

Topographically tagged stimulus control: Maintained generalization and stimulus-specific gradients

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In successive discrimination training, pigeons' responses on an operant key were reinforced in the presence of one wavelength stimulus (555 nm) but not in the presence of another (576 nm). The discriminative stimuli were displayed on a second response key, the signal key. Signal-key responses did not produce reinforcement, and operant-key responses were not reinforced if they followed within 1 sec of a signal-key response. Maintained generalization gradients demonstrated strong stimulus control over responding maintained by both stimulus-reinforcer (signal-key) and response-reinforcer (operant-key) contingencies. Gradients derived from test stimulus presentations preceded by specified wavelengths (stimulus-specific gradients) generally did not vary with the value of the preceding stimulus. Both operant-key and signal-key stimulus-specific gradients exhibited small local behavioral contrast effects, and peak shift occurred for signal-key but not operant-key responding when test stimuli were preceded by wavelengths of 538 nm and 555 nm.

In successive discrimination where one stimulus (S+) is correlated with reinforcement and another (S-) is correlated with extinction, behavior is under the control of two contingencies. A differential response-reinforcer contingency results from scheduling response-contingent reinforcement and extinction in the different stimulus conditions, whereas a stimulus-reinforcer contingency results from the correlation between S+ and food presentation vs. S- and extinction (Schwartz & Gamzu, 1977). Keller (1974) used Catania's (1973) topographical tagging analysis to separate the influences of response-reinforcer and stimulus-reinforcer contingencies in successive discrimination. In Keller's procedure, responding on one key (the "operant" key) illuminated by the same constant stimulus was reinforced in the presence of S+ but not in S-. Operant-key responding was assumed to be controlled by the response-reinforcer contingency. The discriminative stimuli, S+ and S-, were presented on a second key (the "signal" key) where responses had no scheduled consequences and were thereby determined by the stimulus-reinforcer relation.

When discriminative responding maintained by response-reinforcer and stimulus-reinforcer contingencies is topographically tagged, an initial response-rate increase in S+ (local behavioral contrast) occurs for signal-key responding but not for operant-key respond-

ing (Schwartz, 1978; Schwartz, Hamilton, & Silberberg, 1975; Spealman, 1976). This difference in the nature of the response differential during discrimination training for the different response topographies does not appear to be the case for dimensional stimulus control assessed in terms of postdiscrimination generalization gradients (White & Braunstein, in press). Instead, it seems that stimulus control of topographically tagged responding maintained by the stimulus-reinforcer relation parallels that maintained by the response-reinforcer relation. One difficulty with assessing topographically tagged stimulus control, however, is that signal-key rates are usually too low to generate reliable gradients for signal-key responding. This is especially the case if a changeover delay (COD) is programmed to minimize adventitious reinforcement of signal-key/operant-key chaining (Schwartz et al., 1975; Spealman, 1976). In the present study, maintained generalization tests were conducted in order to overcome the problem of low rates of signal-key responding. The study also attempted to separate local contrast effects from dimensional stimulus control by comparing rates for the response topographies to different test stimuli conditional upon the value of the preceding stimulus (Malone, 1976). Local contrast is evident if S+ controls higher rates when it is preceded by S- than when the preceding stimulus is also S+.

METHOD

Subjects

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

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Apparatus

A sound-attenuated experimental chamber with internal dimensions of 33 x 33 x 29 cm contained a three-key intelligence panel. General illumination was furnished by a single GE 1829 lamp located behind a 4 x 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 Electronic 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, 538, 555, 576, or 606 nm, produced by Kodak Wratten Filters 75, 74, 99, 73, and 72B, respectively. 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 electromechanical 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 mixed grain) were obtained. Sessions 3-22 comprised discrimination training in which 25 30-sec presentations of the 555-nm stimulus on the signal key were quasirandomly alternated with 25 30-sec presentations of 576 nm, also on the signal key. The operant key was always illuminated by the vertical line. Operant-key responding in the presence of 555 nm (S+) was reinforced at intervals averaging 30 sec (VI 30 sec) and operant-key responding in 576 nm (S-) was never reinforced (EXT). There were no blackouts between stimulus periods. At no stage in the experiment did a signal-key response produce reinforcement. The only scheduled consequence of a signal-key response was a 1-sec COD: Any operant-key response that followed within 1 sec of a signal-key response could not be reinforced.

