RESPONDING UNDER DISCRETE-TRIAL FIXED-INTERVAL SCHEDULES OF REINFORCEMENT¹

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A fixed-interval schedule of reinforcement was modified by dividing each interval into 4-sec trial periods. No more than one response could occur during each trial because the operandum was inactivated for the remainder of any trial in which a response occurred. For example, under a 28-sec schedule, no more than seven responses could be emitted between reinforcements. Probabilities of responding by pigeons under six values of this discrete-trial fixed-interval schedule were best described by a two-state model: responding was either absent or infrequent immediately after reinforcement; then, at some variable time after reinforcement, there was an abrupt transition to a high and constant probability of responding on each trial. Performances under the discrete-trial procedure were less affected by uncontrolled sources of variance than performances under equivalent free-operant fixed-interval schedules.

Since Skinner's (1938) work on operant behavior in the rat, most operant conditioning studies have used the rate of a free-operant response as dependent variable. Skinner (1966) suggested that the popularity of response rate is due to the relatively high degree of lawfulness in the data. However, as a dependent variable, response rate presents a number of difficulties. First, several learning theorists (Bush and Mosteller, 1955; Estes, 1959; Skinner, 1966) have argued that behavior is essentially a probabilistic phenomenon. Although Skinner (1966) suggested that studying response rate is a step in the direction of understanding response probability, it might be profitable to study directly the probability of responding under various reinforcement schedules. Second, under most free-operant reinforcement schedules, large differences in absolute rates of responding (as opposed to qualitative patterns of responding) are often

found among subjects; and large and unsystematic fluctuations in the response rate of a single subject are found despite the constancy of the experimental environment (Blough and Blough, 1968; Cumming and Schoenfeld, 1960; Schneider, 1969). Third, Blough (1966) argued that the large number of short interresponse times found in free-operant experiments on pigeons are not subject to reinforcement manipulations and are therefore a source of much unsystematic variability.

An alternative to the rate of a free-operant response is the probability of a discrete-operant response. The two differ in the following way: whereas the free operant can occur at any instant in time, the occurrence of the discrete operant is limited to one per trial, with trial duration and intertrial time determined by the experimenter. For example, discrete operants are studied in most choice experiments: a rat can turn left or right in a T-maze on any given trial. Once the choice is made, however, the rat must wait before again being permitted to make a choice (*e.g.*, before being returned to the start box of the maze). In such choice experiments, the dependent variable usually is the number of choices of one alternative divided by the total choices of all alternatives; this variable is often referred to as the "probability" of choosing an alternative. It might simply be due to historical accident that the discrete-operant response and the probability of response measure have only rarely been used

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to monitor the effects of reinforcement schedules on a single response (see, however, the recent work by Jenkins, 1970; and Logan and Ferraro, 1970). The present experiment examined the probability of a discrete operant response under a schedule of reinforcement analogous to the free-operant fixed-interval schedule. The present schedule is referred to as a discrete-trial fixed-interval schedule.

METHOD

Subjects

Five male, adult White Carneaux pigeons with no previous experimental histories were tested seven days per week and fed enough grain after each session to maintain them at 80% of their free-feeding weights.

Apparatus

Two almost identical experimental chambers of the type described by Ferster and Skinner (1957) were used. The dimensions of the subject's compartment were 12 by 12 by 13 in. (30.5 by 30.5 by 33.0 cm). A Gerbrands response key was centered behind a 0.75-in. (1.9-cm) diameter hole in a metal panel separating the subject's compartment from the stimulus and food delivery devices. The only difference between the two chambers was that the key was 8 in. (21.0 cm) above the floor in one chamber and 10.5 in. (26.7 cm) above the floor in the other. There were no obvious differences in responding in the two boxes. The key was transilluminated by a single 6-w bulb. No houselights were used.

Located 4.5 in. (11.4 cm) beneath the key was a 2 by 2 in. (5.1 by 5.1 cm) opening in the panel through which a hopper filled with mixed grain could be made available. The reinforcer was 2.9-sec access to grain. During a reinforcement cycle, the keylight was off and the hopper was illuminated by two 6-w bulbs. White noise was continuously present.

