

*EFFECTS OF VARIATIONS IN THE TEMPORAL
DISTRIBUTION OF REINFORCEMENTS ON
INTERVAL SCHEDULE PERFORMANCE*

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Pigeons were exposed to variable-interval and fixed-interval schedules and schedules approximating variable-interval and fixed-interval schedules. The probabilities of the variable-interval and fixed-interval components in a mixed fixed-interval variable-interval schedule in Experiment I and the minimum and maximum interreinforcement intervals in Experiment II in a variable-interval schedule were manipulated to create intermediate schedule contingencies and contingencies approximating simple variable-interval or fixed-interval contingencies. Maximal control by time as defined by quantitative indices of the temporal pattern of response occurred as fixed-interval contingencies were approximated and minimal control occurred as variable-interval contingencies were approximated. Changes in the temporal pattern of response were systematically related to changes in the temporal distribution of reinforcements with both procedural definitions for manipulating the temporal distribution of reinforcements.

Key words: interval schedules, stimulus control, dimensional control, key peck, pigeons

A schedule of reinforcement can be defined as a rule that relates an organism's responding to the presentation of a reinforcer. In a temporally defined schedule, the rule is based on the time relative to some environmental event at which the response to be reinforced is emitted. One member of this class of schedules is the interval schedule, which specifies that the first response after a period of time has passed is reinforced. Responses before that time have no scheduled consequence. In a fixed-interval (FI) schedule, the temporal value is constant. In a variable-interval (VI) sched-

ule, the temporal value of the schedule is an average of a number of different intervals.

In FI performance, rate of response increases with time from the event that initiates the interval. In VI performance, the pattern of response depends on the distribution of intervals. Constant, increasing, and decreasing rates in time occur with constant probability, arithmetic, and geometric VI schedules (Catania and Reynolds, 1968). Fixed-interval performance has been analyzed in terms of delay of reinforcement (Dews, 1970). Variable-interval performance has been analyzed in terms of differential reinforcement of interresponse times (IRTs) (Anger, 1956; Morse, 1966) or momentary probabilities of reinforcement, although the two analyses are not incompatible (Catania and Reynolds, 1968).

Fixed-interval and variable-interval schedules share the common characteristic of providing reinforcement for the first response after a period of time has passed. In FI schedules, only one interval is employed; VI schedules employ a number of intervals. Logically, the FI schedule is a special case of the general class of interval schedules. Dichotomies between performance on these schedules, in terms of descriptive or explanatory principles, neglect basic similarities in the contingencies provided by the two types of schedules. While perform-

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ance on VI and FI schedules can be analyzed in terms of different variables, similarities in the contingencies provided by the schedules would suggest that the performances generated do not require different descriptive or explanatory systems.

The literature in stimulus control may provide a basis for developing a common analysis of FI and VI schedule performance. Hearst, Besley, and Farthing (1970) delineated two uses of the term stimulus control. One usage refers to control by the presence *versus* absence of a particular stimulus. Evidence for such control is a high probability of responding in the presence of a stimulus associated with reinforcement and a low probability of responding in the presence of a stimulus associated with nonreinforcement. The other usage refers to control by the dimension along which reinforcement contingencies are associated. Evidence for such control is maximal responding near the value of the stimulus associated with reinforcement and lesser responding at other values along the dimension. Typically, the actual amount of responding in the presence of other values depends on their dimensional distance from reinforcement. As the distance from the value that is associated with reinforcement increases, probability of response decreases.

The notion of dimensional control of responding seems relevant to understanding schedule effects for two reasons. First, an interval schedule provides a rule relating reinforcement to certain values along a temporal dimension. Second, since the rule provides that reinforcement be associated with responding at certain values, those values should acquire control over responding. The overall amount of dimensional control would depend on the degree to which differential reinforcement contingencies are associated with responding at values along the dimension. As the degree of differential reinforcement increases, the amount of dimensional control would increase. As the degree of differential reinforcement decreases, more equal control would be exerted by a number of values along the dimension.

