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Key-pecking maintained by negative reinforcement: multiple schedules[1]

Mantenimiento de Picoteo de Llave con Reforzamiento Negativo: Programas Múltiples[1]

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ABSTRACT

Key-pecking in pigeons was maintained through multiple schedules of negative reinforcement. Response-shock interval value was manipulated in one component in three different conditions: *a*) after response rates met the stability criterion on both componentes; *b*) on the second hour of alternate sessions; and *c*) every 30 min of a prolonged session. Only some instances of behavioral contrast and induction were observed in conditions *a* and *b* but contrast occurred systematically in condition *c*.

DESCRIPTORS: negative reinforcement, multiple schedules, stability, alternate sessions, prolonged sessions, schedule components, behavioral contrast, induction, pigeons.

RESUMEN

SeSe mantuvo el picoteo de pichones sobre una llave por medio de programas múltiples de reforzamiento negativo. Se manipuló el valor del intervalo respuesta-choque en un componente bajo tres condiciones diferentes: a) *después de que las tasas de respuesta alcanzaban el criterio de estabilidad en sus dos componentes;* b) *en la segunda hora de sesiones alternas, y* c) *cada* 30 *minutos durante una sesión prolongada. Se observaron sólo algunas instancias de contraste conductual*

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y de inducción en las condiciones a *y* b, *sin embargo, el contraste ocurrió sistemáticamente en la condición* c.

DESCRIPTORES: reforzamiento negativo, programas múltiples, estabilidad, sesiones alternas, sesiones prolongadas, componentes de programa, contraste conductual, inducción, pichones.

Pigeon's key pecking shaped and maintained through negative reinforcement was reported by Ferrari, Todorov and Graeff (1973), Todorov, Ferrari and Souza (1974), and Alves de Moraes and Todorov (1977). Rate of pecking was shown to be a function of the response shock (RS) interval, as with other operants (Smith and Keller, 1970; Hoffman and Fleishler, 1959; Macphail, 1968) and species (Sidman, 1953). The possibility of using the procedure in psychopharmacological experiments was also pointed out (Ferrari *et. al.*, 1973). The present experiment extended the investigation to multiple schedules of free operant avoidance.

METHOD

Subjects. Three adult, male domestic pigeons, from uncontrolled derivations of the species Columba *livia.* Caught wild, the subjects had been used previously in studies of key pecking maintained through negative reinforcement (Ferrari *et. al.*, 1973; Todorov *et. al.*, 1974).

Apparatus. A standard experimental chamber for operant conditioning with pigeons, described by Ferrari *et. al.*, (1973) was used. Shock was produced with a modified Foringer (USA) shock source, equiped with a 40-Kohm series resistor, and delivered through electrodes implanted around the pubis bones (Azrin, 1959). A pulse former controlled shock duration (35 msec); shock intensity (10 mA) was measured by using a 1-Kohm resistor in place of the birds. Standard electromechanical equipment was employed for automatic scheduling and recording of events.

Procedure. Phase I. Key pecking was maintained through a two-component multiple schedule of free operant avoidance of shock. Component duration was 3 min, with an 8-sec timeout separating components. Daily sessions ended after 40 components were scheduled, 20 signalled by green light on the response-key, 20 by a red light, in single alternation. Throughout the experiment and for all subjects, the red light was associated with RS interval of 17 sec, and shock-shock (SS) interval of 2 sec. When the response key was green, the SS interval was 2 sec also, but the RS interval was systematically varied. The sequences were 17, 5, 32, 9.5 and 52 sec for subject DL; 17, 9.5, 32 and 77 sec for subject CG; and 17 and 32 sec for P-52.

Phase IIa. Immediately after Phase I, subjects DL and P-52 were submitted to a procedure similar to that used in Phase I, except for the manipulation of the RS interval associated with the green light. Phase IIa consisted of 11 daily sessions with RS equal to 17 sec for both components during the first hour. On alternate days, and for the last half of the session, the RS interval associated with the green light was changed to 7, 32, 12, 52 and 77 sec, on sessions 2, 4, 6, 8 and 10, respectively. For the remaining (odd numbered) sessions, RS 17 sec was also scheduled for the second hour.