In addition to the standard recording devices, such as counters and a cumulative recorder, a Grason-Stadler model E12505A print-out counter was operative during the last 4 to 6 days of each schedule value. Response latencies were recorded on one channel; the second channel recorded whether or not a response occurred on a trial and the third channel was used to designate reinforcement trials. The data were then punched onto IBM cards by

the two experimenters and subsequent analysis was done on a computer. Random error checks showed a negligible rate of punching errors.

Procedure

The experimental session was composed of 4-sec trial periods, each trial containing no more than one effective response. In the absence of any responding, a trial was divided into 2 sec of key illumination followed by 2 sec during which the keylight was off and the chamber totally dark. When a response occurred during the 2-sec period of light on, the key immediately went dark and remained dark until the end of the 4-sec trial period. Thus, with one exception discussed below, all trials were of constant 4-sec duration and the occurrence or non-occurrence of a response did not affect this time. Responses on a dark key had no scheduled effect; because such responses were very rare, they were ignored in subsequent analyses.

The schedule of reinforcement was analogous to a free-operant fixed-interval (FI) schedule. Under the latter, reinforcement becomes available after a fixed number of seconds since the last reinforcement. Under the present schedule, referred to as a discrete-trial fixed-interval schedule of reinforcement, reinforcement was made available after a fixed number of 4-sec trials had elapsed since the last reinforcement. Note that, as is the case under a free-operant FI schedule, (a) only one response was required to produce the reinforcer under the discrete-trial schedule, and (b) responding before the availability of reinforcement caused no change in the number of interreinforcement trials or in the interreinforcement duration. After a fixed number of 4-sec trials had elapsed (*i.e.*, after the fixed interval had "timed out"), reinforcement became available and occurred after the first response to a lighted key. If no responses were emitted after reinforcement became available, the 2-sec light-on, light-off trial alternation continued just as before, until a response occurring during a light-on period produced immediate access to grain and terminated the trial. Note that the duration of this last trial depended upon when the response occurred in the trial: *e.g.*, if the reinforced response occurred at 0.5 sec of the terminal trial, that trial lasted only 0.5 sec. The relationships between keylight, responses, reinforcer availability, and rein-

Fig. 1. Relationships between keylight, responses, reinforcer availability, and reinforcement on discrete-trial FI 12-sec.

forcement are shown in Figure 1 for discrete-trial FI 12-sec.

Each subject experienced six values of the discrete trial FI schedule: 12, 28, 60, 124, 252, and 508 sec. These values can be translated into the number of trials before reinforcement availability by dividing the FI duration by four. For example, under the discrete-trial FI 12-sec schedule, reinforcement was available after three 4-sec trial periods and the first response in the fourth or ensuing trial was reinforced. Under discrete-trial FI 28-sec, reinforcement was made available 28 sec after previous reinforcement, or at the beginning of the eighth trial, *etc.* The order in which the birds encountered the schedules, and the daily number of sessions at each schedule value, are given in Table 1. The daily sessions terminated when 55 reinforcements had occurred.

All discrete-trial FI 508-sec sessions were presented overnight.

Occasionally, a malfunction in the print-out counter forced the experimenters to discard some data. Otherwise, all reinforcement intervals during the last 4 to 6 sessions at each value are included in subsequent analyses. With three exceptions, each of these analyses is based on at least four terminal sessions. For Bird 267 at discrete-trial FI 252-sec, an intermittent failure after the first of the terminal five days restricted analysis to 53 reinforcements; and for Birds 348 and 260 on discrete-trial FI 28-sec a failure on the fourth terminal day restricted the analyses to 163 and 157 reinforcements respectively. In all other cases, analyses are based on from 205 to 330 reinforcement intervals. In addition, an intermittent failure in the response-latency counter

Table 1

Experimental design. The cell entries are the order in which each bird experienced the different schedules. The numbers in parentheses next to the cell entries are the number of days at each schedule value.

Subjects	Discrete-trial fixed-interval value (sec)					
	12	28	60	124	252	508
260	1(71)	3(36)	2(109)	5(51)	4(43)	6(74)
261	1(70)	6(56)	2(109)	4(36)	3(47)	5(53)
263	1(71)	6(56)	2(109)	5(42)	3(47)	4(34)
267	1(71)	6(62)	2(109)	3(36)	5(50)	4(55)
348	6(63)	5(50)	4(71)	2(36)	3(44)	1(123)

occurred for Bird 261 on FI 508-sec. Consequently, no latency data were available for this bird on this schedule value.