Differential reinforcement with respect to the dimension of line tilt was manipulated in a study by Hearst, Koresko, and Poppen (1964), in which they varied the schedule of reinforcement associated with the stimulus in the pres-

ence of which responses were reinforced. As the value of the VI schedule decreased, steeper gradients were obtained. Dysart, Marx, McLean, and Nelson (1974) systematically varied VI schedules associated with two wavelengths. As the values of the schedules became more discrepant, the slopes of the generalization gradients increased. Pierrel, Sherman, Blue, and Hegge (1970) varied the difference between an auditory intensity in the presence of which responding was reinforced and an auditory intensity in the presence of which responding was not reinforced. As the difference increased, the discrimination index relating responding in the presence of the two values increased.

In the studies described above, differential control by the dimension or values along the dimension was a function of the degree of differential reinforcement. Two methods of varying differential reinforcement were employed. In one case, the difference in intensity between the stimuli was varied. In the other cases, the schedules of reinforcement associated with the stimuli were varied. In the present studies, differential reinforcement with respect to responding at values along a temporal dimension was manipulated in two ways. In Experiment I, the probabilities of the FI and VI components were manipulated in a mixed FI 100-sec VI 100-sec schedule. The effect of this manipulation was to vary the frequency of reinforcement for the first response after 100 sec had passed. In Experiment II, the minimum and maximum intervals in a VI 100-sec schedule were systematically manipulated, which resulted in variations in the concentration of reinforcements for responding around the average value of 100 sec. These experiments examine the effects of varying differential reinforcement with respect to responding at values along a temporal dimension through two methods of manipulating the distribution of interreinforcement intervals. These manipulations seem analogous to manipulations that affected generalization gradient shape and discrimination performance in the stimulus control experiments described above. If the pattern of response is systematically related to the degree of differential reinforcement provided with respect to responding in time, evidence would be provided that FI and VI performance represent two extremes on a continuum, rather than dichotomized classes of performance. As a consequence, FI and VI performance might

be analyzed in terms of principles ordinarily restricted to discussions of stimulus control.

EXPERIMENT I

METHOD

Subjects

Subject HJ5 was a White King pigeon and Subject HJ6 was a Homing pigeon. Both were experimentally naive males reduced to 80 to 85% of their free-feeding weights.

Apparatus

A three-key pigeon chamber, 40.6 by 40.6 by 40.6 cm, was illuminated by a 110-V, 7-W houselight throughout each session. The bottom of the hopper was located 10.2 cm above the floor and the middle key, located directly above the hopper, was 24.1 cm above the floor. Only the middle key, illuminated by a green light, was operative during an experimental session. The force requirement to operate the key was 0.2 N. The chamber was placed in a larger sound-attenuating box equipped with a blower for ventilation and sound masking. Electromechanical control and recording equipment was located outside the experimental room.

Procedure

Key pecking was shaped and maintained by providing 3.5-sec access to Purina pigeon chow. After each key peck, the keylight was darkened for the duration of the operating time of a pulseformer, approximately 40 msec. The keylight was also darkened during reinforcement. Following several preliminary sessions in which schedule values were raised to 100 sec, Subject HJ5 was initially exposed to a mixed FI 100-sec VI 100-sec schedule with a VI component probability of 1.0 (simple VI condition). Subject HJ6 was exposed to the same schedule with a VI component probability of 0.0 (simple FI condition). When successive performances were stable, the VI component was manipulated in a sequence of the following values: 1.0, 0.90, 0.70, 0.50, 0.30, 0.10, and 0.0. Each subject was exposed to a VI and FI sequence and FI to VI sequence. Thus, for both subjects the schedules were gradually transformed from VI 100-sec to FI 100-sec and from FI 100-sec to VI 100-sec. The VI schedule consisted of the following arithmetic order of intervals: 0, 140, 130, 170, 60, 160, 20, 80, 50, 150, 100, 180,

10, 70, 30, 190, 120, 90, 200, 40, and 110 sec. The stability criterion in the simple FI and VI conditions consisted of five consecutive sessions in which none of the overall rates varied from the mean by more than 10%. In other conditions, stability consisted of three consecutive sessions meeting this criterion following at least three sessions of initial exposure to a condition. Daily sessions were 1 hr long.

When the FI component was in effect, the distribution of a subject's responses was determined by recording responses in 10 class intervals. When the VI component probability was 1.0, the distribution of a subject's responses was determined by recording responses in 10 class intervals for the first 100 sec.

