CHANGEOVER DELAY EFFECTS ON TOPOGRAPHICALLY TAGGED DISCRIMINATIVE BEHAVIOR

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In a multiple variable-interval extinction schedule, pigeons' responses on an operant key were differentially reinforced in the presence of discriminative stimuli located on a signal key. Changeover delays of zero, one, two, or four seconds specified the time following a signal-key response within which an operant-key response was not reinforced. Systematic reduction of signal-key response rates with increasing changeover-delay duration indicated that signal-key responding was largely maintained by reinforcement of adventitious signal-key/operant-key response chains.

Key words: discrimination, signal-key, changeover delay, multiple schedules, key peck, pigeon

Discriminative behavior is thought to be governed by differential stimulus-reinforcer and response-reinforcer relations (Schwartz & Gamzu, 1977). Their effects have been identified in a procedure where discriminative stimuli are removed from the manipulandum or "operant key" and are displayed on the "signal key" (Keller, 1974). The effects of the two contingency relations are thus separated by topographically tagging different responses to the contingencies determining them (Catania, 1973). Responses on the operant key where the stimulus is constant are determined by a differential response-reinforcer or operant contingency. That is, operant-key responding is maintained by its consequences, typically reinforcement in one stimulus condition (S1) and extinction in the other (S2). Responses directed towards the discriminative stimuli located on the signal key have no programmed consequences and are therefore considered to be elicited by the stimulus-reinforcer or Pavlovian contingency. That is, S1 is correlated with high probability food presentation inde-

pendently of signal-key responding and S2 with absence of food (Schwartz, 1978).

In the previous studies to date (Keller, 1974; Schwartz, 1975, 1978; Schwartz, Hamilton, & Silberberg, 1975; Spealman, 1976; Spealman, Katz, & Witken, 1978; White & Braustein, 1979; White & Thomas, 1979; Woodruff, 1979; Williams & Heyneman, 1981), pigeons' operant-key response rates are high in S1 and low in S2, typical of the response differential defining discriminative behavior. In addition, stimulus-directed signal-key responding also has a high probability in S1 and low in S2. Signal-key responding in the two-key procedure is thought to resemble autoshaped responding in response-independent schedules of reinforcement (Gamzu & Schwartz, 1973; Schwartz, 1978; Schwartz & Gamzu, 1977).

The strength of the two-key procedure relies on the separation of operant and Pavlovian influences on the topographically tagged responding. Reinforcement of adventitious response chains constitutes a mechanism whereby the contingencies may interact (Schwartz, Hamilton, & Silberberg, 1975; Spealman, 1976). Such chains have been regarded as a methodological problem and have been minimized by arranging a changeover delay (COD). The COD prevents reinforcement of an operant-key response for a specified period after a signal-key response, although unreinforced responses can occur within the COD interval. In effect, the COD minimizes

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the effect of the operant contingency on signal-key responding (Catania, 1966).

Spealman (1976, p. 90) examined the possibility of adventitious chaining by adding a 1-sec COD to his two-key procedure. He concluded that the COD "did not have a deleterious effect" on signal-key responding. In fact, addition of the COD led to an average 17% reduction in signal-key response rates. In Schwartz, Hamilton, and Silberberg's (1975) study, mean signal-key rates were at most 1 response per minute when a 2-sec COD was a standard aspect of their procedure. And in White and Braunstein (1979) signal-key rates averaged 3.6 responses per minute with a 1-sec COD. However, signal-key rates were overall higher in studies where there was no COD. Without a COD, Schwartz (1975, Condition F2) reported signal-key rates averaging about 14 responses per minute, and in Schwartz's (1978) study, rates in the first 5-sec of S1 were greater than 20 responses per minute. Generally the data suggest a deleterious effect of COD on signal-key response rates. But, in view of large differences in individual performance, cross-experiment comparison does not unequivocally establish a COD effect. Williams and Heyneman (1981) compared signal-key response rates in the two-key procedure with and without a 2-sec COD and reported a reduction in signal-key rates under the COD. For three of four birds, however, the absolute difference in rates with and without the COD was small, owing to relatively low rates of signal-key responding without the COD. The present study confirmed and extended Williams and Heyneman's (1981) finding by showing a systematic reduction in signal-key response rates as COD duration increased over four values.