RESULTS

Figure 2 presents selected cumulative response records for Bird 263 on all discrete-trial FI values. In each case, these are the eleventh through twentieth reinforcement intervals from the first terminal session. The fifth interval in each set is enlarged and presented to the right. Four features of these records indicate that performance can be described as two-state or break-and-run. First, a pause occurs immediately after reinforcement. Second, the pause duration is variable. Third, after the pause

there is a rapid acceleration to a high and approximately constant probability of responding. Fourth, one or more responses occasionally occur before the point of maximum acceleration (e.g., intervals 8 and 9 on FI 124-sec).

The basic patterns shown in Figure 2 are representative of all birds at all values and suggest that responding consists of two components or states: a first state with a low probability of response lasting a variable number of trials, followed by a second state with a high probability of response. The intersection of these components will be referred to as a breakpoint. A convenient method for analyzing such two-state, break-and-run, performance was suggested by Schneider (1969). This

Fig. 2. Selected cumulative response records for Bird 263 on all values of the discrete-trial FI schedule. These cumulative records differ from those typically presented, in that the abscissa represents trials rather than time. Thus, the slopes shown in the insert represent response probability rather than response rate. The fifth interval in each set is enlarged and presented to the right. The arrows point to the breakpoints (see text) for these enlarged intervals. Note that to facilitate presentation, the records for each succeeding FI value have been reduced to one-half the size of the preceding FI value. This reduction does not affect the slope of the records.

method permits exact quantitative statements to be made about the location of the breakpoint and its variance as well as the level of responding in the first and second states. Using a least-squares procedure, the location of the breakpoint is determined for each interreinforcement interval (see Schneider, 1969). The arrows in Figure 2 show the location of the breakpoints for the enlarged intervals. Once the breakpoints are located, all interreinforcement intervals for a given bird at a given schedule value (typically about 270 intervals) are superimposed so that the breakpoints coincide. Thus, for the purpose of averaging data, the individual reinforcement intervals are "anchored" at the breakpoints rather than at the beginning of the intervals, as is usually the case (*e.g.*, Dews, 1962). The trials are then numbered with reference to breakpoint—*e.g.*, first trial before breakpoint, second trial before breakpoint, *etc.*, and first trial after breakpoint, second trial after breakpoint, *etc.*—and the probability of response in each trial is calculated in the following way: the number of times that a subject responded in a given trial (*e.g.*, the first trial after breakpoint) is divided by the number of times a response could have been emitted (*i.e.*, the total number of times that the first trial after breakpoint occurred). The result is a function describing the probabilities of response during

each trial before and after breakpoint. (The boundary conditions used here are identical to those used by Schneider, 1969, and the reader interested in performing this analysis is referred to the Appendix in that article.)

Figure 3 shows the probabilities of response before and after the breakpoint for each bird on discrete-trial FI 252-sec. The average function for the five birds is also presented. The solid line step function represents perfect two-state behavior, *i.e.*, a low and constant probability of response on trials before the breakpoint followed by an instantaneous transition to a high and constant probability after the breakpoint. The obtained data approximate the ideal two-state function quite closely. The major discrepancy from an ideal two-state function is a slight but systematic increase in response probability during the first state for most of the subjects.

Figure 4 presents the probability of response before and after the breakpoint averaged over all birds for each of the six interval values. The steplike nature of the obtained functions is sharper for small values than for the larger ones. Again, however, all functions approximate the ideal two-state function quite closely. Each subject's average first- and second-state response probabilities under each FI are shown in Tables 2 and 3. Average probability of responding in the first state increased with in-

Table 2
First-State Response Probabilities

Subjects	Discrete-trial fixed interval value (sec)					
	12	28	60	124	252	508
260	0.02	0.05	0.06	0.07	0.09	0.03
261	0.02	0.02	0.05	0.04	0.04	0.02
263	0.01	0.01	0.02	0.06	0.04	0.02
267	0.00	0.01	0.04	0.05	0.05	0.01
348	0.01	0.02	0.01	0.03	0.09	0.01
Average	0.01	0.02	0.04	0.05	0.06	0.02

