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Multiple and concurrent schedules of fixed-interval reinforcement

Programas de Reforzamiento Múltiples y Concurrentes, de Intervalo Fijo [1]

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ABSTRACT

Key pecking by three pigeons was maintained under a multiple fixed-interval 50-sec, fixed-interval 120-sec schedule in Phase I, the same fixed-interval schedules programmed concurrently in Phase II. Again the same concurrent schedules with the addition of a 5-sec timeout period as consequence of changeover responses in Phase III, and concurrent variable-interval 50-sec, variable interval 120-sec, with a 5-sec timeout period contingent on changeovers, in Phase IV. Under multiple and concurrent fixed-interval schedules, in the first three phases of the experiment, ratios of response rates (response rates in one schedule divided by response rates in the second schedule) were close to one for all subjects, while ratios of obtained reinforcements per minute varied from 2.28 to 3.00. However, there was an extreme preference for the schedule providing higher frequency of reinforcement in concurrent variable-interval schedules, while obtained reinforcement ratios remained approximately equal to those observed on the previous phases.

DESCRIPTORS: choice, matching, multiple schedules, concurrent schedules, fixed-interval schedules, pigeons.

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RESUMEN

En una primesa fase, se mantuvo el picoteo de tres pichones bajo un programa múltiple intervalo fijo 50 seg.-intervalo fijo 120 seg. En la fase II se programaron concurrentemente los mismos programas. En la fase III se pusieron en efecto los mismos programas, con la adición de un período de tiempo fuera de 5 segundos como consecuencia a respuestas de cambio ("changeover"). En la fase IV se puso en efecto un programa concurrente intervalo variable 50 seg.-intervalo variable 120 seg. con un periodo de tiempo fuera de 5 segundos contingente sobre cambios. Durante los programas de intervalo fijo, múlitples y concurrentes de las primeras tres fases del experimento, las razones de tasa de respuesta (tasa de respuesta en un programa divididas entre la tasa de respuestas del segundo) mostraron valores cercanos a uno para todos los sujetos, mientras que las razones de los reforzamientos obtenidos por minuto variaron entre 2.28 y 3.00. Sin embargo, hubo una extrema preferencia por el programa que proveía una frecuencia de reforzamiento más alta en los programas concurrentes de intervalo variable, mientras que las razones de reforzamientos obtenidos se mantuvieron iguales a las observadas en las fases previas.

DESCRIPTORES: opciones, igualación, programas múltiples, programas concurrentes, programas de intervalo fijo, pichones.

The relation between response ratios and reinforcement ratios in concurrent schedules of variable interval reinforcement (conc VI VI) has been extensively studied and may be described as

$$R_1/R_2 = c\,(r_1/r_2)^a \qquad (1)$$

where R_1 and R_2 are response rates for two alternatives, r_1 and r_2 are the rates of reinforcement provided by those alternatives, c is a constant measuring preference for one schedule due to uncontrolled variables, and a is an index of the sensitivity of the response ratio to changes in the ratio of reinforcement frequencies (Baum, 1974; Lobb & Davison, 1975; Todorov, 1971; Trevett, Davison, & Williams, 1972; White & Davison, 1973). Parameters a and c were found to be close to or equal to unity in most studies of concurrent schedules of variable interval reinforcement.

However, when performance is maintained by concurrent fixed-interval, fixed-interval (conc FI FI) schedules, the value of a in Equation 1 may vary according to the subject's pattern of responding (White & Davison, 1973) .The constant a was found to be close to unity when response patterns on both concurrent schedules were similar, i.e., either the scallops characteristic of FI or the constant rate patterns of VI schedules. When responding was typical of FI schedules in one component and of VI schedules in the other component, a was systematically lower than one. Similar findings were reported by Nevin (1971) and Trevett *et al.* (1972) when responding was maintained by concurrent fixed-interval, variable-interval (conc FI VI) schedules. The value of a in these experiments varied between 0.5 and 0.7.

The present experiment was intended as an investigation of the relationship between local response patterns and the equation relating ratios of responses and reinforcements in conc FI FI schedules. Preliminary training in multiple fixed-interval, fixed-interval (mult FI FI) schedules was used, with interval values identical to those with which White & Davison (1973) found systematic deviation from matching and unequal response patterns. By insuring that subjects had well established FI scallops in both schedule components before being shifted to conc FI FI, the value of *a* in Equation 1 should be close to one if indeed similar response patterns are a prerequisite for response ratios to match approximately reinforcement ratios.

METHOD

Subjects

Three experimentally naive male adult pigeons, from uncontrolled derivations of the species Columba *livia*, caught wild, were maintained within 15 g of 80% of their free feeding weight.

