**PREFERENCE AND DISCRIMINATION BETWEEN
RESPONSE-DEPENDENT AND RESPONSE-INDEPENDENT
SCHEDULES OF REINFORCEMENT¹**

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Four Asian quail (*Coturnix coturnix japonica*) were exposed to concurrent-chain schedules, the terminal links of which were either variable-interval 30 sec and variable-time 30 sec, or fixed-interval 30 sec and fixed-time 30 sec. Except for one bird that exhibited a preference for the variable-interval schedule over the variable-time schedule, no consistent preferences were demonstrated for response-dependent or response-independent schedules. However, response rates were three times greater on response-dependent than on response-independent schedules. The discrimination between terminal-link schedules was rapidly recovered after the schedule positions were reversed. Casual observations revealed that the birds engaged in stereotypic circling and pecking while the response-independent schedules were operative.

The relationship between preference for a schedule of reinforcement and the behavior maintained by that schedule is uncertain when equivalent rates of reinforcement generate different rates of behavior. The concurrent-chains procedure (Autor, 1969) provides temporally independent measures of both preference for a schedule and the amount of behavior maintained by a schedule. Within this paradigm, schedule preference assessed in terms of initial-link response rates is a direct function of the rate or immediacy of reinforcement in the terminal link (Fantino, 1969; Herrnstein, 1970). However, in some cases when terminal-link schedules provide equivalent rates of reinforcement pigeons demonstrate a preference for one schedule over the other. For example, Fantino (1968) found that pigeons preferred fixed-interval schedules to schedules that provided the same amount of reinforcement but which required high rates of terminal-link

responding. Autor (1969) and Killeen (1968) gave pigeons the choice between schedules that arranged reinforcement contingent upon key pecking and schedules that arranged reinforcement contingent upon any behavior other than key pecking. They found that preference was a function of the immediacy of reinforcement, rather than the response requirements in the terminal link. Similarly, Killeen (1971) showed that pigeons have no preference between schedules that provide equivalent rates of reinforcement but which maintain different patterns of terminal-link responding.

The present experiment was designed to extend the findings of Autor (1969), Fantino (1969), and Killeen (1968) to schedules that differ only in terms of the dependency between key pecking and reinforcement. In the present study, the response-dependent and response-independent schedules provided equivalent rates of reinforcement, but there was absolutely no correlation between key pecking and reinforcement in the response-independent schedules. A reversal design was employed to assess the possibly confounding effects of stimulus conditions associated with the terminal-link schedules. The use of reversal designs to detect confounding effects of associated stimulus conditions in conceptually equivalent schedules of reinforcement has been frequently absent in the literature.

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METHOD

Subjects

Four experimentally naive male coturnix quail (*Coturnix coturnix japonica*) were maintained at 75% of their free-feeding body weights throughout the study. Birds were approximately 180 days old at the beginning of the study and were individually housed throughout the study.

Apparatus

Two Lehigh Valley (Model #132-02) two-key operant conditioning chambers for pigeons were used. The floors of the experimental chambers were raised 10.5 cm to accommodate the smaller size of the coturnix. Two Plexiglas response keys were located 16.5 cm above the floor and 16.5 cm apart (from center to center) on the magazine wall. Chamber and key illumination was provided by 0.6-W lamps (GE 1820). Seventy-two decibels of white noise was provided (Grason Stadler White Noise Generator Model #901B) in addition to the noise of a ventilator fan. Standard solid-state (BRS series 200) and electromechanical programming and recording equipment was located in a remote corner of the laboratory. All variable-interval (VI) and variable-time (VT) schedules were constant probability interval distributions generated from randomized intervals (Fleshler and Hoffman, 1962).

Procedure

Preliminary training followed the general outline provided by Ten Eyck (1970). After initial shaping of key pecks, all birds were exposed on alternate days to VI 60-sec schedules. After meeting Ten Eyck's (1970) stability criterion, the birds were placed on a chain VI 30-sec VI 30-sec schedule operative on the right and left keys on alternating days. The initial-link VI 30-sec schedule arranged a change in key color from white to green (left key) or red (right key). The terminal-link VI 30-sec schedule arranged grain delivery. Reinforcers consisted of 3.5 sec access to grain. After grain was delivered, the response key was illuminated by white light and the initial-link VI program was again activated. All birds were exposed to the chain schedule until responding appeared stable upon examination of the cumulative records of the preceding five days.