METHOD

Subjects

Four experimentally naive adult feral pigeons, obtained from a local supplier, were maintained at 75% (± 10 g) of their free-feeding weights. The birds were housed in a colony room on a 16-hr light/8-hr dark cycle and had continuous access to grit and water. Prescribed weights were maintained by supplementary feeding.

Apparatus

A sound-attenuating experimental chamber with internal dimensions of 33 by 33 by 29 cm

contained a three-key intelligence panel. General illumination was furnished by a single GE 1829 lamp located behind a 4 by 33 cm strip of diffusing white Plexiglas mounted across the top of the intelligence panel. An exhaust fan provided general masking noise. The translucent response keys measured 2 cm in diameter and were located 20 cm above the wire-mesh floor and 9 cm apart, center to center. Industrial Electronics Engineers in-line displays were mounted behind each key. Only the left and center keys were used: the right key was taped over. A single .2 cm wide white-on-black vertical line was always displayed on the left key which served as the operant key. The center key (signal key) could be illuminated by stimuli with dominant wavelengths of 490 nm or 555 nm, produced by Kodak Wratten Filters 75 and 99. Closure of microswitches mounted behind the operant and signal keys each required a minimum force of .1 N. Experimental events were controlled and recorded by electro-mechanical relay apparatus located in an adjacent room.

Procedure

In Session 1, responding on the operant key was shaped according to the method of successive approximations. During Sessions 1 and 2 the signal-key was taped over and operant-key responding was reinforced on a schedule that progressively increased the average interreinforcement interval from continuous reinforcement to 30 sec. Each session was terminated when 50 reinforcements (3-sec access to grain) were obtained. Each session thereafter comprised discrimination training (mult VI 30-sec EXT) in which 25, 30-sec presentations of the 555 nm-stimulus on the signal key were quasi-randomly alternated with 25, 30-sec presentations of the 490-nm stimulus, also on the signal key. Operant-key responding in the presence of 555 nm (S1) was reinforced at intervals averaging 30 sec (VI 30-sec) and operant-key responding in 490 nm (S2) was never reinforced (EXT). There were no blackouts between stimulus periods. Neither key was illuminated during reinforcement. Reinforcements scheduled but not obtained at the end of an S1 component were cancelled.

For Sessions 3 through 22 there was no changeover delay (COD) for all birds. Following Session 22, CODs of 1, 2, or 4 sec were arranged. Each COD was in effect for 13 sessions.

The orders of COD conditions were randomly determined for each bird. The respective orders of COD conditions for Birds B1, B2, B3, and B4 were: 0,1,2,4; 0,1,4,2; 0,4,1,2; 0,2,4,1. The COD was timed from each signal-key response. Any operant-key response occurring within the COD could not be reinforced. If reinforcement was set up during the COD the first operant-key response following termination of the COD was reinforced. Any signal-key response during the COD reset the COD timer.

For each bird in each condition, the rates of operant-key responding in S1 as a percentage of operant-key responding in both S1 and S2 (discrimination ratio) for each of the last three sessions per condition were always within 10% of the mean discrimination ratio for the three sessions. Obtained reinforcement rates in each

session did not deviate from programmed frequencies with two exceptions: both in the first sessions of the 4-sec COD condition, one for B2 and the other for B3.

RESULTS

Figure 1 shows the rates of operant-key and signal-key responding in S1 and S2 averaged over the last three days of each COD condition, plotted as a function of COD duration. Neither operant-key discrimination ratios nor reinforcement rates changed appreciably across the different COD conditions. It may be assumed therefore that the programmed operant-key contingency was unaffected by the COD. Figure 1 shows that signal-key responding in S1 decreased systematically as COD duration increased. Under 0-sec COD, signal-key rates in S1 ranged from 15.4 to 91.5 responses per minute, and under 4-sec COD the rates ranged from 5.0 to 9.3 responses per minute. The reductions in S1 signal-key responding under 4-sec COD as a proportion of the responding under 0-sec COD were .93, .89, .84, and .64 for each of the four birds respectively. For Birds B1, B2, and B4, signal-key rates in S1 were higher than those in S2, typical of previous data, but in the anomalous instance of B3, signal-key rates were higher in S2. The decrease in S1 signal-key responding with increasing COD was also reflected in a decrease in the ratios of signal-key responses to operant-key response, showing that the reduction in signal-key behavior with increasing COD was not merely the result of an overall reduction in responding.