RESULTS

From the distribution of responses obtained when the FI component was in effect, local rates of response were calculated for each class interval. For each condition, response rate was determined as a function of the time at which that rate occurred. Response rate was fitted to the time of occurrence by the method of least-squares to the following model:

$$R = aT^k$$

where R equals response rate in responses per minute, T equals time in seconds, and a and k are constants derived from the least-squares solution. This method of analysis provided a consistent, quantitative basis for evaluating changes in the temporal pattern of response throughout the experiment.

Figure 1 shows response rate as a function of time under all conditions of the experiment. In the simple VI condition, the pattern of response was characterized by a small increase in response rate from 0 to 100 sec. As the probability of the VI component decreased, lower initial rates occurred and larger increases in rate occurred from 0 to 100 sec. Performance in the simple FI condition was characterized by a low initial rate and a rapid increase in rate from 0 to 100 sec. These changes are indicated by changes in the shape of the curves obtained from the least-squares solution. Similar changes occurred in the performance of Subject HJ6 and are shown in the right-hand portion of Figure 1. The major difference in the performance of Subject HJ6 was that higher absolute rates of responding occurred.

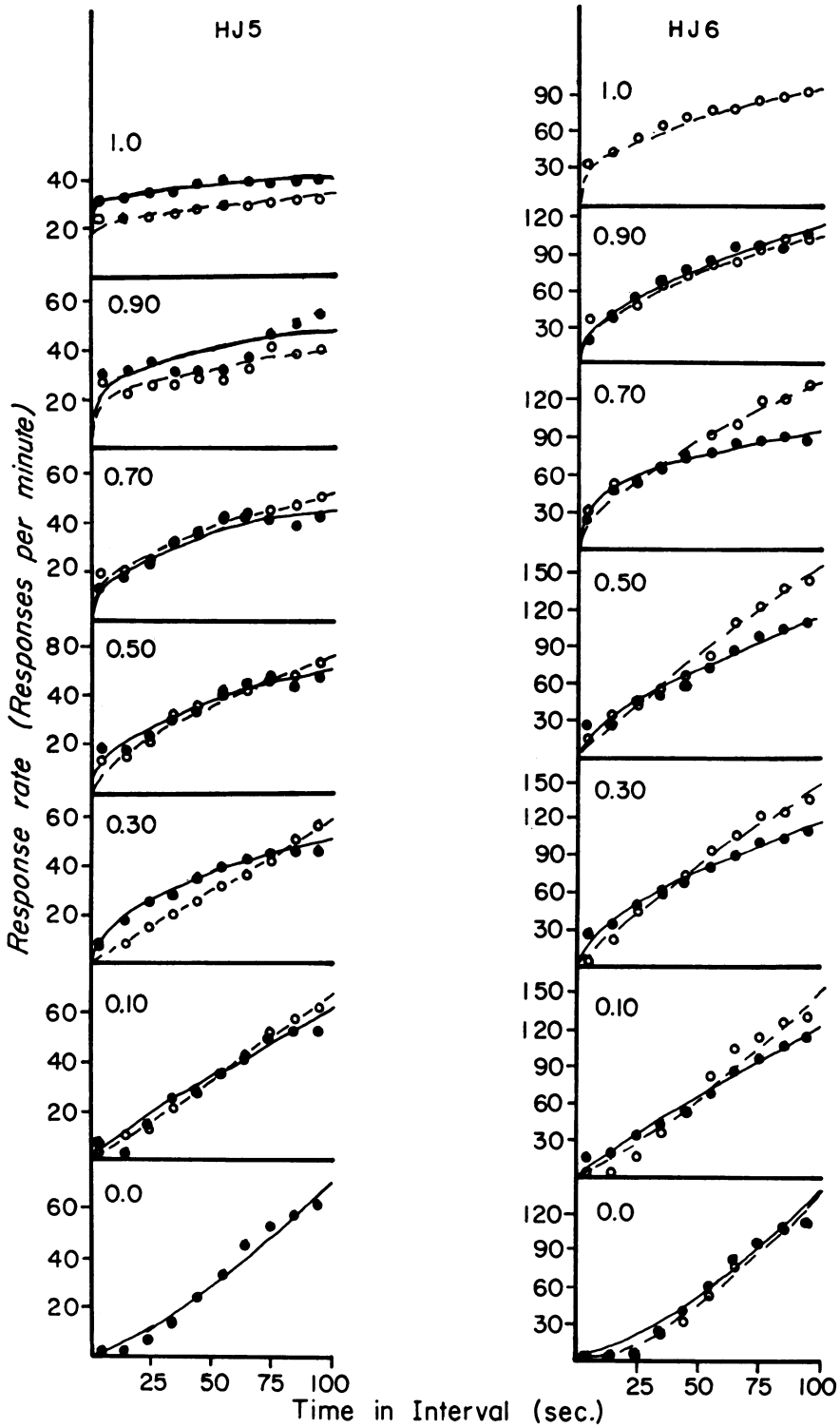


Fig. 1. Response rate as a function of time of emission of that rate for Subjects HJ5 and HJ6 under various probabilities of the VI component (filled circles and solid lines—VI to FI sequence; open circles and dotted lines—FI to VI sequence).

Different effects were obtained in the VI to FI and FI to VI sequence. In the VI to FI sequence, initial rates of response were typically greater and rate changes in time smaller than in the same condition in the FI to VI sequence. These effects are also shown in the parameters derived from the least-squares solution shown in Table 1. In the VI to FI sequence for Subject HJ5, the value of a for a condition was greater in all cases and the value of k was smaller in five of six cases. In the VI to FI sequence for Subject HJ6, the value of a for a condition was greater and the value of k was smaller in five of six cases.