Maintained generalization tests were conducted in Sessions 23-25. A test comprised 45 30-sec presentations of the test stimuli under conditions of extinction, interspersed by 23 30-sec presentations of 555 nm correlated with VI 30-sec reinforcement of operant-key responding. The 45 test periods consisted of nine blocks of the five wavelength values, randomly ordered with the restriction that each value preceded itself and each other at least once.

RESULTS

Figure 1 shows that the operant-key response-rate differential did not begin to develop until after nine discrimination sessions. By the end of training, the percent of operant-key responses to S+ was 79% and 74% for Subjects B15 and B18, respectively. The signal-key rate differential also began to appear after eight discrimination sessions, although there was no obvious relation between fluctuations in a signal-key and operant-key responding.

Figure 2 presents response rates averaged over the nine 30-sec presentations of each test stimulus for each of three tests, separately for operant-key and signal-

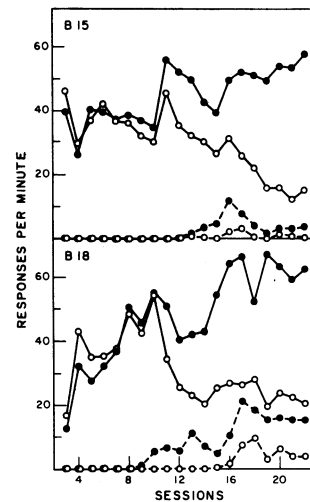


Figure 1. Response rates in the presence of S+ (filled circles) and S- (unfilled circles) on the operant-key (continuous lines) and signal-key (dashed lines) during discrimination training.

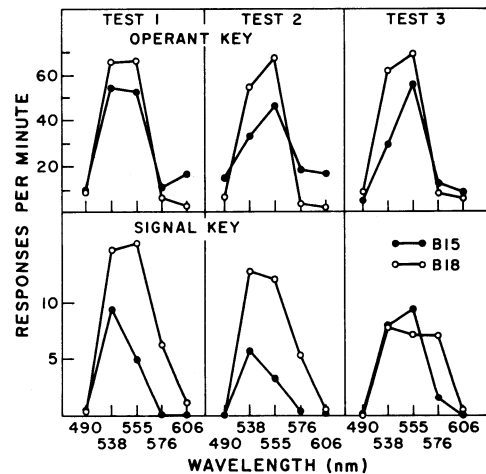


Figure 2. Wavelength generalization gradients for operant-key (upper panel) and signal-key (lower panel) responding, for Subjects B15 and B18.

key responding, for individual subjects. In Test 1, both operant-key and signal-key gradients exhibited area or peak shift. In Test 2, operant-key gradients peaked at the S+ value (555 nm), whereas signal-key gradients peaked at 538 nm. In Test 3, the operant-key gradients and the signal-key gradient for B15 peaked at S+, and the signal-key gradient for B18 showed increased responding to 576 nm. Apart from the fact that signal-key responding occurred at far lower rates than operant-key responding, there is very little evidence for systematic differences between the topographically tagged gradients. It is clear, however, that in the context of maintained generalization testing, reliable and sharp gradients were obtained for signal-key responding.

Of the 45 (unreinforced) wavelength stimulus pres-

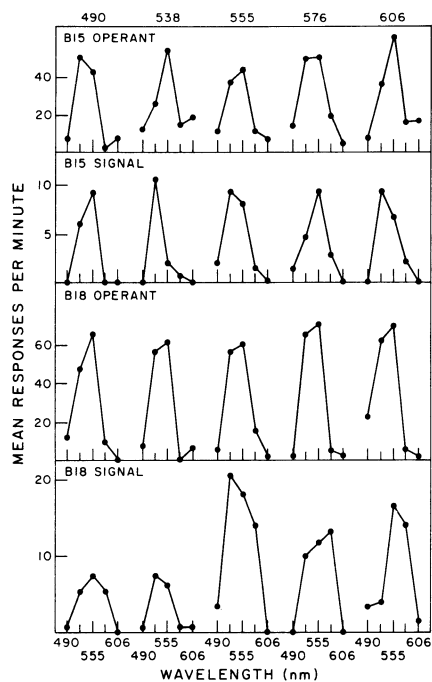


Figure 3. Stimulus-conditional wavelength generalization gradients for operant-key and signal-key responding. The wavelength values across the top of the figure refer to the stimulus preceding test values from which each gradient was derived.