Apparatus

A three-key response chamber for pigeons, described by Cumming & Berryman (1961), was used with the middle key continuously dark and unoperative. The side keys were 3.2 cm diameter backlighted translucent disks, with a distance of 13.2 cm between their centers. Experimental events were programmed automatically with electromechanical equipment located in a different, sound attenuated room.

Procedure

MULT FI 50 FI 120. After shaping of pecks at the response keys the birds were subjected to a multiple alternating fixed-interval 50-sec, fixed-interval 120-sec schedule (mult FI 50-sec, FI 120-sec) for 34 sessions of 40 reinforcements each. FI 50-sec was associated with the left, blue response key, and FI 120-sec with the right, red response key. Reinforcement was a 10-sec period of access to powdered grain. During reinforcements all lights in the experimental chamber were darkened, only the feeder remaining illuminated; interval tape programmers stopped and response keys were unoperative.

CONC FI 50 FI 120. In this phase the schedule was changed to conc FI 50-sec, FI 120-sec. The FI schedules were programmed independently and the subjects could switch from responding in one key to the other at any time, with no special consequences programmed for changeovers.

Such contingencies were in effect for 23 sessions of 40 reinforcements each for all birds.

CONC FI 50 FI 120, CO-TO. The procedure was the same as in the previous phase, except for the programming of a 5-sec timeout period as a consequence of changeovers (Todorov, 1971, 1973). After a changeover (first response in one key after a response in the other key) all lights in the experimental chamber were darkened, interval tape programmers stopped and response keys were unoperative. All birds were subjected to such contingencies for 28 sessions.

CONC VI 50 VI 120, CO-TO. The schedule was changed to conc VI 50-sec, VI 120-sec, with all other conditions remaining as in the previous phase. All birds were run for 33 sessions in this phase.

RESULTS

Response ratios (response rates in FI or VI 50-sec divided by response rates in FI or VI 120-sec) and obtained reinforcement ratios from the three subjects in the last five sessions of all experimental conditions are shown in Table 1. Response ratios in the first three phases of the experiment

TABLE 1

Response and obtained reinforcement ratios in different experimental conditions

Conditions	Subjects					
	51		52		53	
	Resp Ratios	Reinf	Resp Ratios	Reinf	Resp Ratios	Reint
MULT FI 50 FI 120	1.17	2.40	0.96	2.40	0.79	2.40
CONC FI 50 FI 120	0.88	2.33	1.04	2.33	1.33	2.28
CONC FI 50 FI 120 CO-TO	0.88	2.92	0.72	2.85	1.08	3.00
CONC VI 50 VI 120 CO-TO	4.00	2.64	13.29	3.00	13.29	2.92

were close to one for all subjects, while obtained reinforcement ratios varied from 2.28 to 3.00. The change from MULT FI 50 FI 120 to CONC FI 50 FI 120 (no especial consequences programmed for changeovers) had practically no effect on response ratios. The introduction of a 5-sec timeout following changeovers in CONC FI 50 FI 120, CO-TO did not change considerably response ratios either. But the change to CONC VI 50 VI 120, CO-TO resulted in extreme preferences for responding in the component with higher frequency of reinforcement, with practically no effect on obtained reinforcement ratios.

Figure 1 shows response rates in successive quarters of the fixed-interval schedules in the first three phases of the experiment (upper graphs) and as percentages of the rate in the final quarter of each schedule (lower graphs). The data shown are the average of three subjects; individual data are given in Table 2. In MULT FI 50 FI 120 responding in the first three quarters of each interval represent about the same percentage of the final rate in that interval. The lines representing data from FI 50-sec and FI 120-sec almost overlap; in both cases response rate was very low in the beginning of the interval and increased as time to the next reinforcement increased.

In CONC FI 50 FI 120, with no special consequences for changeovers, the temporal patterning characteristic of FI schedules disappeared in FI 120-sec. Response rates were about the same in the four quarters of the interval. In the shorter FI a temporal pattern was maintained, but with

TABLE 2

Response rates (resp/min) in successive quarters of the fixed-interval schedules in different experimental conditions

Subjects	Quarters	MULT FI 50	MULT FI 120	CONC FI 50	CONC FI 120	CONC FI 50 CO-TO	CONC FI 120 CO-TO
51	1	2	3	14	29	3	15
	2	31	25	25	30	18	41
	3	72	49	29	24	34	47
	4	67	67	31	26	46	40
52	1	1	4	16	24	1	12
	2	12	24	26	28	7	19
	3	49	42	33	26	18	31
	4	56	51	36	26	29	35
53	1	2	10	33	25	6	44
	2	22	39	34	28	31	56
	3	37	70	38	27	67	57
	4	107	90	40	27	83	61

