*THE OPERANT CONDITIONING OF RESPONSE VARIABILITY:
FREE-OPERANT VERSUS DISCRETE-RESPONSE PROCEDURES*

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The operant conditioning of response variability under free-operant and discrete-response procedures was investigated. Two pigeons received food only if their pattern of four pecks on two response keys differed from the patterns emitted on the two immediately preceding trials. Under the free-operant procedure, the keys remained illuminated and operative throughout each trial. There was little variability in the response patterns that resulted, and the pigeons received fewer than one third of the available reinforcers. Under the discrete-response procedure, a brief timeout period followed each response. Variability increased under this procedure, and the pigeons obtained three fourths of the available reinforcers. Previous successes and failures to produce response variability may have been due to the use or failure to use, respectively, a discrete-response procedure. Respondent effects inherent in the free-operant procedure may encourage the development of response stereotypy and, in turn, prevent the development of response variability.

Key words: response stereotypy, response variability, free-operant procedure, discrete-response procedure, key peck, pigeons

Schwartz (1980) made food deliveries contingent upon pigeons' emitting four responses in any sequence on each of two keys. A fifth response on either key ended a given trial without reinforcement. Although all possible combinations of four left and four right responses were reinforced, most pigeons developed stereotyped response sequences in which one particular sequence became dominant. In a subsequent experiment, Schwartz (1982) attempted to prevent the development of response stereotypy by making reinforcement dependent on a response sequence differing from the one emitted on the previous trial. The pigeons continued to emit stereotypic response sequences under this contingency even though this sharply reduced the obtained percentage of available reinforcers. Schwartz concluded that response variability could not be increased by contingent reinforcement, thus implying that variability is not a reinforceable dimension of behavior.

In contrast, Page and Neuringer (1985) succeeded in increasing response variability by making reinforcement dependent on variable response sequences. They argued that the failure of Schwartz's procedures to produce variability was an artifact of the four-responses-per-key constraint. Page and Neuringer

pointed out that a random generator under the same constraint obtained 29% of the available simulated reinforcers, which was less than the 40% figure obtained by Schwartz. They demonstrated that elimination of the constraint enabled pigeons to obtain over 90% of the available reinforcers. In subsequent experiments, pigeons generated highly variable response sequences under a variety of conditions, and obtained about two thirds of the available reinforcers even when a given response sequence was reinforced only if it differed from those emitted on the previous 50 trials. Page and Neuringer concluded that response variability is a reinforceable dimension of behavior.

Although Page and Neuringer (1985) provided a reasonable explanation for the low percentage of reinforcement obtained under the four-responses-per-key constraint imposed by Schwartz, it is not clear that the elimination of the constraint was the only variable responsible for the demonstration that response variability can be reinforced. In fact, in the one case (Experiment 2) in which they compared the constraint versus no-constraint conditions under the procedure followed by Schwartz, they found no significant difference in variability under the two conditions. This result may have been due to the contingency requiring only that a response sequence differ from the immediately preceding one. Thus little variability was required to obtain a high

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percentage of the available reinforcers. However, in addition, Experiment 2 was the only one of the series by Page and Neuringer in which a free-operant procedure was used (i.e., response keys continuously available). In all of their other experiments, in which response variability was increased, a discrete-response procedure was used that involved a brief timeout (keylights off) after each response. Thus, it is possible that these brief timeouts played a role in producing response variability both within and between trials.

The present experiment examined the operant conditioning of response variability under free-operant and discrete-response procedures. Pigeons first were exposed to baseline conditions in which any combination of four responses on either of two keys produced reinforcement. Once responding stabilized, reinforcement was made dependent on a response sequence differing from the sequences emitted on two immediately preceding trials (Lag 2). These conditions were in effect under either a free-operant procedure in which the response keys were continuously illuminated and operative (except during reinforcement or intertrial intervals), or a discrete-response procedure in which a 2-s timeout followed each response.

METHOD

Subjects

Two naive white Carneaux pigeons served as subjects. Each was maintained at 80% of its free-feeding weight throughout the experiment.

Apparatus

A three-key Lehigh Valley (Model 1519) pigeon chamber was used. The response keys, arranged in a row 25 cm above the grid floor, were 8.3 cm apart, center-to-center. The center key was inoperative. The left and right keys were transilluminated white by IEE projectors. A houselight above the center key illuminated the chamber.

Reinforcement was 4.5-s access to mixed grain delivered via a lighted hopper through a 5.7- by 5-cm opening located 15 cm below the center key. The keylights and houselight were turned off during reinforcement. Electromechanical equipment in an adjacent room controlled all events except when the pigeons

did not meet the contingency in the lag condition (see Procedure). In this case, the experimenter depressed a hand switch that prevented reinforcement.

