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A within-subject comparison of three response-elimination procedures in pigeons

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The present study compared the response-eliminating properties of omission training, extinction training, and a variable-time schedule within pigeons following training on a variable-interval schedule. The results indicated that both omission training and extinction training eliminated responding significantly more efficiently than did the variable-time schedule, although they did not differ significantly from each other in their response-eliminating effects. In addition, response rates during the variable-time schedule tended to increase above baseline (i.e., positive behavioral contrast) in all subjects by the end of training. Possible explanations for these effects were discussed.

Recently much research (Johnson, McGlynn, & Topping, 1973; Miller & LeBlanc, 1972; Reuter & LeBlanc, 1972; Topping & Ford, 1974; Topping & Larmi, 1973; Topping, Pickering, & Jackson, 1971, 1972; Uhl, 1973; Uhl & Garcia, 1969; Uhl & Homer, 1974; Uhl & Sherman, 1971; Zeiler, 1971) has been conducted in an attempt to assess the relative response-eliminating effects of various procedures. Most of these studies have focused on comparisons of omission training (OT), in which the subject is reinforced for omitting a previously reinforced response, and extinction training (ET), in which the subject is no longer reinforced.

It has also been demonstrated (cf. Halliday & Boakes, 1972; Lattal, 1972; Zeiler, 1968) that response-independent food presentations can successfully reduce responding. Zeiler introduced the terminology "fixed time" (FT) and "variable time" (VT) to describe response-independent schedules in which food presentations were delivered after periodic and aperiodic intervals of time, respectively.

Although VT reinforcement schedules have rarely been compared with OT or ET in terms of the ability to eliminate responding, two such studies have been conducted. In a study by Neuringer (1970), pigeons were reinforced for their first three keypeck responses. Subsequently, three of the birds were switched to a VT 30-sec schedule while three other subjects received ET. Results indicated that ET eliminated responding much more effectively than did VT. Similarly, Rescorla and Skucy (1969) trained rats to barpress on a variable-interval (VI) 2-min schedule before exposing them to a VT 2-min schedule or ET. Their findings also revealed that ET eliminated responding significantly more efficiently than did VT.

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Primarily because of the paucity of data comparing VT with other response-elimination techniques, the present experiment was designed to compare OT, ET, and VT. In addition, the present study was designed to gain information on the relative response-eliminating effectiveness of these three procedures in individual organisms. That is, OT, ET, and VT were compared within pigeons via the use (cf. Topping & Ford, 1974; Zeiler, 1971) of a multiple schedule in which a different exteroceptive stimulus was correlated with each of the three procedures.

METHOD

Subjects

Six experimentally naive adult male White Carneaux pigeons, obtained from the Palmetto Pigeon Plant, Sumter, South Carolina, were maintained at approximately 75% of their free-feeding weights. All subjects were individually housed and had free access to water and grit.

Apparatus

A standard three-key pigeon chamber, 49.5 x 35.5 x 35.5 cm, was located within a sound-attenuating ventilated cubicle. The 2.5-cm-diam response keys were centered 25.4 cm from the floor and 10 cm apart on the display panel. Only the center key was employed in the present study, and the remaining keys were covered by metal plates. A minimum force of .15 N was required to operate the key, and responses produced auditory feedback. The key was transilluminated by either white, red, blue, or green light; and the experimental chamber was diffusely lighted from above by a 7.5-W light bulb. A 5-cm-square opening, centered 7.6 cm from the bottom of the display panel, functioned as the food aperature. Food presentations consisted of a 3.5-sec access to the illuminated aperture, which contained Purina Hen Chow. A white-noise generator operated to mask extraneous noises, and a blower regulated the temperature inside the chamber. A system of electromechanical programming equipment was located in a separate room and was used to control the apparatus and record the data.