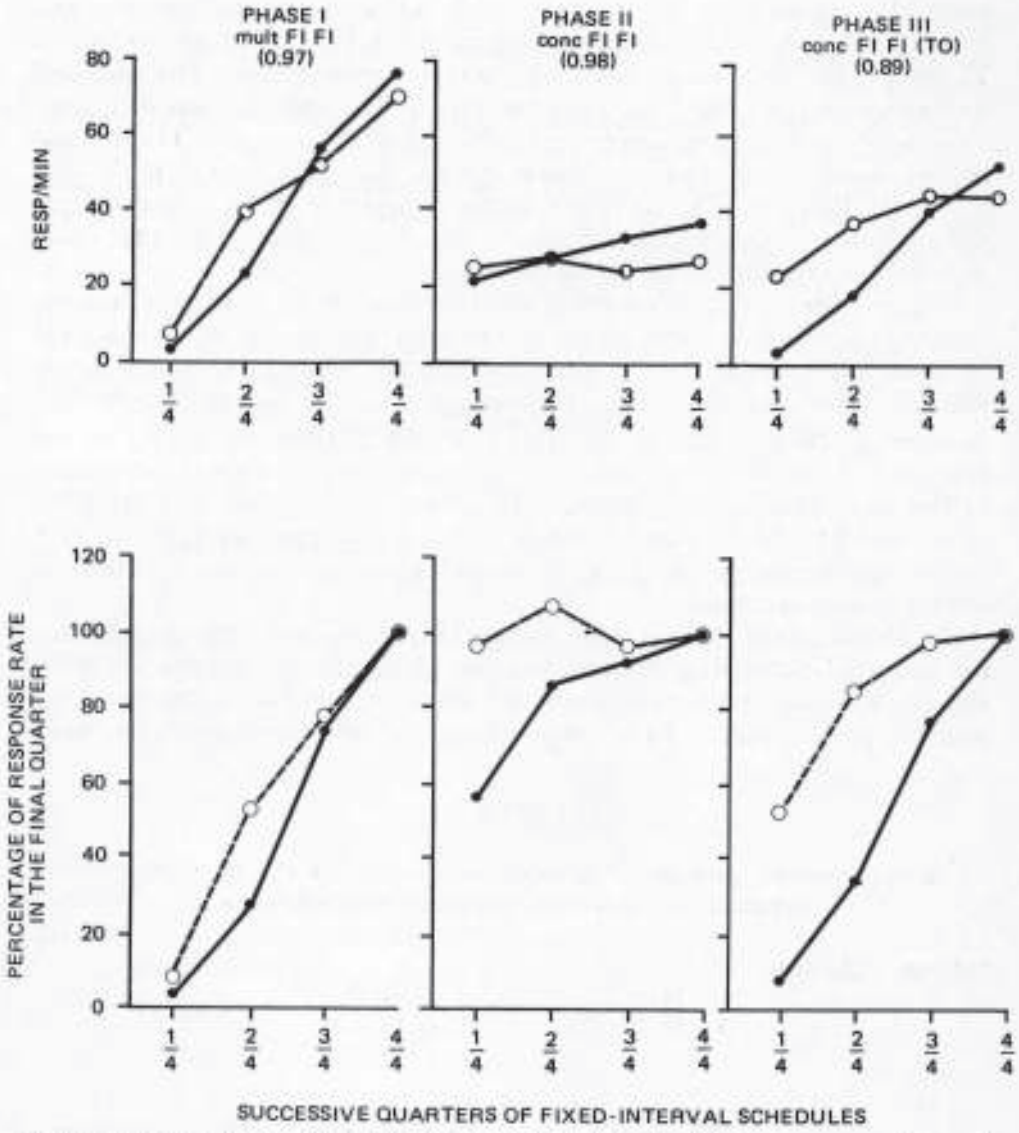

Fig. 1. Response rates in successive quarters of fixed-interval schedules (upper graphs) and rates as percentages of response rate in the final quarter (lower graphs). Solid lines represent data from FI 50-sec, broken lines from FI 120-sec. The data shown are the average of three subjects; individual data are given in Table 2. Numbers between parenthesis represent average response ratios from the three subjects in each condition.

relatively more responding in the first three quarters of the interval. The 5-sec timeout scheduled as a consequence of changeovers in CONC FI 50 FI 120, CO-TO restored the typical temporal pattern in FI 50-sec, with less effect in the longer FI. Responding in FI 120-sec increased also as

time since the last reinforcement in that component increased, but the rate of responding in the first quarter of the interval was about half of the final rate.

The numbers in parenthesis in Figure 1 represent average response ratios from the three subjects in each condition (individual data are given in Table 1). In spite of different response patterns, response ratios tended to be insensitive to the different experimental conditions investigated in the first three phases, with values less than half of those from obtained reinforcement ratios (Table 1).