Table 3
Second-State Response Probabilities

Subjects	Discrete-trial fixed-interval value (sec)					
	12	28	60	124	252	508
260	0.98	0.98	0.93	0.72	0.87	0.47
261	0.98	0.97	0.93	0.93	0.90	0.60
263	0.95	0.93	0.95	0.78	0.87	0.71
267	0.95	0.99	0.96	0.96	0.95	0.45
348	0.93	0.99	0.97	0.96	0.93	0.74
Average	0.96	0.97	0.95	0.87	0.90	0.59

Fig. 3. Probability of response before and after the breakpoint for five birds on discrete-trial FI 252-sec. The figure labelled "average" is the mean of these five birds. The solid line step function represents perfect two-state behavior (see text). Each unit along the abscissa corresponds to 40 sec (10 trials). Each point represents one trial.

creasing FI value up to FI 252-sec and then decreased at FI 508-sec. Average probability of responding in the second state generally decreased with increasing FI value.

The cumulative records in Figure 2 suggested that breakpoints occurred at variable times after reinforcement. Figure 5 shows the distribution of breakpoint values for Bird 263 on each of the FI values. For example, under the discrete-trial FI 12-sec schedule, more than 85% of the breakpoints were located in the 8- to 12-sec bin, while the remaining breakpoints were divided between the 4- to 8-sec bin and the greater-than-12-sec bin. The break-

point distributions shown here are typical of all birds. With the exception of discrete-trial FI 12-sec, the distributions tend to be symmetrical. The hatched bars in Figure 5 give the frequency of one-response intervals, *i.e.*, those intervals in which the first response exceeded the scheduled FI value and was reinforced. Only in the case of discrete-trial FI 508-sec does the number of one-response intervals constitute a significant proportion of the distribution.

As FI value increased from 12 sec to 508 sec, the time to the occurrence of a breakpoint also increased. Figure 6 shows how the mean break-

point between the two states, averaged over all birds, changed as a function of FI. Except for discrete-trial FI 508-sec, the mean breakpoint is a linear function of FI length and occurs at approximately $\frac{45}{100}$ of the way through the interval. The deviation of discrete-trial FI 508-sec from this pattern is due to the frequent occurrence of one-response intervals during the middle of each session (see Figure 5).

Changes in response latencies, measured from the onset of a trial to the occurrence of a response, were less striking and less systematic than changes in response probabilities. Figure 7 presents the average latency of response, given that a response was emitted, for trials before and after the breakpoint (broken line) for all subjects on FI 252-sec. (The greater variability in average latency of response on trials before the breakpoint is due to the infrequent occurrence of responses in the first state.) Changes in response latencies before and after breakpoint were not the same for all subjects. Response latency for Bird 260 was approximately constant throughout the inter-

val. For Bird 261, response latency fell after the breakpoint and rose toward the end of the interval. For Bird 263, response latency fell and then rose in the first state (before the breakpoint) and gradually decreased thereafter. For Birds 267 and 348, response latency tended to decrease gradually across the first and second states. However, there appears to be a steep drop at the breakpoint for Bird 348, while the decline in response latency for Bird 267 appears to be more gradual. Terminal latencies range from about 0.4 to 1.0 sec for the different birds. Individual differences in the pattern of response latencies also occurred at the other FI values.

Tables 4 and 5 present each subject's average first- and second-state response latencies under each FI value. Average response latency in the first state increased slightly with increasing FI value. The relationship between FI value and second-state response latencies differed from bird to bird. Table 5 shows that second-state latency tended to increase with increasing FI value for Bird 260 while it tended to decrease up to FI 252-sec and then

Fig. 4. Probability of response before and after the breakpoint averaged over five birds for six values of the discrete-trial FI schedule. The solid line step function represents perfect two-state behavior (see text). Each unit along the abscissa corresponds to 40 sec (10 trials). Each point represents one trial.

Fig. 5. Breakpoint distributions for Bird 263 on six different discrete-trial FI schedules. Each distribution was normalized so that the frequencies summed to 1.0. The hatched bar represents the frequency of those intervals in which the reinforced response was the only response in the interval. The size of the left-most bin for the four largest FIs was adjusted so that the remaining seven bins in these intervals (excluding the hatched bin) could be of equal size.

increase at FI 508-sec for Birds 263, 267, and 348. The latency data for Bird 261 (although incomplete) shows no systematic change as a function of FI duration. Furthermore, a comparison of Tables 4 and 5 shows that in six of

29 cases, first-state response latencies were actually shorter or equal to second-state response latencies (Bird 260, FIs, 12, 124, and 508-sec; Bird 261, FI 28-sec; Birds 263 and 348, FI 12-sec).

