

Pausing in multiple fixed-ratio schedules

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Pigeons were maintained on multiple fixed-ratio schedules with food reinforcement for a keypeck response. A regular pattern of short-short-long-long-etc. was employed for the fixed-ratio sequence within a session. Pausing following reinforcement was shown to be determined by the length of the forthcoming fixed ratio, the relation of this fixed-ratio length to the schedule paired with it, and the place of the fixed ratio in the patterned sequence. The sequential effect indicated shorter pauses for a given fixed ratio when its completion would be followed by the shorter fixed ratio, and longer pausing at the point of transition from a shorter to a longer fixed ratio.

The performance generated by a particular schedule of reinforcement can be influenced by other schedules in the total test situation. These schedule interactions (Reynolds, 1961a,b) indicate that relations among conditions of reinforcement are important in determining the performance generated by each individual schedule in the set of procedures employed.

Nevin and Shettleworth (1966), Pliskoff (1961, 1963), Staddon (1969), and Wilton and Gay (1969) have all produced evidence that the pattern or sequence of schedules contributes to interactive effects. Enhanced effects of schedule interaction have been shown at the point of schedule change (Azrin, 1960) or interface of stimuli related to different schedules (Catania & Gill, 1964).

Effects in postreinforcement pausing on fixed-ratio (FR) schedules related to the sequence of schedule presentation have been demonstrated by Mintz, Mourer, and Gofseyeff (1967). In the multiple FR schedules they employed (FRs of different length, each distinctively cued), the pause duration related primarily to the length of the forthcoming FR. Interaction manifested itself in differences between pausing following changes to, as opposed to repetitions of, a given FR. The present study extends this earlier investigation to quantitative manipulation of FR length. The analysis is aimed both at a clearer formulation of the determinants of FR pausing and a further examination of how the specific context contributes to schedule interaction.

METHOD

Subjects

Two mature male white Carneaux pigeons were used as subjects. Both were maintained at 80% of their free-feeding weights. Both were experimentally naive prior to the study. Water was continuously available both in the home cage and the test environment. A standard grain mixture of 50% kaffir, 40% vetch, and 10% hemp was used for reinforcement.

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Apparatus

A Lehigh Valley two-key operant chamber for pigeons (Model 1519-2) was used, with only the right-hand key in operation. A force of approximately .15 N was required to operate the key. White noise was provided to mask apparatus sounds. The measurement of time intervals reported was accomplished by appropriate gating of a 10-Hz pulse train generated by a Scientific Prototype Reed System clock.

Procedure

Each bird performed on a series of multiple-FR schedules. The schedules involved two components which alternated in pairs. Thus a long-long-short-short-long-long-etc. sequence was used in each session for a total of 65 reinforcements. Reinforcement was 3.5 sec access to the grain mixture. The two components of the multiple schedule were correlated with the color of the transilluminated key, red for the longer component and green for the shorter component. The key light was turned off during reinforcement and illuminated with the color appropriate to the next schedule in the sequence immediately following reinforcement. The houselight remained illuminated from the beginning of the session until the last reinforcement was delivered.

A given pair of schedules was run repeatedly until a 10-day sample of stable performance was obtained. This typically required 3-4 months, five sessions per week. Stability was assessed by inspection of the frequency distributions of pause duration with regard to both central tendency and variability.

The sequence of procedures is shown in Table 1. It can be seen that, for each bird, one component of the multiple schedules was held constant throughout the experiment. In addition to the multiple schedules, each bird underwent phases during which only one FR was employed, as indicated in Table 1.

RESULTS

For each subject one component of the multiple schedules was fixed throughout the experiment (fixed

Table 1
Sequence of Experimental Conditions

Pigeon 24	Pigeon 10
mult FR 20 FR 40 FR 40	mult FR 20 FR 50 FR 20
mult FR 30 FR 40	mult FR 20 FR 36
mult FR 50 FR 40	mult FR 20 FR 12
mult FR 70 FR 40	mult FR 20 FR 6
mult FR 1 FR 40	mult FR 20 FR 1

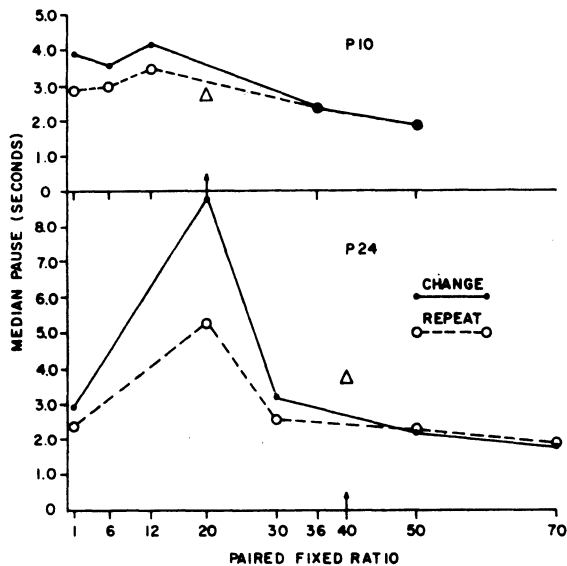


Figure 1. Median pause duration for the fixed FR component (FR 20 for P10, FR 40 for P24) as a function of the length of the varied FR paired with it. "Change" represents pauses during the first of two successive fixed components; "repeat" represents pauses during the second successive fixed component. Pausing on simple FR is shown by a triangle.