Table 1 also summarizes the correlation coefficients and overall rates of responding throughout sessions across conditions of the experiment. For Subject HJ5, the value of the correlation coefficient was high, with the exception of the condition in which the probability of the VI component was 0.90. For Subject HJ6, the value was high in all cases.

EXPERIMENT II

METHOD

Subjects, Apparatus, Procedure

Two experimentally naive White King pigeons were reduced to 80 to 85% of their free-feeding weights. The same apparatus was employed as in Experiment I, with keylight contingencies, reinforcement, and reinforcement time the same as in Experiment I.

Subjects were given preliminary training at schedule values lower than in the initial experimental condition. In the initial condition, Subject HJ7 was exposed to a VI 100-sec schedule and Subject HJ8 to an FI 100-sec schedule. The VI schedule employed the same sequence of intervals as in Experiment I and the stability criteria were the same.

When successive performances stabilized, the minimum and maximum interreinforcement intervals were varied for each subject in a

Table 1

Parameters (a , k) and correlation coefficients (r) of best-fit lines and overall rates of response throughout sessions for each condition of the experiment.

Subject	VI		a	k	r	Absolute Rate (resp/min)
	Component Probability	Number of Sessions				
HJ5	1.00	23	28.59	0.08	0.95	40.3
	0.90	16	16.51	0.23	0.75	43.5
	0.70	10	7.67	0.39	0.96	37.0
	0.50	21	7.16	0.42	0.96	34.8
	0.30	6	5.60	0.48	0.98	34.5
	0.10	9	0.95	0.91	0.98	31.8
	0.00	26	0.14	1.35	0.99	30.8
	0.10	7	0.58	1.04	0.99	34.0
	0.30	16	0.71	0.96	0.99	32.4
	0.50	9	3.96	0.57	0.99	34.6
	0.70	6	7.11	0.43	0.98	36.8
	0.90	12	15.18	0.20	0.73	32.3
	1.00	18	18.32	0.11	0.92	28.9
	HJ6	0.00	60	0.11	1.55	0.99
0.10		13	0.55	1.22	0.98	69.0
0.30		7	2.91	0.86	0.99	83.6
0.50		9	2.49	0.90	0.99	92.7
0.70		6	9.39	0.58	0.98	90.3
0.90		6	12.04	0.47	0.97	79.0
1.00		18	17.69	0.36	0.99	77.4
0.90		15	10.92	0.51	0.99	74.1
0.70		8	18.63	0.36	0.98	74.3
0.50		6	6.24	0.63	0.99	73.3
0.30		7	8.41	0.57	0.99	75.1
0.10		6	1.79	0.92	0.99	65.5
0.00		25	0.17	1.46	0.99	55.7

sequence of the following values: 0-200, 10-190, 25-175, 50-150, 70-130, 90-110, and 100 sec. Each subject was exposed to a VI to FI and FI to VI sequence. Thus, the schedules for each subject were gradually transformed from FI to VI and VI to FI. In every condition but the simple FI condition, 21 equally spaced interreinforcement intervals were used. In each condition, the distribution of a subject's responses was determined by recording responses in 10 class intervals for the first 100 sec.