Table 4
Response Latency (sec) in the First State

Subjects	Discrete-trial fixed-interval value (sec)					
	12	28	60	124	252	508
260	0.46	0.94	1.06	1.06	1.02	1.12
261	1.10	0.64	0.94	0.98	0.96	—
263	0.78	0.90	0.82	0.76	0.98	1.06
267	0.58	1.00	0.82	0.94	0.88	0.94
348	1.10	0.82	0.84	1.04	1.08	1.06
Average	0.80	0.86	0.90	0.96	0.98	1.04

Fig. 6. Mean breakpoint averaged over five birds as a function of minimum interreinforcement time on six values of the discrete-trial FI schedule. The slope of the line that was fitted to the first five points is 0.45 (least squares estimate).

To account for sources of variability in the present data, *i.e.*, to determine what variables account for the obtained values of the breakpoints and response probabilities, two analyses of variance were performed. The first, shown in Table 6, is an analysis of variance of the logarithm of the breakpoint. Log breakpoints were used because the standard deviation was approximately proportional to the mean and the distributions looked normal when plotted in logarithmic coordinates. Fixed-interval

value accounted for 99% of the total variance in breakpoint, while the effect due to subjects was less than 1%. Table 7 presents a similar analysis of variance for overall response probability, *i.e.*, total number of responses per session divided by total number of trials in the session. The FI value accounted for 74% of the variance in overall response probability, whereas subjects accounted for only 3% of the variance. Note that the analysis of variance in Table 7 does not depend upon the two-state

Table 5
Response Latency (sec) in the Second State

Subjects	Discrete-trial fixed-interval value (sec)					
	12	28	60	124	252	508
260	0.60	0.70	0.84	1.18	0.98	1.12
261	0.90	0.78	0.82	0.68	0.78	—
263	1.02	0.78	0.72	0.72	0.74	0.76
267	0.70	0.66	0.62	0.42	0.44	0.52
348	0.66	0.76	0.68	0.68	0.62	0.78
Average	0.78	0.74	0.74	0.74	0.72	0.80

Fig. 7. Average latency of response when emitted for trials before and after the breakpoint for all birds on FI 252-sec.

Table 6
Log Breakpoint (Analysis of Variance)

Source	Sum of Squares	d.f.	F	P	% S.S. Total
Fixed Interval	40.095	5	593.1	0.005	99%
Subject	0.057	4	1.055	n.s.	0%
Residual	0.270	20			
S.S. Total	40.423	29			

model. Analyses of variance were not performed on the latency data because response latencies were not obtained for one bird on FI 508-sec.

DISCUSSION

Schneider (1969) reported results obtained from pigeons under free-operant fixed-interval schedules analogous to those in the present experiment. These were normal FI schedules in which the response key remained lighted and operative throughout the interval. Although there were some basic differences between the two studies, *e.g.*, different birds, different orders of presentation of schedule values, and slightly different FI values, the studies are similar enough to warrant comparison of the data. The most obvious similarity in the results is found in the response patterns: responding under both free-operant and discrete-trial FI schedules was described as two-state break-and-run. Both response rate and response probability were low after reinforcement; then, there was a rapid acceleration to a relatively high response rate (probability) in the second state. This same type of two-state, break-and-run behavior has been reported in other free-operant FI studies in which subjects were given prolonged exposure to schedule values (Cumming and Schoenfeld, 1958; Mechner, Guevrekian, and Mechner, 1963; Sherman, 1959; Shull and Brownstein, 1970; Shull, 1970). In both the present experiment and Schneider's (1969) free-operant study, the time at which the tran-

sition from first to second state occurred, or the breakpoint, was a linear function of fixed-interval duration. However, the slopes of the two functions differed: a slope of 0.45 was obtained in the present experiment, whereas the slope was 0.67 in the free-operant experiment. Causes for this difference cannot yet be determined. In both studies, 99% of the variance in breakpoint could be attributed to the fixed-interval value, while the variance in breakpoint due to subjects was small and inconsequential. The conclusion reached is that the pattern of responding under discrete-trial FI schedules is quite similar to that under free-operant FI schedules.