Table 3 shows the ratios of changeovers (from the shorter to the longer interval) per reinforcement in FI or VI 50-sec in the last three phases of the experiment (concurrent schedules). In CONC FI 50 FI 120, with no special consequences for changeovers, the ratios of changeovers to FI

TABLE 3

Ratios of changeovers (from FI or VI 50-sec to FI or VI 120-sec) to reinforcements in the shorter interval

Subjects	CONC FI 50 FI 120	CONC FI 50 FI 120 CO-TO	CONC VI 50 VI 120 CO-TO
51	13.5	1.3	1.3
52	15.8	1.0	1.1
53	18.8	2.5	1.0

120-sec per reinforcement in FI 50-sec were high. The change to CONC FI 50 FI 120, CO-TO resulted in a decrease in those ratios to a level close to a changeover per reinforcement, which was maintained in CONC VI 50 VI 120, CO-TO.

DISCUSSION

The ratio of response rates failed to match the ratio of reinforcement rates in all experimental conditions investigated. Reinforcement rate in FI 50-sec (first three phases) or VI 50-sec (last phase) was always more than twice the reinforcement rate in FI or VI 120-sec, but in mult FI FI and conc FI FI response rates in both component schedules tended to be about the same. That this apparent insensitivity of relative responding to relative reinforcement cannot be attributed to key or color bias (Baum, 1974) was shown by the strong preference that developed in CONC VI 50 VI 120, CO-TO for the key associated with the higher reinforcement density.

Response patterns typical of fixed-interval schedules were observed in both components of MULT FI 50 FI 120, but these patterns disappeared entirely in the longer fixed interval in CONC FI 50 FI 120. The introduction of a 5-sec timeout following changeovers restored the curvature in the shorter FI, but not completely in the longer one. Previous data (Todorov, 1971), of which phase CONC VI 50 VI 120, CO-TO is a replication, indicate that one effect of timeouts contingent on changeovers is the increase in control exerted by a schedule over responding associated with that schedule. But even with a timeout duration long enough to produce extreme preference for VI 50-sec over VI 120-sec, in CONC FI 50 FI 120, CO-TO response ratios undermatched ratios of reinforcement rates; only the temporal pattern of responding indicated some control of component schedules over responding associated with those schedules.

An explanation for this mismatch can be formulated in terms of local response strategies interfering with molar relationships. The data in CONC FI 50 FI 120, CO-TO indicate that responding occurred at a very low rate in FI 50-sec after a reinforcement in that schedule. Visual inspection of cumulative records showed that in the period after a reinforcement in FI 50-sec the subjects would switch to responding in FI 120-sec; few switches to the longer FI schedule occurred in the end part of FI 50-sec. Considering the relative difficulties of maintaining simultaneously two asyncronous and repetitive temporal discriminations, it seems reasonable to describe the subject's behavior as controlled mainly by the short FI schedule, with FI 120-sec as an option for periods when reinforcement was clearly not available in FI 50-sec. Thus, part of responding in FI 120-sec might be explained as interim activities (Staddon & Simmelhag, 1971; Staddon, 1972). So this explanation of responding in CONC FI 50 FI 120, CO-TO involves two assumptions: *a*) that responding is controlled mainly by the shorter FI schedule; and *b*) that part of the responses on the longer FI schedule are interim activities controlled by the time between reinforcements in the short FI.

Support for these asumptions is found in phase CONC VI 50 VI 120, CO-TO of the present investigation. An extreme preference for the short VI schedule was observed. Since time after last reinforcement is not a good predictor of time for the next reinforcement in VI schedules, much more responding right after reinforcements can be expected in VI than in FI schedules. With the ratio "number of changeovers to the longer interval schedule/reinforcements in shorter interval" remaining about the same after the change from CONC FI 50 FI 120, CO-TO to CONC VI 50 VI 120, CO-TO (Table 3), the number of responses in the longer interval per changeover decreased considerably. There was no more room for responding in the longer interval as interim activities controlled by the short interval, for there was practically no discrimination based in time since reinforcement in VI 50-sec. It seems that subjects would sample

the state of VI 120-sec with a few responses and go back to responding in VI 50-sec until the next reinforcement.

Another source of support for this interpretation are the data from White & Davison (1973). Typical FI patterns in both components of conc FI FI were found when the FI values were quite different, i.e., the short FI was less than 30 sec and the longer one was more than 120 sec. Under these conditions, the pause after reinforcements in the shorter FI is small since reinforcements are closer in time, leaving less room for interim activities. Number of successive reinforcements in the shorter FI also is a good predictor of time for reinforcement in the longer FI, and may function as an external clock (Ferster & Skinner, 1957) in controlling the temporal pattern of responding. When FI values were not so different, the data from White & Davison (1973) show that response patterns were more similar to those maintained by variable-interval schedules.

Under these conditions, attempts at finding a general function which describes both behavior maintained by conc FI FI and conc VI VI schedules may be destined to be disturbed by those factors which are characteristic of FI schedule performance.

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