RESULTS

From the distribution of responses obtained during the first 100 sec, local rates of response were calculated for each class interval. Response rate was fitted to the time of occurrence with the same model as in Experiment I.

Figure 2 shows response rate as a function of time across all conditions of the experiment. For Subject HJ7, performance in the simple

VI condition was characterized by a small increase in response rate from 0 to 100 sec. As the difference between the maximum and minimum interreinforcement interval decreased, lower initial rates occurred and greater increases in rate occurred with time. Subject HJ8's performance, shown in the right-hand portion of Figure 2, was characterized by similar changes in the pattern of response.

Figure 2 also shows average rates of responding at times greater than 100 sec. These rates were calculated by determining the number of responses at times greater than 100 sec and dividing by the total time for which responding at times greater than 100 sec was possible. In general, extrapolations of the curves beyond 100 sec provide poor estimates of rate of response beyond 100 sec.

Table 2 shows the parameters derived from the least-squares solution, overall rates of response throughout sessions, and correlation

Table 2

Parameters (a , k), correlation coefficients (r) of best-fit lines and overall rates of response throughout sessions for each condition of the experiment.

Subject	Difference between Maximum and Minimum Interreinforcement Interval		a	k	r	Absolute Rate (resp/min)	
	(in seconds)	Number of Sessions					
HJ7	200	20	13.85	0.14	0.78	25.4	
	180	6	10.39	0.22	0.98	24.0	
	150	6	2.89	0.58	0.99	27.9	
	100	25	1.39	0.78	0.95	29.0	
	60	7	0.95	0.83	0.97	23.8	
	20	6	1.04	0.81	0.99	24.5	
	0	20	0.75	0.91	0.99	26.4	
	20	17	0.32	1.10	0.98	24.4	
	60	14	0.32	1.16	0.97	30.3	
	100	13	1.83	0.69	0.92	26.2	
	150	6	3.73	0.58	0.90	36.0	
	180	6	6.07	0.47	0.96	37.8	
	200	15	9.40	0.28	0.98	26.5	
	HJ8	0	38	0.26	1.30	0.97	45.5
		20	6	0.08	1.56	0.99	43.4
60		18	0.08	1.57	0.97	45.3	
100		14	0.59	1.08	0.96	44.1	
150		9	3.06	0.68	0.95	43.5	
180		13	15.17	0.30	0.93	51.5	
200		52	17.69	0.15	0.98	31.7	
180		6	21.31	0.13	0.97	42.1	
150		15	14.98	0.26	0.95	40.4	
100		7	9.40	0.43	0.94	48.6	
60		10	2.08	0.78	0.97	39.7	
20		11	0.76	1.03	0.95	35.6	
0		12	0.37	1.19	0.98	39.8	