Procedure

As soon as the pigeons were eating reliably from the food hopper, which was delivered according to a VT 30-sec schedule, they were autoshaped to peck a white key (Brown & Jenkins,

Table 1
Summary of Individual Data

Subject Number	Color	Baseline Response Rate (R/min)	Procedure	Transformed Response Rates During Response Elimination 1	2	3	4	5	6	7
	R	93.22	OT	1.02	.65	.30	.05	.00	.00	.00
2	G	84.00	ET	1.35	.74	.49	.09	.03	.13	.19
	B	94.32	VT	.59	1.03	.85	.47	.23	.81	1.10
	R	80.67	OT	.98	.77	.35	.15	.04	.02	.07
4	B	82.39	ET	1.00	.95	.26	.04	.00	.00	.02
	G	66.38	VT	1.08	1.62	1.84	1.78	1.80	2.14	2.06
	B	105.83	OT	1.06	.63	.31	.04	.07	.09	.02
7	G	103.94	ET	.87	.55	.15	.03	.02	.00	.00
	R	108.71	VT	.99	1.35	1.29	1.06	1.34	1.35	1.04
	G	145.08	OT	1.25	.84	.12	.06	.16	.08	.06
11	B	147.29	ET	1.22	.95	.33	.06	.19	.16	.01
	R	128.33	VT	1.08	2.05	1.74	2.02	2.01	2.04	2.06
	G	136.73	OT	1.05	.92	.23	.16	.11	.30	.07
12	R	121.17	ET	1.21	.84	.30	.19	.11	.05	.05
	B	140.00	VT	.80	1.03	.35	.83	1.24	1.17	1.18
	B	58.17	OT	1.03	.89	1.31	.73	.71	.43	.31
14	R	55.92	ET	1.01	.86	.90	.65	.39	.31	.05
	G	55.72	VT	.81	1.53	2.18	2.31	1.94	1.94	1.72

1968). Once pecking commenced, the response key was constantly transilluminated by white light, and the birds were gradually switched from a continuous reinforcement schedule to a VI 30-sec schedule. Response rates on the VI 30-sec schedule were stabilized during the next 11 daily sessions.

Following stabilized responding on the VI 30-sec schedule, the subjects were exposed to alternating sequences of red, blue, and green key colors. These stimuli alternated randomly every 2 min with the restriction that the same color could not occur more than twice in succession. A 10-sec blackout separated the presentation of any two successive stimuli, and the VI 30-sec schedule was in effect during all stimuli. Each colored stimulus occurred four times during each daily session. Response rates to the red, blue, and green colors were stabilized over the course of the next 16 sessions.

Subsequent to response stabilization on the red, blue, and green colors, the response elimination phase was initiated. For each bird, each of the three colors was associated with one of the three response-elimination procedures (OT, ET, and VT), and the relationship between key color and response-elimination procedure was completely counterbalanced across subjects. During OT, each response postponed delivery of the food for 20 sec (response-reinforcement interval), and the food was presented every 20 sec if no responses were emitted (reinforcement-reinforcement interval). In ET, grain presentations were no longer available. On the VT schedule, food was delivered on the average of every 20 sec, regardless of responding. Each colored stimulus was presented four times each day; in addition, the restriction on the order of presentation of the stimuli and the 10-sec blackout between successive stimuli remained in effect. The response-elimination sessions were conducted daily for 7 days.

RESULTS AND DISCUSSION

Table 1 presents individual data in terms of the baseline response rate (mean of the last three VI sessions on the multiple schedule) for each color, the response-elimination procedure associated with each color, and the transformed response rate during each day of response elimination for each procedure (see Table 2 for the mean daily response rates associated with each procedure during response elimination). The response rates during response elimination were transformed by the shape-function technique suggested by Anderson (1963). This transformation treats each subject's daily response rate as a proportion of his mean baseline response rate. Thus, a transformed value of 1.00 indicates responding at the baseline rate, a transformed value of .00 indicates little or no responding, and a transformed value greater than 1.00 indicates an increase in response rate as compared to the baseline rate.