Procedure

Sessions were conducted 5 to 7 days per week. Pecking the left (Bird 475) or right (Bird 470) response key first was shaped, and then, on alternate days, the response requirements were increased to a fixed-ratio four (FR 4) on each key. Two sessions then occurred in which both keys were available continuously and a total of four responses on either or both keys produced the reinforcer. Finally, two additional sessions occurred following the same procedure except that a 2-s delay, during which the keylights and houselight were turned off, followed the fourth response and preceded food delivery. The 2-s delay preceded food delivery under all conditions of the experiment, which provided time for the experimenter to assess, during the lag condition, whether a given response sequence differed from the sequences on the previous two trials. The apparatus delivered food after the delay unless the experimenter depressed a hand switch, which instead imposed an additional 3.5-s timeout after which a new trial was begun. During each of the last four shaping sessions, 50 reinforcers were given.

Baseline. Each pigeon was exposed to two baseline conditions, one involving a free-operant procedure and the other a discrete-response procedure. During the free-operant procedure, the keylights were illuminated and operative throughout each trial. Any combination of four responses on either or both keys produced, first, a 2-s timeout during which the keylights and houselight were turned off, followed by reinforcement. In the discrete-response procedure, a 2-s timeout during which the keylights and houselight were turned off followed each response. Responses during the timeout were recorded but had no programmed consequences.

Bird 475 received 10 baseline sessions under the free-operant procedure, followed by 10 sessions under the discrete-response procedure. The order was reversed for Bird 470. During each session, 50 reinforcers were delivered.

Lag 2. Following the two baseline conditions, each pigeon was exposed to the lag condition in which reinforcement occurred only if

Fig. 1. The percentage of available reinforcers obtained during the lag condition under the free-operant and discrete-response procedures.

the response sequence emitted on a given trial was different from the sequences emitted on the two immediately preceding trials. If the contingency was not satisfied, the experimenter depressed a hand switch during the 2-s timeout following the fourth response, which both prevented the delivery of reinforcement and imposed an additional 3.5-s timeout in which the keylights and houselight remained darkened. Each pigeon received 15 sessions of the lag condition under the free-operant procedure, 15 sessions under the discrete-response procedure, 15 additional sessions under the free-operant procedure, and, finally, 15 additional sessions under the discrete-response procedure. Each session was made up of 50 trials.

RESULTS

The percentage of available reinforcers obtained by each pigeon under the free-operant and discrete-response procedures during the lag condition is shown in Figure 1. Introduction of the discrete-response procedure immediately and substantially increased the percentage of reinforcers obtained by both birds,

followed by an equally immediate and substantial decrease upon reinstatement of the free-operant procedure. Overall, the average percentages of reinforcers obtained under the free-operant and discrete-response procedures were, respectively, 32 and 80 for Bird 475 and 28 and 71 for Bird 470.

Figure 2 shows the distribution of the 16 available response sequences under the baseline and lag conditions for both the free-operant and discrete-response procedures. During baseline, Bird 475 engaged in a LLLL response sequence 100% of the time under the free-operant procedure and 98% of the time under the discrete-response procedure. Bird 470 showed similar stereotypy under the free-operant procedure (99% LLLL) but its behavior varied somewhat under the discrete-response procedure (78% LLLL, 22% RRRR).

The introduction of the lag condition had qualitatively different effects on variability under the free-operant and discrete-response procedures. Under the free-operant procedure, the response sequences of both pigeons consisted almost exclusively of LLLL and RRRR sequences. The very few other sequences that were emitted typically occurred early in the

ture, even in the absence of the constraint, produced highly stereotyped responding.

Due to a number of procedural differences between my experiment and the series of experiments conducted by Page and Neuringer (1985), it is not possible to determine the relative contributions of the discrete-response procedure and the elimination of the response constraint to the high levels of variability found in both instances. Although little variability was produced in the present experiment under the free-operant procedure even without a response constraint, it is likely that the effect was influenced by a number of variables, including the number of responses required for reinforcement, lag value, and the length of the timeout.

One can only speculate at this point about why the discrete-response procedure has such powerful effects on variability. The immediate increase in response variability when the discrete-response procedure was introduced, as well as the immediate decrease upon its removal, suggests the operation of a variable inherent in the free-operant procedure that encourages response stereotypy, or conversely, prevents variability. This variable may be respondent in nature and, like the demonstration by Williams and Williams (1969) that auto-shaped pecking persists even when it prevents the delivery of food, the pigeons continued to peck the initially chosen response key. The imposition of the timeout after each response may have removed the eliciting stimulus,

thereby enabling responding to shift from one key to the other.

Free-operant procedures may contain strong respondent contingencies that interact with and may even override operant effects (Schwartz, 1984, pp. 328–366). On the other hand, discrete-response procedures may eliminate at least some of these respondent contingencies and thus reveal more general properties of operant behavior. If so, a comparison of various behavioral processes under free-operant and discrete-response procedures may provide a means for investigating respondent-operant interactions as well as separating respondent from operant effects.

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