component). Further, the regular alternation of pairs of components produced postreinforcement occasions when a component "change" took place and an equal number of "repeat" occasions. For instance, for P24 one phase of the experiment was a multiple FR 30, FR 40. Half of the subject's FR 30 cycles were "change" conditions, the just-completed cycle being FR 40; the other half were "repeat," with FR 30 following completion of FR 30. In this case, the varied component (FR 30) was the shorter component, although both subjects went through some phases with shorter and some with longer varied components.

Data analysis was directed primarily at the influence exerted on pausing by the sequential pattern of contingencies and their quantitative relations. Figure 1 shows the median pause on the fixed component (FR 20 for P10, FR 40 for P24) of the schedules as a function of the magnitude of the varied component paired with it. Pausing clearly varies considerably for these given FRs, depending on the magnitude of the paired FR. Further, pausing varies depending on whether the fixed schedule occurs as a repeat of the fixed component, or as a change to it, following the varied component.

Both P10 and P24 show nonmonotonic functions for the FR pausing reflected in Figure 1. The curves suggest maximum pausing when the schedule is paired with one of approximately one-half its magnitude. Thus P24's pausing on FR 40 is greatest when FR 20 is the paired component. Similarly, of the values examined, pairing FR 20 with FR 12 led to the longest FR 20 pausing for P10.

The influence of the schedule sequence can be seen by comparing the "change" and "repeat" points in Fig-

ure 1 for a given value of the paired FR. Where this paired schedule is smaller than the fixed FR (to the left of the vertical arrows in Figure 1), "change," corresponding to onset of the first of the two fixed components, invariably generated longer pausing than "repeat." In these conditions with the fixed FR the longer schedule, completing a "repeat" cycle produced a transition to the shorter component. Completion of a "change" cycle led to repetition of the fixed FR, which for these conditions was the longer component of the multiple schedule.

To the right of the vertical arrows in Figure 1, the plotted points reflect pausing when the fixed FRs were paired with FRs of greater length. "Change" and "repeat" produced no differences for P10; a small but reliable difference is shown for P24 (the distributions differ beyond the .05 level based on a Kolmogorov-Smirnov two-sample test). For P24 a consistent pattern is shown. This bird invariably paused less on those occasions of FR 40 that would be followed by the shorter of the two FRs employed in that phase of the study. Although P10 does not show the crossing of the functions, whenever differences between "change" and "repeat" occurred, they were consistent with this effect.

Figure 2 shows median pause duration on the varied FR component as a function of its magnitude. The functions display a monotonic increase of the sort suggested by numerous earlier studies. Either in terms of the relative lengths of the two components of the multiple schedules, or overall response requirement for rein-

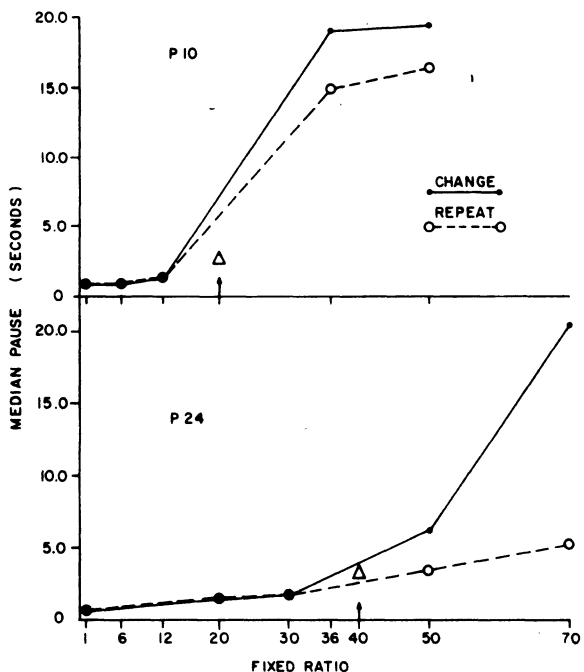


Figure 2. Median pause duration for the varied FR as a function of its length. "Change" represents pauses during the first of two successive varied FRs in the patterned multiple schedule; "repeat" represents pauses during the second successive varied component. Pausing on simple FR is shown by a triangle.

forcement, longer pausing would be expected—and is shown—for longer FRs. However, “change” and “repeat” again diverge considerably. The smallest values of the varied component generated brief pauses of little or no difference in the two cases. With larger values of the varied component (to the right of the vertical arrows in Figure 2), “repeat” generated shorter pauses than “change.” In these instances, completion of a “repeat” cycle would be followed by presentation of the shorter FR requirement. These data again indicate that the pausing on a given schedule is influenced both by the FR magnitude and by the sequential relation of schedule presentation. Pausing on a given FR may be reduced by having completion of the ratio provide a change to a schedule requiring fewer responses.