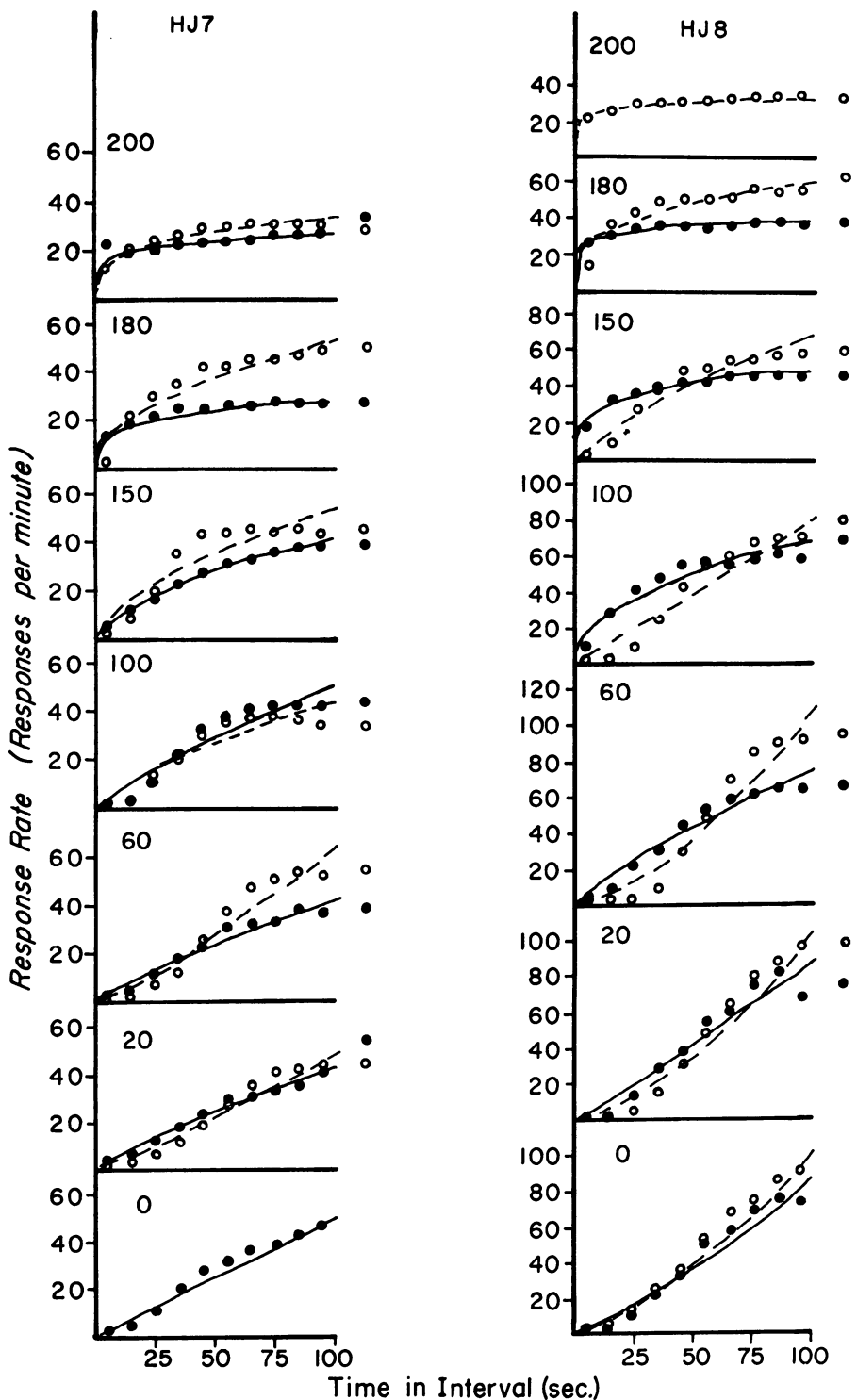


Fig. 2. Response rate as a function of time of emission of that rate for Subjects HJ7 and HJ8 under various differences between the minimum and maximum interreinforcement intervals (filled circles and solid lines—VI to FI sequence; open circles and dotted lines—FI to VI sequence). Average response rate at times greater than 100 sec is shown to the right of the curves.

coefficients obtained. The fit is generally good for both subjects. However, the curves fail to predict accurately the average rates of responding beyond 100 sec. Thus, the major function of the curves is to describe patterns of response in the first 100 sec, rather than patterns of response over all possible times at which responding occurred.

Two different effects occurred, depending on the sequence. In the VI to FI sequence, initial response rates were typically greater and rate changes in time were smaller than in the same condition in the FI to VI sequence. The parameters of the curves shown in Table 2 also show this effect. For Subject HJ7, the value of a was greater and the value of k was smaller in the VI to FI sequence in four of six cases. For Subject HJ8, the value of a was greater and the value of k was smaller in the VI to FI sequence in all six cases. The second sequence effect occurred following exposure to the simple FI condition. Both subjects showed further decreases in initial rate and larger increases in rate with time when the difference between the minimum and maximum interreinforcement increased from 0 to 20 to 60 sec. The pattern did not reverse until the difference increased to 100 sec, in which the minimum interval was 50 sec and the maximum interval was 150 sec.

DISCUSSION

Varying the probabilities of the VI component and FI component or the difference between the minimum and maximum interreinforcement interval redistributed reinforcements in time. Simple FI and VI contingencies, approximations to these contingencies, and intermediate contingencies were established under different conditions of the experiments. In both experiments, as schedule contingencies approximated a simple VI schedule, performances were obtained that approximated VI performance. Likewise, as schedule contingencies approximated a simple FI schedule, performances were obtained that approximated FI performance. The degree to which responding was differentially reinforced with respect to time determined the degree to which differential responding with respect to time occurred. As the probability of the VI component decreased in Experiment I, or the difference between the maximum and minimum inter-

reinforcement decreased in Experiment II, greater control was exerted by time, as evidenced by increases in the slopes of the curves. Control was maximal as FI contingencies were approximated and minimal as VI contingencies were approximated. The parameters of the curves provide a quantitative basis for evaluating changes in the amount of control exerted by the dimension of time.