Phase IIb. Only subject CG was used in this phase. On the day after the last session in Phase I, this subject was exposed to a session with a duration of 6 hr and 13 min. For the first 103 min, RS length was 17 sec for both components. Thereafter, the RS interval length associated with the green light was changed every 30 min, in the following order: 5, 77, 7, 52, 9.5, 32, 12, 22 and 17 sec.

During Phase I, a minimum of 14 sessions was required before computation of stability in response rate was considered. The criterion required that, of the last six sessions in each condition, the average response rate from the first three sessions in a given component should not exceed the average from the last three sessions by more than 10% of the average rate for that component from all six sessions. As an additional precaution, response rates on both components should show no ascendant or descendant tendencies.

RESULTS

Phase I. Figure 1 shows that response rate on the variable (green) component was an inverse function of the RS interval length, varying from 20 resp/min in RS 5 sec to 3/resp/min in RS 52 sec, for subject DL. The data from subjects CG and P-52 replicate the tendency.

Response rate on the constant (red) component did not vary with changes in the variable (green) component for subjects CG and P-52. For subject DL, response rate on the constant component dropped from 12 to 6 resp/min when the RS value in the variable (green) component was changed from 17 to 5 sec. For subsequent changes in the variable component, response rate in the constant component varied between 7 and 9 resp/min.

Phase IIa. The data from subjects DL and P-52 in this phase, shown in Table 1, were similar to those from Phase I. Response rate in the variable component was an inverse function of the RS interval length, while in the constant component it did not vary systematically. Data from subject DL show a decreasing tendency in response rate over the eleven sessions, for both components. For subject P-52, response rate during the constant component remained between 4 and 5 resp/min throughout all changes in RS value in the variable component.

Phase IIb. A systematic effect of changes in the variable component over responding in the constant component can be seen in Figure 2. For subject CG, when the RS value in the variable component was varied each 30 min in a single session, changes in response rate on the constant component were

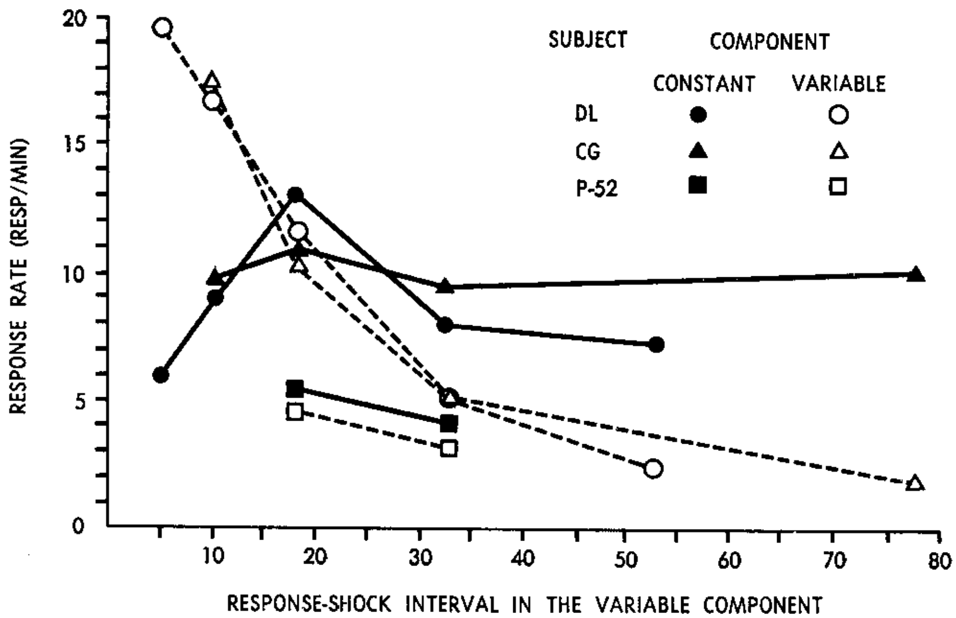

Fig. 1. Response rates on the constant (red) and the variable (green) components as functions of the RS interval in the variable component, in Phase I of the present experiment (steady state data).