In both Figures 1 and 2, the median pause on the fixed FRs when they were run alone rather than in a multiple schedule (FR 20 for P10 and FR 40 for P24) are shown for comparison with the same FRs when included in the multiple procedures. The change/repeat distinction, of course, did not pertain to this procedure.

DISCUSSION

The term postreinforcement pause, although descriptively accurate, is analytically misleading. A major determinant of pausing appears to be the magnitude of the behavior requirement for subsequent reinforcement. The importance of forthcoming ratio length in determining pause duration has been noted by Griffiths and Thompson (1972) and Mintz et al. (1967), among others. The preresponse pause (PRP) is presumably determined by stimuli present when the opportunity to respond is provided. The latency in initiating responding is greater as the behavior required for reinforcement is greater. Within the range of behaviors typically investigated in FR procedures, the just-completed behavior probably is of less direct consequence. If there is a modest requirement for reinforcement such as a single response, pausing is likely to be very brief regardless of how many responses have just been completed. Conversely, substantial pauses may follow very brief behavioral chains when stimuli indicating longer chains are presented.

Inherent in a multiple procedure are cued transitions from one component to another. In the present study, the regular program of alternation of pairs of schedule components appears to have allowed discrimination of the specific sequential pattern.

Effectively a four-component schedule was involved, although only two FR values and two differing stimuli were provided. For a given FR and its associated stimulus, subjects paused less when FR completion would also produce the stimuli for the shorter of the two FRs, and longer when the longer FR was forthcoming. Since no exteroceptive stimuli were differentially correlated with first and second occasions of a schedule, the control was presumably mediated by the animals' own behavior and stimuli present in the recent past.

The present design does not permit isolation of the interactive effect of a preceding schedule as opposed to a forthcoming schedule. However, the data are fully consistent with a facilitation deriving from a transition to a shorter forthcoming schedule. Stated most generally, the results show differentiation in pausing between the first and second occasions of the longer schedule, with longer pauses when the shorter schedule had just been completed and shorter pauses when the shorter schedule was forthcoming. Differentiation within a schedule was less evident when the schedule was the shorter of the two FRs.

Two effects are possible in accounting for the data. One, a direct effect, lengthened pausing at the point of transition from a shorter to a longer FR. The other is the aforementioned facilitation of responding when completion of the present FR produces transition to the shorter FR along with the primary reinforcer contingent upon the responding. It is likely that both contribute to the data, although further work will be necessary to isolate their influence.

The magnitude of the differences in pausing between first and second occasions of a schedule (“change” vs. “repeat”) were, in several phases of the study, surprisingly large. Although comparisons of absolute magnitude of effect are difficult to evaluate, it would appear that behavior-contingent schedule changes may be more potent than changes in the magnitude of food reinforcement. Several studies (Keesey & Kling, 1961; Mintz, Mourer, & Weinberg, 1966) have shown relatively little change in FR pausing (in multiple schedules) as a function of reinforcement magnitude or number. However, the present data provided as large as fourfold differences in pause duration for a given FR, depending on the quantitative and sequential relation of this FR to the schedule paired with it.

The interactions among components in a multiple schedule are important factors in the analysis of behavior. The present study provides a strong indication that the behavior-produced advent of a new schedule may exert considerable control. This may be particularly potent in ratio procedures, where completion of the ratio has the dual consequence of producing reinforcement and leading to the next schedule in the programmed series. However, even in procedures in which advent of the next schedule is not so strictly behavior contingent, adventitious relations of this sort must certainly develop. Interactive effects may in part be explained in terms of such superstitious contingencies where changing schedules are coincident with changing patterns of behavior.

Concepts like “schedule interaction” and “reinforcement density” imply effective operation of events distributed over relatively long periods of time. Further, events that are not present are still assumed to influence the momentary behavior of the organism. This study may provide some clue as to how such temporal integration operates. Extensive exposure to the experimental situation may provide conditioned reinforcers for responding in the form of changing schedules. Kelleher (1966) has pursued such effects in his analysis of second-order schedules. In essence, the organism not only achieves reinforcement on a schedule, but also changes schedules by behaving. A determinant of response likelihood is the prior history of such changes. As provision of the conditions under which primary reinforcers are obtained makes response more likely, so response likelihood may also vary with real or adventitious schedule changes related to response.

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