Flatter slopes of the curves represented weaker control by the dimension of time. As reinforcement became equally probable for responding at a number of points in time, each point exerted approximately the same amount of control, resulting in a decrease in the amount of dimensional control. Thus, decreases in dimensional control were related to shifts to approximately equal control by a number of temporal values. In Experiment I, the actual amount of control by one value, as represented by response rate relative to those rates that occurred at other values, depended on two factors. One was the probability of reinforcement associated with responding at that value. The other was the distance to 100 sec, the value for which the most frequently reinforced responding occurred under all conditions of the experiment except the simple VI condition. Although the probabilities of reinforcement for responding at 10 sec and 90 sec were somewhat similar, response rate was higher at 90 sec, due to its proximity to 100 sec. Thus, control by any particular value depended on the probability of reinforcement associated with that value and the temporal distance to 100 sec. In Experiment II, the amount of control by any one temporal value depended on its distance from the minimum interreinforcement interval and the degree to which reinforcement was concentrated around the average interreinforcement interval. A value of 10 sec, for example, exerted greater control when the minimum interreinforcement interval was 25 sec, as compared with 50 sec. Across conditions of the experiment, larger temporal values exerted greater control than smaller values because the larger values either occurred in the temporal region in which responding was reinforced or nearer to that region than smaller temporal values.

In both experiments, performance in a given condition was differentially affected by the subject's more immediate history. If a subject had been more recently exposed to a VI

schedule, larger initial rates and smaller increases in rate with time occurred. This effect occurred with both procedural definitions of the continuum between VI and FI schedules. The results from the two sequences in each experiment remained quantitatively similar, nonetheless. In Experiment II, a different type of sequence effect occurred. Decreases in initial rate and larger rate increases in time occurred over the first two conditions of the FI to VI sequence when the difference between the maximum and minimum interreinforcement interval increased from 0 to 20 to 60 sec. In the VI to FI sequence, when the difference decreased from 60 to 20 to 0 sec, the opposite effects occurred. For Subject HJ7, the FI to VI sequence occurred after the VI to FI sequence. Thus, responding at lower temporal values was reinforced in the more remote history of the subject. The continued nonreinforcement may have had the effect of further reducing their associated response rates. For Subject HJ8, the FI to VI sequence occurred before the VI to FI sequence. Responding at lower temporal values had never been reinforced, except in initial shaping sessions. Thus, responding at these values may have been further reduced from continued nonreinforcement.

The procedures for varying the temporal distribution of reinforcements produced systematic changes in the degree to which time exerted dimensional control over responding. Analogous procedures in stimulus control experiments have resulted in similar effects with respect to line tilt, wavelength, and auditory intensity. Three conditions, if met, provide minimal evidence for viewing interval schedule control in terms of principles of stimulus control. These are:

1. FI and VI performance represent extremes on a continuum of temporal control with maximal control occurring when FI contingencies are approximated and minimal control when VI contingencies are approximated.
2. The amount of dimensional control should be quantifiable under varying temporal conditions of reinforcement.
3. When dimensional control is weak, other sources of control must be specified and the amount of control systematically related to these sources.

In the present experiments, maximal and

minimal control was approximated as maximal and minimal differential reinforcement with respect to time occurred. Intermediate degrees of control occurred when intermediate contingencies were in effect. The parameters of the best-fit lines provided a quantitative index of the degree of control. The use of the measures for these purposes is consistent with Ray and Sidman's (1970) views on the interpretation of the slope of generalization gradients. Ray and Sidman (1970) also suggested that weak control implies control by other sources. One source in Experiment I was the probabilities of reinforcement associated with a particular value relative to other values. A second source of control by any particular value was the temporal distance between that value and 100 sec, the value with which reinforcement was most frequently associated. In Experiment II, weak overall control was explained by a shift in control to numerous values as reinforcement was concentrated over a wider range of values. Control by a particular value was largely dependent on the distance from the minimum interreinforcement interval. Catania and Reynolds (1968) described many of their findings in terms of similar variables. Blough (1969) presented gradients when two S+ stimuli were employed. The control exerted by any one value largely depended on the distance to the two S+ stimuli. As the distance increased, control decreased. An obvious extension of Blough's procedure would be to three or more stimuli employed as S+. At some point, such a procedure would be trivial, since all values would exert equal control if they were associated with the same schedule of reinforcement. However, the trivial case may be instructive in terms of control by temporal values in constant probability VI schedules. In constant probability VI schedules, a large number of equally spaced temporal values are employed. Responding at these values is associated with the same probability of reinforcement given the opportunity to respond. Constant rates of responding in time result, suggesting equal control by all values employed in the schedule. Thus, in the constant probability VI schedule, the lack of overall temporal control results from the absence of differential temporal contingencies. Similar arguments have been used to explain performance obtained with other VI scheduling arrangements, although these need not be discussed.