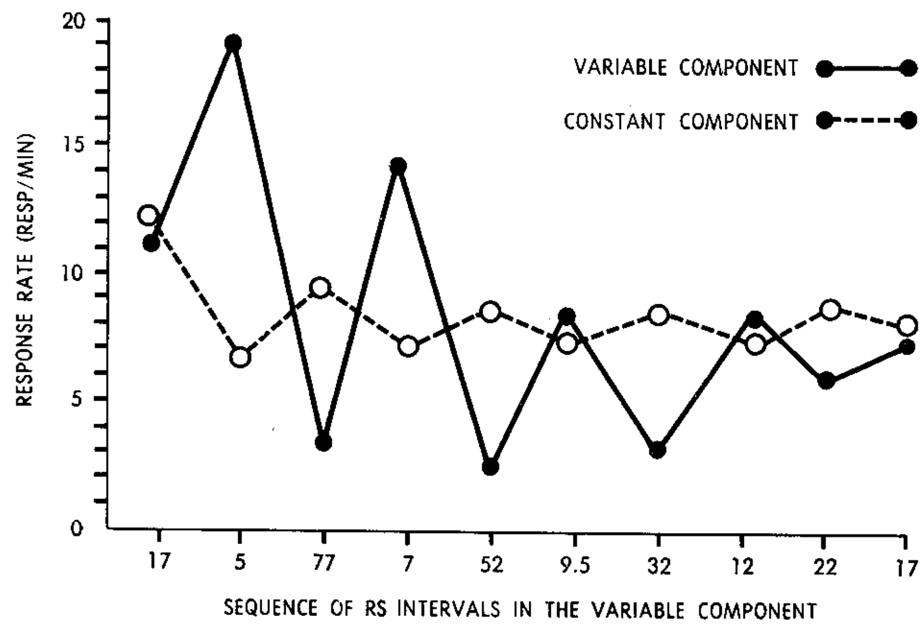

Fig. 2. Response rates on the constant (red) and the variable (green) components as functions of the RS interval in the variable component, in Phase IIb of the present experiment (extended session, subject CG).

always in a direction opposite to changes in rate of responding in the constant component. Response rate in the variable component was again an inverse function of RS value in that component.

TABLE 1

RS interval values and related response rates in each component of the multiple schedule for subjects DL and P-52, Phase IIa of the experiment.

Sessions	RS value (sec) red	RS value (sec) green	Resp/min red	Resp/min green
Subject DL				
1	17	17	10.7	10.8
2	17	7	8.8	19.1
3	17	17	8.2	10.3
4	17	32	10.8	6.3
5	17	17	9.9	9.4
6	17	12	7.9	9.4
7	17	17	11.2	11.2
8	17	52	7.5	2.7
9	17	17	9.6	8.1
10	17	77	3.8	1.5
11	17	17	5.6	5.5
Subject P-52				
1	17	17	5.0	4.2
2	17	7	4.9	6.8
3	17	17	4.9	4.7
4	17	32	4.8	2.6
5	17	17	4.6	3.6
6	17	17	4.3	3.5
7	17	12	5.0	5.0
8	17	17	5.1	4.8
9	17	52	4.3	4.0
10	17	17	5.2	4.2
11	17	77	4.1	1.6

Table 2 shows the empirical constants and coefficients of determination for the power function which describes the relationship between average inter-response time (IRT, the reciprocal of response rate) and RS interval length, for subjects DL and CG (Phase I of the present experimente), and for subjects on an unsignalled avoidance procedure (data reported by Todorov *et. al.,* 1974). The best fitting power function for each subject accounts for more than 90% of the variability in each case.