Preference assessment. The concurrent-chains procedure (Autor, 1969) was used to provide independent measures of choice and response rates maintained by a particular schedule. During the initial link of the chain schedules, both keys were illuminated by white light. Pecks on the right or left key occasionally (VI 30-sec schedule) changed the color of that key and darkened the other key. Subsequent pecks on the illuminated key produced grain on the average of every 30 sec. Pecks on the darkened key had no scheduled consequences. Independent concurrently operating interval programmers arranged stimulus changes in the initial link.

Throughout the present investigation, VI 30-sec schedules were used in the initial link. Terminal-link schedule conditions, the associated key color, and the number of sessions during which each condition was in effect are presented in Table 1. The key color associated with a schedule (green [G], red [R]) is noted next to the schedule abbreviation in Table 1. After exposure to identical VI 30-sec terminal-link schedules, Birds 3 and 6 were given the choice between VI 30-sec and VT 30-sec schedules. Birds 5 and 9 were given the choice between fixed-interval 30-sec (FI) or fixed-time 30-sec (FT) terminal-link schedules. Identical tapes were used for response-dependent (VI and FI) and response-independent (VT and FT) schedules of reinforcement. The only difference between response-dependent and response-independent schedules was the necessity of a key peck for grain delivery on the response-dependent schedules. The response-independent schedules delivered grain on a temporal basis regardless of what the bird was doing. Each experimental session was terminated after the delivery of 40 reinforcers.

RESULTS

Initial and terminal-link data were analyzed in terms of both the absolute response rates (responses per minute) on each key and the response rate on the left key relative to the total response rate during that component of the concurrent-chain schedules. Initial-link choice proportions for the left key were obtained by dividing the number of initial-link responses emitted on the left key by the total number of initial-link responses. The arithmetic means of the choice proportions for the last five days of

Table 1

Means of the absolute and relative response rates during the last five days of each experimental condition.

Bird	Schedule and Stimulus Conditions		Number of Sessions	Initial Link			Terminal Link		
				Choice Proportion (Left Key)	Response Rate per Minute		Rate Proportion (Left Key)	Response Rate per Minute	
					Left Key	Right Key		Left Key	Right Key
3	VI-G	VI-R	19	0.50	16.2	16.7	0.45	49.8	58.1
	VI-G	VT-R	39	0.73	22.4	7.7	0.70	48.7	20.2
	VT-R	VI-G	29	0.49	12.0	12.9	0.18	10.0	48.5
	VI-G	VI-R	20	0.69	13.1	5.7	0.42	31.1	41.5
5	VI-G	VI-R	20	0.64	14.4	8.7	0.56	58.5	46.3
	FT-G	FI-R	35	0.82	19.6	3.5	0.21	25.7	85.0
	FI-R	FT-G	30	0.29	4.0	9.1	0.65	52.8	29.0
	VI-G	VI-R	20	0.77	12.9	3.9	0.62	70.9	43.1
6	FI-G	FT-R	12	0.81	14.7	3.5	0.59	82.0	52.5
	VI-G	VI-R	32	0.59	21.5	16.5	0.58	95.7	70.4
	VT-G	VI-R	51	0.40	15.9	24.6	0.12	11.6	90.3
	VI-R	VT-G	20	0.65	26.8	14.9	0.87	75.6	11.0
9	VI-G	VI-R	25	0.76	39.3	6.1	0.57	79.1	62.1
	VI-G	VI-R	38	0.67	20.2	10.1	0.58	51.1	37.5
	FT-G	FI-R	44	0.15	4.2	35.5	0.25	15.2	41.9
	FI-R	FT-G	28	0.48	9.9	10.5	0.68	80.8	39.5

each experimental condition are presented in Table 1. Terminal-link rate proportions were obtained by dividing the response rate on the left key by the sum of the response rates emitted on each key in the terminal link. The figures in the table are the arithmetic means of the terminal-link rate proportions obtained for the last five days of each experimental condition. Initial- and terminal-link response rates for the left and right keys were obtained by dividing the total number of responses emitted on a particular key by the number of minutes that key was illuminated during that component of the concurrent-chain schedule. The arithmetic means of initial- and terminal-link response rates for each key for the last five days of each experimental condition are presented.