The variables that account for the present results appear similar to variables operating in stimulus control procedures, except that different dimensions are involved and their specifications in terms of units of measurement are different. Investigators have been reluctant to describe temporal control in terms of principles of stimulus control. One reason is that time, in itself, presents no specific stimulus energy to an organism and involves no obvious receptor (Catania, 1970, p. 38), unlike other dimensions such as wavelength. The absence of an obvious receptor may have led to an emphasis on response properties, rather than environmental properties in analyses of performance on temporally defined schedules of reinforcement. The issue of emphasizing response properties *versus* environmental properties in such analyses may be verbal, rather than empirical, and follow from procedural differences in exposing explicit discriminative stimuli such as wavelength *versus* a temporally defined schedule (Catania, 1970, p. 13). A paradox arises in the case of time because no specific antecedent unit of stimulus energy is suggested to control responding. However, time exists independently of a subject's responding, is measurable, and, in the case of temporally defined schedules, is the dimension according to which reinforcement contingencies are assigned. In addition, rates of response are generally meaningful data in terms of the time at which they occur. The same holds true for other dimensions, such as wavelength in stimulus control experiments.

The minimal conditions for viewing interval schedule control in terms of stimulus control appear to have been satisfied. More stringent criteria for such a view would involve the demonstration that phenomena associated with stimulus control, such as behavioral contrast, also occur along a temporal dimension when changes occur in the reinforcement frequencies associated with two values. Successful demonstrations of behavioral contrast in such an instance would strengthen the conceptualization that interval schedule control can be understood in terms of stimulus control. The

major consequences of such a conceptualization would be the unification of two previously separate areas, a reduction in the number of principles of behavior, and an increase in the generality of principles of stimulus control.

REFERENCES

- Anger, D. The dependence of interresponse times upon the relative reinforcement of different interresponse times. *Journal of Experimental Psychology*, 1956, **52**, 145-161.
- Blough, D. S. Generalization gradient shape and summation in steady-state tests. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 91-104.
- Catania, A. C. Reinforcement schedules and psychophysical judgments: a study of some temporal properties of behavior. In W. N. Schoenfeld (Ed.), *The theory of reinforcement schedules*, New York: Appleton-Century-Crofts, 1970. Pp. 1-44.
- Catania, A. C. and Reynolds, G. S. A quantitative analysis of responding maintained by interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 327-383.
- Dews, P. B. The theory of fixed-interval responding. In W. N. Schoenfeld (Ed.), *The theory of reinforcement schedules*. New York: Appleton-Century-Crofts, 1970. Pp. 43-61.
- Dysart, J., Marx, M. H., McLean, J., and Nelson, J. A. Peak shift as a function of multiple schedules of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1974, **22**, 463-470.
- Hearst, E., Besley, S., and Farthing, G. W. Inhibition and the stimulus control of operant behavior. *Journal of the Experimental Analysis of Behavior*, 1970, **14**, 373-409.
- Hearst, E., Koresko, M. B., and Poppen, R. Stimulus generalization and the response-reinforcement contingency. *Journal of the Experimental Analysis of Behavior*, 1964, **7**, 369-379.
- Morse, W. H. Intermittent reinforcement. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 52-108.
- Pierrel, R., Sherman, J. G., Blue, S., and Hegge, F. Auditory discrimination: a three-variable analysis of intensity effects. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 17-35.
- Ray, B. and Sidman, M. Reinforcement schedules and stimulus control. In W. N. Schoenfeld (Ed.), *The theory of reinforcement schedules*. New York: Appleton-Century-Crofts, 1970. Pp. 187-214.

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