TABLE 2

Empirical constants and coefficients of determination for the power function which describes the relationship between average interresponse time (IRT) and RS interval length, for subjects in the present experiment and for subjects on an unsignalled avoidance procedure (data reported by Todorov *et. al.*, 1974).

Subjects	$IRT = a(RS)^b$		
	a	b	r^2
Present Experiment			
DL	0.52	0.92	0.93
CG	0.48	0.89	0.98
Todorov *et. al.* (1974)			
DL	0.31	1.18	0.99
RV	0.64	0.87	0.94
P-51	0.93	0.80	0.95

TABLE 3

Empirical constants and coefficients of determination for the power function which describes the relationship between the ratio of average IRT in the constant component (IRT_c) to average IRT in the variable component (IRT_v) and the ratio of RS lengths in those components (RS_c and RS_v).

Subjects	$IRT_c/IRT_v = a(RS_c/RS_v)^b$		
	a	b	r^2
DL	1.03	0.93	0.997
CG	0.95	1.11	0.999

The relationship between the ratio of average IRT in one component to average IRT in the other component, and the ratio of RS lengths is shown in Table 3. Data from subjects DL and CG (Phase I of the present experiment) show that average IRT ratios aproximately matched ratios of RS length. Both constants, *a* and *b*, are close to one for each subject.

DISCUSSION

The data from the present experiment extend previous findings concerning negative reinforcement of key pecking by pigeons (Alves de Moraes and Todorov, 1977; Ferrari *et. al.*, 1973; Foree and LoLordo, 1974; Lewis, Lewin, Stoyak, and Muehleisen, 1974; Todorov *et. al.*, 1974) to the control of different response rates by a multiple schedule of unsignalled avoidance. In the constant component, response rate was an inverse function of the RS interval length, while rate of responding in the constant component was not systematically affected. However, some instances where behavioral contrast or induction (Reynolds, 1961; Wertheim, 1965) were observed should be mentioned.

In Phase I, when the RS interval was varied from 17 to 5 sec in the variable component, response rate from subject DL in the constant component dropped to about half of its value in the baseline condition (behavioral contrast). In Phase IIa, the data from subject DL show behavioral induction when long RS intervals were used in the variable component. In Phase IIb, subject CG, behavioral contrast was clear for all manipulations of the RS interval. The changes in response rate in the constant component were always in the direction opposite to changes in rate of responding in the variable component.

These results indicate that when data from steady states are considered (Phase I), little or no interaction between conditions prevailing in each component of the multiple schedule is observed. Under this hypothesis of no interaction between components, the data from subject DL in a previous experiment (Todorov *et. al.*, 1974) would predict values for *a* and *b* in Table 3 very close to those which were obtained:

$$\begin{aligned} IRT_c/IRT_v &= 0.31(RS_c)^{1.18}/0.31(RS_v)^{1.8} \\ &= 1.00\ (RS_c/RS_v)^{1.18} \end{aligned}$$

This interpretation is consistent with the suggestion advanced by Todorov, Ferreira de Carvalho and Meira Menandro (1977) that respondig after prolonged exposure to the standard Sidman avoidance schedule can be described as a power function of the RS interval length, in a way similar to the relationship between responding and time requirements in temporal differentiation schedules (DeCasper and Zeiler, 1974; 1977; Catania, 1970). The present data suggest that interactions between components of the multiple schedule (when the standard Sidman schedule is utilized) occur only when changes in RS value are made before a steady state is reached, i, e., before the fixed temporal relation between responses and shocks assume total control over responding (Phases IIa and IIb). It is possible that on these transition phases interactions are similar to those observed when the avoidance schedule precludes the possibility of clear temporal discriminations, and shock-frequency reduction is the major variable responsible for avoidance behavior (e. g., de Villiers, 1972; 1974).

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