Operant-key response rates (Figure 1) were higher in S1 than in S2, characteristic of the usual differential seen in multiple VI-EXT schedules. Operant-key rates did not change reliably with COD duration.

Strip chart (Rustrak) records were obtained for the last session of each COD condition. Figure 2 shows the records for each bird for S1 Components 27 and 28, and 46 and 47, chosen arbitrarily from the 25 S1 components. The data from these components were typical of the data from the other S1 components during the last session per condition. The first channel shows operant-key responses, the second signal-key responses, and the third (3-sec) reinforcers. Records for the pairs of components 27, 28 and 46, 47 were presented together because they

Fig. 1. Operant-key and signal-key response rates (responses per minute) in stimuli S1 (filled circles) and S2 (unfilled circles) as a function of changeover delay.

Fig. 2. Strip-chart records of operant-key (top channel) and signal-key (middle channel) responding and reinforcements (bottom channel) for S1 component pairs 27, 28 and 46, 47, in the last session of each changeover delay condition (COD 0, 1, 2, or 4 sec).

were not separated by S2 and represented continuous 60-sec periods of S1 presentation. In all cases, operant-key response rates were steady and were interrupted only by either short bursts of signal-key responding or by reinforcers. Three features of the data in Figure 2 are of particular interest. First, the records clearly show the reduction in signal-key behavior with increasing COD that is summarized in Figure 1. Second, signal-key responding was distributed evenly throughout the component, especially for the 0-sec COD, although with longer CODs signal-key responses nearly always but not exclusively occurred at the beginning of the components (cf. Schwartz, 1978). Third, without a COD, short bursts of signal-key responses alternated with short bursts of operant-key responses. This pattern persisted under longer CODs, but with a reduction in the frequency of signal-key bursts and in responses per burst. For Birds B3 and B4 for which signal-key rates were overall low, these "bursts" were predominantly single responses. The pattern of alternating bursts is particularly clear for Birds B1 and B2 which exhibited high overall rates of signal-key responding.

DISCUSSION

The present data clearly demonstrate that increasing COD duration reduces signal-key response rates (Figure 1). The systematic reduction over a range of COD values from zero to 4 sec thus strengthens Williams and Heyneman's (1981) result. The COD functions to bring topographically distinct responses more specifically under the control of their separate contingencies, by introducing a delay between one response and reinforcement of another. That is, the COD reduces the effect on signal-key responding of the contingency for operant-key responding. Patterns of within-component responding were consistent with the hypothesis that the COD disrupted adventitious signal-key response chains. Figure 2 indicated that the reduction in signal-key responding resulted from decreases in both the number of responses per signal-key burst and the number of bursts. Furthermore, Figure 2 suggests that when they occurred, signal-key bursts immediately preceded bursts of operant-key pecking. The contribution of adventitious chaining to the maintenance of signal-key responding in

the two-key procedure without a COD may therefore be substantial. Our conclusion is entirely consistent with that offered by Williams and Heyneman: "the best interpretation of the COD effects is in terms of eliminating adventitious reinforcement of signal-key pecking" (1981, p. 176).

The present study sought to establish the role of response-reinforcer contingencies in maintaining signal-key responding. The persistence of low signal-key rates under the 4-sec COD indicates that stimulus-reinforcer contingencies also contribute to their maintenance, although these were not manipulated here. Longer CODs may have led to the eventual elimination of signal-key pecking, in which case even the low signal-key rates under 4-sec COD might be construed as maintained by response-reinforcer contingencies. Low rate signal-key responses in the two-key procedure with a 2-sec COD are of short duration (Schwartz, Hamilton, & Silberberg, 1975). Schwartz and Williams (1972) and Schwartz (1977) have argued that short-duration responses are insensitive to their consequences and are therefore elicited. Zirias and Silberberg (1978) and Whipple and Fantino (1980) have shown, to the contrary, that short peck durations may be differentially reinforced. Therefore, although signal-key procedures with a COD reduce the effects of response-reinforcer contingencies on signal-key responding, control by the operant relation may persist.

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