Inspection of initial-link choice proportions during the VI 30-sec VI 30-sec terminal-link schedule conditions revealed a substantial initial-link response bias in favor of the left key. Since the schedules of reinforcement were identical, one would predict a choice proportion of 0.50 (Herrnstein, 1970). The deviations from 0.50 were averaged across the last five sessions of the two VI VI conditions (Birds 3, 5, and 6) and the single VI VI condition for Bird 9 to obtain an average response-bias measure for each bird. The following biases for the left

key were obtained: Bird 3, 0.10; Bird 5, 0.18; Bird 6, 0.20; Bird 9, 0.19.

Examination of choice proportions and terminal-link proportions across schedule conditions reveals that the source of this response bias was the key color associated with the terminal-link schedules. Data obtained from Bird 5 provide the clearest demonstration of the rather substantial effects of terminal-link color preference on initial-link responding. Bird 5 pecked the key that turned to green more often whether that key was associated with an FT 30-sec schedule (choice proportion = 0.82) or with an FI 30-sec schedule (choice proportion = 0.81). In both conditions, however, there was a substantial difference in terminal-link response rates (rate proportion FT, FI = 0.21; rate proportion FI, FT = 0.61), indicating that Bird 5 discriminated between response-dependent and response-independent schedules. In fact, all four birds maintained substantial differences in terminal-response rates associated with response-dependent and response-independent schedules. After the first exposure to response-independent schedules, a mean (for all birds) of only 22% of all terminal-link responses was emitted on the response-independent key. When the locations of the two terminal-link schedules were re-

versed, an average of only 26% of all terminal-link responses was emitted on the response-independent key. Although terminal-link schedules maintained substantial differences in response rates for Bird 3, initial-link choice proportions reflected preference for the VI schedule only when that schedule was operative on the left key. For Bird 9, initial-link choice proportions were also quite variable, although terminal-link responding indicated consistent discrimination between response-dependent and response-independent schedules.

Although the behavior of Birds 3, 5, and 9 indicated relative indifference between schedules of response-dependent and response-independent reinforcement, Bird 6 demonstrated a preference for VI-R schedules that seemed to outweigh a substantial preference for the green response key (bias for VI-G = 0.20). When the initially preferred green key was associated with the VI 30-sec schedule, the animal's choice proportion shifted to the key producing the VI 30-sec schedule and the associated red stimulus light. When identical VI 30-sec schedules were associated with red and green key illumination (*i.e.*, return to baseline), the relative distribution of Bird 6's initial-link responding shifted back to the key that produced the green stimulus.

Casual observations of the birds during the terminal-link schedules revealed marked differences in the location of pecks during the response-dependent and response-independent schedules. When the response-independent schedules were operative, the birds tended to peck in the air, on the walls of the chamber, or on the inoperative darkened key. The behavior in the response-independent schedules was similar to the "terminal" behavior of pigeons in the "superstition" experiments reported by Staddon and Simmelhaag (1971).

DISCUSSION

The results demonstrated that quail, with the exception of Bird 6, do not show a consistent preference between schedules that provide identical rates of response-dependent and response-independent reinforcement. In spite of the variability in initial-link preference, response-dependent and response-independent schedules maintain radically different rates of key pecking in the terminal link.

Killeen (1968) obtained very similar results when pigeons were exposed to terminal-link schedules that differed only in that one schedule arranged grain delivery for key pecks while the other schedule specifically reinforced any behavior *except* key pecks. In the present study, the response-independent schedule arranged reinforcement on a purely temporal basis irrespective of the organism's behavior.

Although the quail emitted very similar terminal-link rates of responding on identical VI 30-sec schedules, substantially different rates developed when response-independent schedules were operative on one terminal-link key. Concomitant with the decrement in response rate was the development of stereotypic behavior during the terminal-link response-independent schedules. These concomitant changes suggest that those key pecks that did occur on response-independent schedules are more correctly viewed as responses elicited by a particular rate of reinforcement (Killeen, 1968; Staddon and Simmelhaag, 1971) rather than as superstitious responses maintained by adventitious reinforcement (Neuringer, 1970). The specific form, pattern, or location of responses elicited by a schedule of reinforcement may be controlled by the specific contingency between responding and reinforcement. It is clear from the present results and from Killeen's (1968, 1971) results that constraints on the form of terminal-link behavior (*e.g.*, key pecking *versus* stereotypic behavior) do not influence preference in the same manner as constraints on the relative rate of terminal-link behavior (Fantino, 1968).

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