The main difference between the results of the two experiments was that overall response rates under Schneider's (1969) free-operant schedule were more variable across subjects than were overall response probabilities under the present discrete-trial schedule. That is, there were greater differences between subjects under the free-operant than under the discrete-trial procedure. This can be seen by comparing Table 3 in Schneider's experiment with Table 7 in the present study. These tables show analyses of variance of overall rate of responding in the former case and overall probability of responding in the present case. Whereas 74% of the total variance in response probability was accounted for by fixed-interval value under the present discrete-trial procedure, only 31% of the variance in response rate was accounted for by FI value under the free-operant procedure. Furthermore, subjects ac-

Table 7
Overall Probability (Analysis of Variance)

Source	Sum of Squares	d.f.	F	P	% S.S. Total
Fixed Interval	0.383	5	13.388	0.005	74%
Subject	0.017	4	0.750	n.s.	3%
Residual	0.114	20			
S.S. Total	0.514	29			

counted for only 3% of the variance in response probability under the discrete-trial schedule, while subjects accounted for 34% of the variance in response rate under the free-operant schedule. It is concluded that whereas patterns of responding under the two schedules are similar, schedule parameters account for considerably more variance in the amount of responding under the discrete-trial procedure than under the free-operant procedure. Uncontrolled subject differences are relatively unimportant in determining the amount of responding in the discrete-trial case when compared with the situation in the free-operant case.

Blough (1966) and Herrnstein (1966) suggested possible reasons why free-operant response rate is characterized by relatively high variability. Blough (1966) argued that the large number of short interresponse times found in free-operant studies are not subject to reinforcement manipulations and are therefore a source of much unsystematic variability. According to Blough, such "double pecks" might be due to the lack of a clearly defined response. Herrnstein (1966) suggested that the unsystematic fluctuations found in the response rate of a single subject, as well as fluctuations across subjects, might be due to adventitious reinforcement of "non-criterial" or idiosyncratic aspects of the response, *e.g.*, the topography, duration, or mode of execution. Since reinforcement does not depend upon such non-criterial response attributes, they can vary unsystematically without influencing frequencies of reinforcement. In discrete-trial situations, these difficulties are less serious. First, the problem of "double pecks" is avoided because each trial is terminated by a single peck. Second, non-criterial attributes, such as topography, duration, and mode of execution of the response, will have less effect on the simple occurrence or non-occurrence of a single response during a 4-sec trial than on the rate of many responses during a similar time period. Note, however, that in the present experiment these non-criterial attributes could exert considerable influence over response latency. Therefore, adventitious reinforcement may be responsible for the individual differences in the patterns of response latencies during the first and second states (see Figure 7). The lack of a systematic relation-

ship between FI value and response latency (see Tables 4 and 5) may also reflect adventitious reinforcement of "non-criterial" aspects of the response.

The almost identical patterns of responding obtained under discrete-trial and analogous free-operant schedules offer further support for two closely related hypotheses. First, Dews (1962, 1970) suggested that response chains cannot account for patterns of responding under fixed-interval schedules of reinforcement. In his experiments, as in the present case, inactivating an operandum had little or no effect on response patterns. Second, Neuringer and Schneider (1968) and Neuringer (1969) argued that the number of responses emitted between reinforcements exerts relatively little control over the patterns of these responses; rather, the time between reinforcements controls response patterns independently of the number of responses emitted. The work of Anger (1956), Herrnstein (1964), and Nevin (1969) is consistent with this hypothesis. Under the present discrete-trial procedure, many fewer responses were emitted per reinforcement than under the analogous free-operant procedure. Thus, the similarity between patterns of responding under analogous free-operant and discrete-trial procedures suggests that these patterns are influenced by neither response chains nor numbers of interreinforcement responses.

The present results do not, however, suggest that patterns of discrete-trial responding will always be identical to patterns of free-operant responding. The Neuringer and Schneider (1968) results indicate, to the contrary, that when temporal relationships are altered, patterns will vary correspondingly. Thus, for example, response patterns under a discrete-trial analogue to a fixed-ratio schedule (*e.g.*, one and only one response can occur during each 4-sec trial, and 75 responses must be emitted for reinforcement) would probably not be identical to patterns under a free-operant fixed ratio 75. According to the present analysis, changes in response probability will parallel changes in response rates at analogous moments in time, if and only if the temporal relationships in the two situations are identical. When temporal relationships are honored, probabilities of discrete operants vary, as do rates of free operants.

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