A 3 (procedures) by 7 (days) randomized block factorial analysis of variance (Kirk, 1968) was performed on the response-elimination data in Table 1. This analysis yielded significant main effects for subjects ($F = 11.00$, $df = 5/100$, $p < .001$), indicating that the pigeons exhibited different mean relative response rates during response elimination, as well as for procedures ($F = 146.44$, $df = 2/100$, $p < .001$) and days ($F = 8.33$, $df = 6/100$, $p < .001$), the latter two significant effects indicating that OT, ET, and VT differed in their relative effectiveness of response elimination and that different relative response rates were maintained on the days of

Table 2
Mean Transformed Response Rates for OT, ET, and VT During Response Elimination

Procedure	Days 1	2	3	4	5	6	7
OT	1.07	.78	.44	.20	.18	.15	.09
ET	1.11	.82	.41	.18	.12	.11	.05
VT	.89	1.44	1.38	1.41	1.43	1.58	1.53

response elimination, respectively. In addition, a significant Procedures by Days interaction was observed ($F = 7.78$, $df = 12/100$, $p < .001$), indicating that OT, ET, and VT had differential effects on the relative response rates during the 7 days of response elimination.

Tests of simple main effects were conducted to analyze the Procedures by Days interaction, and results of this analysis revealed that the relative response-eliminating effects of the three procedures differed significantly ($p < 001$) on Days 2-7. Newman-Keuls tests indicated that OT and ET did not differ significantly from each other in their response-eliminating effects on Days 2-7, although both eliminated responding significantly ($p < .01$) more efficiently than did VT on each of these days.

The present finding that ET eliminated responding significantly more efficiently than did VT is consistent with the results of previous studies (Neuringer, 1970; Rescorla & Skucy, 1969). However, the similar response-eliminating effects of OT and ET in the present experiment are inconsistent with the results of other investigations (Johnson et al., 1973; Miller & LeBlanc, 1972; Pickering & Topping, 1974; Topping & Ford, 1974; Topping & Larmi, 1973; Topping et al., 1971, 1972; Zeiler, 1971), which have found that OT decreased responding more effectively than did ET.

In attempting to account for the equivalent effects produced by OT and ET in the present study, the most tenable explanation to us involves the interval values employed during OT. That is, we have recently obtained results in our laboratory which suggest that OT eliminates responding faster than does ET when relatively short interval values (e.g., 5-10 sec) are used in OT; however, when long intervals (e.g., 60 sec) are employed in OT, the effects of OT and ET tend to be similar. Although Topping & Larmi (1973) showed that OT reduced responding more rapidly than did ET when interval values of 20 sec were used in OT (as in the present experiment), the Topping and Larmi study employed a between-subjects design. It is possible that the nature of the design interacts with the interval values in OT in determining the relative response-eliminating effects of OT and ET. In a previous experiment almost identical to the present one, Topping and Ford (1974) employed a within-subject design and found that OT eliminated responding more efficiently than did ET when short intervals (i.e., 6 sec) were used in OT.

Another interesting finding was that VT failed to produce any permanent reductions in responding in any of the birds in the present investigation. All of the subjects exhibited response rates above their baseline rates on the final day of response elimination, and three of the pigeons (Nos. 4, 11, and 14) showed marked positive behavioral contrast (cf. Reynolds, 1961). The failure of VT to reduce responding, and especially the drastic elevation in response rate by three of the birds, suggests that keypecking was superstitiously conditioned during VT. Since the pigeons received frequent presentations of the grain during VT and were responding at high rates prior to the initiation of VT (see Table 1), it is quite possible that the VT 20-sec schedule functioned like a VI 20-sec schedule (i.e., the subjects were probably pecking the response key just prior to the food presentations). If in fact the VT schedule did function like a VI schedule, it is understandable that keypecking persisted and that the response rates did not show any sustained reductions during VT in any of the birds. Furthermore, if the VT schedule operated like a VI schedule, then the observed increases in responding above baseline during VT would be expected (cf. Topping & Ford, 1974). That is, Topping and Ford used VI, OT, and ET schedules during three different components of a multiple schedule and observed positive behavioral contrast during the VI component in each of three pigeons.

Because of the possible explanations of the VT effects in the present experiment, more research needs to be conducted using this particular response-elimination procedure. It might be interesting to compare OT, ET, a VT schedule in which responses are of no consequence, and a VT schedule (cf. Rescorla & Skucy, 1969) in which food presentations are delayed if a response occurs within a certain time interval (e.g., 3-5 sec) prior to the scheduled food presentation.

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