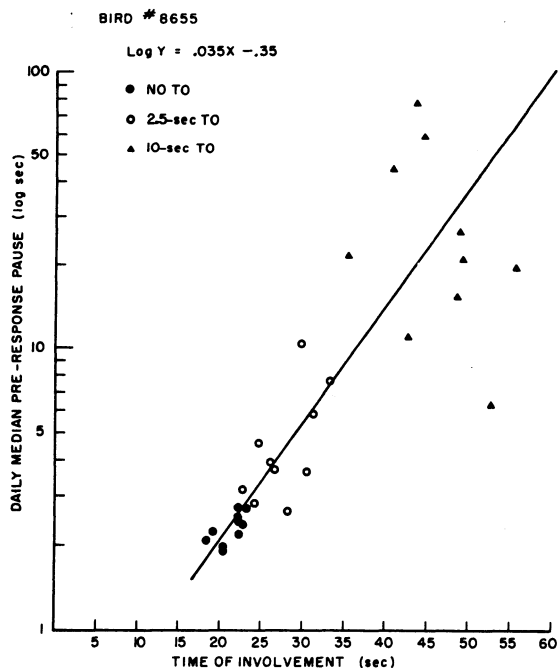


Figure 2. Scattergrams of TOIs and pause durations for Bird 8655.

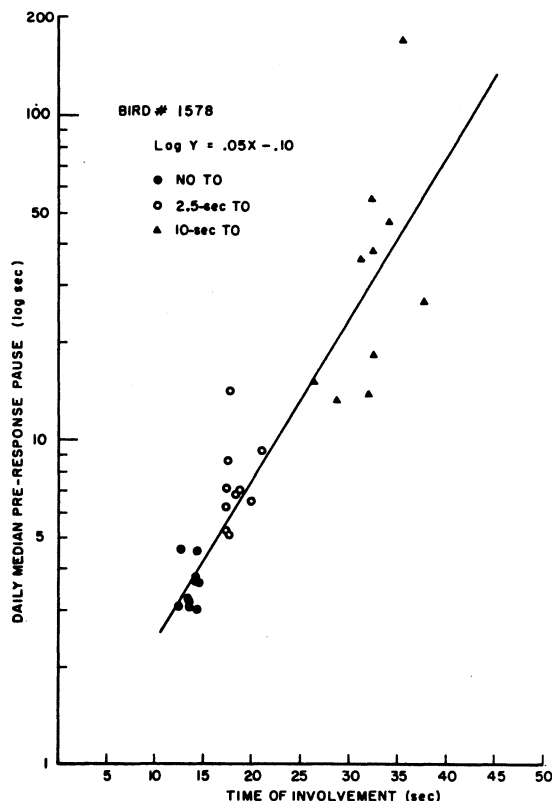


Figure 3. Scattergrams of TOIs and pause durations for Bird 1578.

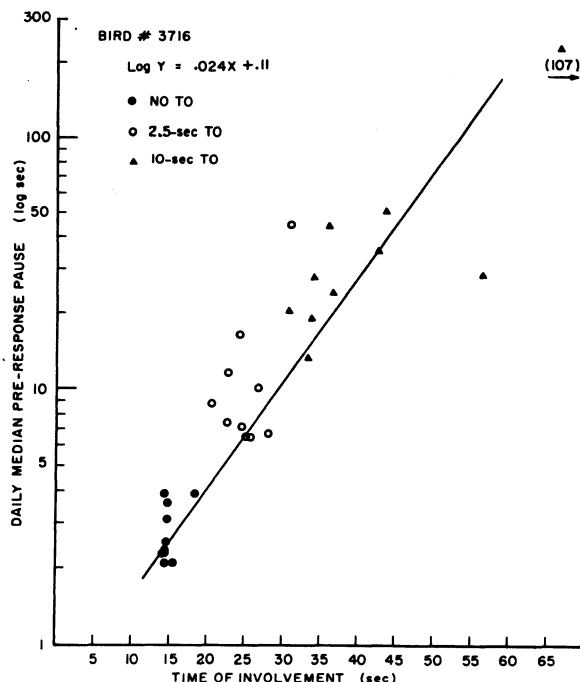


Figure 4. Scattergram of TOIs and pause durations for Bird 3716.

a FR sequence also altered the time of involvement in the ratio, which was in turn predictive of pause duration.

The addition of the TO component in itself cannot account for the increase in pause duration. In both TO components, the increase in the TOI exceeded the time attributable to the TO duration (2.5 sec and 10 sec). The presence of the stimulus signaling the TO appears to have been instrumental in the extension of the TOI, much as a correlated block counter (Ferster & Skinner, 1957) prolongs a FR response sequence and consequently delays reinforcement.

Present data indicate that the greater the duration of the TO, the greater the disruption of the preceding behavior. Barowsky (1973) and Barowsky and Mintz (1975) have shown that the position of the TO in the FR sequence generates a similar effect: the later the TO, the greater the disruption. In those studies, prolongation of the TOI was largely related to the length of the pre-TO sequence of responses; the TO duration was constant. The common predictive property appears to be the temporal displacement of reinforcement from the behavior being considered. Manifestly weaker control is shown in behavior remote from reinforcement, regardless of whether the remoteness is attributable to an earlier position in the FR sequence or a longer TO duration. The earlier position in the FR cycle, of course, corresponds to temporal remoteness.

Pausing prior to any responding appears to be a special instance of weakened control. The organisms' history with regard to the temporal separation between initiating the behavior required for reinforcement and experiencing reinforcement appears predictive of pause duration. The longer the temporal separation (TOI), the weaker the control as shown by longer pausing. Well established relations between FR length and pause duration are consistent with this interpretation.

Important questions remain concerning the appearance of graded rates of response when exteroceptive stimuli are employed in FR schedules. The simple FR with no exteroceptive stimuli generates a relatively invariant pattern of response rates across the entire sequence. Present data demonstrate reduced rates prior to a regularly positioned TO. However, Ferster and Skinner (1957) show similar effects merely with an exteroceptive stimulus change. Indeed, the occurrence of some regularly positioned exteroceptive stimulus appears critical in producing nonhomogeneous rates of responding during FR. As well as prolonging TOI, the TOs of the present study appear to signal relative proximity to reinforcement.

Concerning the demonstrated shorter pauses when a particular component is repeated, Barowsky (1973) has offered a possible "recency" explanation. In essence, this suggested residual stimulus control related to the immediately preceding reinforcement in the presence of the specific stimulus. Present data replicate this phenomenon but offer nothing more on the viability of this explanation.

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