Efficiency of DRL responding as a function of response effort*

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The present study examined the relationship between DRL efficiency and response effort. One group of pigeons was required to emit a keypeck of at least 45 g force to operate the response key, while a second group had to respond with a minimum force of 15 g. Results indicated that the 45-g Ss were significantly more efficient than the 15-g Ss, although this finding was not due to the former Ss' ability to inhibit responding.

Kramer & Rilling's (1970) review of differential reinforcement of low rate (DRL) schedules indicates that the performance of pigeons on this schedule is markedly inferior to that of other species. In terms of the percentage of reinforced responses, i.e., efficiency ratios, Kramer & Rilling (1969) found that pigeons were approximately 2% efficient on a DRL 20-sec schedule. Similarly, Holz & Azrin (1963), Holz, Azrin, & Ulrich (1963), and Staddon (1965) have observed less than 2% efficiency on DRL 30-sec schedules.

Recently Hemmes (1970) has concluded that the pigeon's inefficiency on DRL schedules is dependent on the nature of the operant response. Noting that all previous studies with pigeons had employed the keypecking response, Hemmes used a treadle response and witnessed between 20% and 25% efficiency on DRL 20-sec schedules.

Utilizing Hemmes's (1970) conclusion, the present experiment was designed to further investigate nontemporal determinants of DRL performance in pigeons. It was noted that all previous work on keypecking had used situations in which Ss had to respond with a minimum of 12-16 g force to operate the key. It was hypothesized that requiring Ss to respond with a much greater force to operate the key would result in greater efficiency since Ss would probably be less likely to emit effective responses.

SUBJECTS

Six experimentally naive male White King pigeons, individually housed, served as Ss and were maintained at approximately 75% of their free-feeding weights for a period extending from 1 week prior to the experiment through the duration of the experiment.

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APPARATUS

A standard three-key pigeon chamber, 19½ x 14 x 14 in., was located within a sound-attenuating ventilated cubicle. The 1-in.-diam keys were centered, 10 in. from the floor and 4 in. apart, on a metal panel separating the S's chamber from the area containing the stimulus- and food-presenting mechanisms. Only the center key was employed in the present experiment, and the other keys were covered by metal plates. A minimum force of either 15 or 45 g was required to operate the key, and responses produced auditory feedback. A one-plane readout allowed white light to be projected on the response key, and the experimental chamber was diffusely lighted from above by two small lightbulbs. Three inches from the bottom of the intelligence panel was centered a 2 x 2 in. opening, through which a solenoid-operated grain hopper could be presented. Reinforcement consisted of a 5-sec access to the illuminated grain hopper. A white-noise generator functioned throughout the experiment to mask extraneous noises and a blower regulated the temperature inside the chamber. A system of automatic controlling and recording equipment allowed the data to be collected in a separate room.

PROCEDURE

Following reduction to their respective 75% weights, Ss received 2 days of magazine training, during which 40 reinforcements were given daily according to a noncontingent variable-interval (VI) 20-sec schedule. On the next 3 days Ss were shaped (CRF) to peck the response key and allowed to make 40 continuously reinforced responses daily. To operate the key, half of the Ss (Group 15) were required to emit a response of at least 15 g force, while the remaining Ss (Group 45) had to give a response of at least 45 g force. These conditions held throughout the experiment. Ss were then switched to a DRL 4-sec schedule, and the DRL value was increased daily in 1-sec steps until a

DRL 20-sec schedule was obtained. All sessions with the DRL schedules were terminated after 40 reinforcements or 90 min, whichever occurred first. All Ss received a total of 30 daily sessions on the DRL 20-sec schedule.

RESULTS AND DISCUSSION

The mean response rate and percentage of reinforced responses during the final 4 days on the DRL 20-sec schedule are presented for each S in Table 1.

A t test was performed on the percentage of reinforced responses data of Table 1 in order to compare the two groups. Results of this analysis yielded a significant difference ($t = 10.96$, $df = 4$, $p < .01$), indicating that Group 45 was more efficient in responding than Group 15. An additional t test was conducted on the response rate data and indicated that Group 45 was responding at a significantly lower rate ($t = 3.64$, $df = 4$, $p < .05$) than Group 15.

It is also important to note that the percentages of reinforced responses for Ss in Group 15 were very much in agreement with findings from previous studies employing similar DRL conditions (Holz & Azrin, 1963; Holz, Azrin, & Ulrich, 1963; Kramer & Rilling, 1969; Staddon, 1965).

The present results support Hemmes's (1970) conclusion that DRL performance is a function of the nature of the operant and emphasize the importance of nontemporal factors on spaced-responding schedules. Obviously, having to keypeck with at least a 45-g force is quite different from responding with a minimum force of 15 g. Visual observation of Group 45 indicated that the superior performance of these Ss was *not* attributable to their ability to suppress keypecking during the required temporal intervals. Instead, these Ss typically hovered near the response key and emitted numerous noncriterion keypecks, i.e., pecks of less than 45 g force, or head movements in the direction of the key. These noncriterion responses and head movements functioned to mediate the 20-sec interval in a fashion analogous to superstitious behavior. These mediating responses obviously provided less time for effective

Table 1
Terminal DRL Responding

	S	Response Rate	Percentage of Reinforced Responses
Group 15	1	8.41/min	0.92
	2	10.67	0.68
	3	10.92	1.03
Group 45	4	6.94	21.44
	5	7.33	16.72
	6	6.13	22.37

keypecks and could explain the lowered response rates and subsequent more efficient DRL responding in Group 45.

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