entations in each test, there were a total of 25 occasions on which each stimulus was preceded by itself or each other stimulus. The remaining test periods consisted of 20 stimulus presentations that were preceded by a period of reinforcement (S+). Figure 3 presents operant-key and signal-key gradients for responding to each test stimulus, classified according to the immediately preceding test stimulus value (stimulus-specific gradients). Each gradient in Figure 3 was derived from data averaged over three tests for each of the five test stimuli preceded by one of the five wavelength values. Responding to test stimuli preceded by reinforced S+ periods did not contribute to the stimulus-specific gradients. On the whole, the operant-key gradients for both birds and the signal-key gradients for B15 were strikingly similar. Local contrast effects would be reflected in higher response rates to 555 nm (the previous S+) when it is preceded by 576 nm (the previous S-) than when it is preceded by 555 nm. This was the case for operant-key responding in both birds (differences of 6.7 and 10 responses/min for B15 and B18, respectively) and for signal-key responding in B15 (a difference of 1.3 responses/min). For B18, signal-key responding to 555 nm was 6.0 responses/min greater when it was preceded by 555 nm than when it was preceded by 576 nm.

One consistent difference between the topographically tagged stimulus-specific gradients (Figure 3) was the occurrence of maximal responding to 538 nm

(i.e., peak shift) when the test stimuli were preceded by 555 nm and 538 nm for signal-key responding, but not for operant-key responding (where gradients peaked at 555 nm).

DISCUSSION

Topographically tagged generalization gradients obtained from the present maintained test procedure demonstrated reliable and strong stimulus control over signal-key pecking maintained by the stimulus-reinforcer contingency (Figure 2). Maintained testing was therefore established as a useful procedure for generating enough behavior to examine stimulus control of signal-key responding in situations that otherwise result in response rates too low for stimulus control assessment.

Schwartz (1978) and Spealman (1976) have reported strong local contrast effects during discrimination training for signal-key responding, but not for operant-key responding. These data led Schwartz (1978) to conclude that local contrast in standard single-key multiple schedules was the result of the addition of responding elicited by the differential stimulus-reinforcer contingency to that maintained by the response-reinforcer contingency (cf. Schwartz & Gamzu, 1977). In view of the strong evidence for what has become known as "additivity theory," the present data are somewhat surprising. In the present study small local contrast effects were observed for operant-key responding in both subjects and for signal-key responding in B18. Notwithstanding the general unreliability of local contrast (Hamilton & Silberberg, 1978), Schwartz's (1978) analysis demands that any signal-key responding should be characterized by local contrast effects.

It may be, however, that signal-key responding in the two-key procedure is determined by factors additional to elicitation of responding by the differential stimulus-reinforcer contingency. Another potential factor is occurrence of interim behavior that normally competes with terminal behavior in periodic and aperiodic reinforcement schedules (Staddon, 1977). In the standard single-key discrimination procedure, behavioral contrast in terminal responding occurs only when interim responding in the unchanged (VI) component is inhibited (Hinson & Staddon, 1978). Absence of contrast for operant-key responding in the two-key procedure (Keller, 1974; White & Braunstein, in press) can be accounted for if it is assumed that signal-key responding is interim behavior that is compatible with the terminal behavior. Indeed, signal-key behavior allows economical terminal (operant-key) responding in that it is associated with information pick-up from the signal-key discriminative stimuli. This view also predicts the general similarity of the stimulus-specific gradients for operant-key responding, and peak shift in the signal-key stimulus-specific gradients preceded by 555 nm and 538 nm. Interim responding in the presence of 555 nm is inhibited when the preceding stimuli are in the region of S- (576 nm, 606 nm), but not when the preceding stimuli are 538 nm or 555 nm (cf. Hinson and Staddon, 1978). If to some extent signal-key responding is interim activity that does not compete with the operant-key terminal behavior, signal-key stimulus-specific gradients will change with the value of the preceding stimulus, whereas operant-key gradients will not. But whether that change should be reflected in signal-key peak shift following 555 nm and 538 nm depends on the exact nature of the contribution of interim behavior to peak shift.

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