STIMULUS CONTROL IN A DISCRIMINATION BASED ON A DISTINCTIVE FEATURE¹

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Six pigeons were instrumentally trained to discriminate between two displays that differed only by the presence of a distinctive feature on the positive or food-correlated display. In accordance with previous studies, subjects learned the discrimination and, in the presence of the positive display, directed most of their responses to the distinctive feature, although responses to the common feature were also reinforced. Subsequent generalization tests revealed that on the positive display, both common and distinctive features produced decremental gradients, contradicting Farthing's (1971) statement that the common feature acquires a control function opposite that of the distinctive feature. Procedural differences probably caused the discrepancy in results; within a display, Farthing presented common and distinctive features successively; the present study used simultaneous presentations of common and distinctive stimuli.

When a pigeon receives reinforcement for responding to one stimulus display (the positive display) and none for responding to a second display (the negative display), the situation is termed a "go/no-go" discrimination. Generally, positive and negative displays have qualitatively different stimulus characteristics and a bird learns such a discrimination, responding to the positive display, and not responding to the negative display. Sainsbury and Jenkins (1967), however, trained birds in a go/no-go discrimination in which the displays had related stimulus characteristics. The positive and negative displays were composed of elements from two categories: (a) common features (C stimuli)—these included all stimuli that appeared in both positive and negative displays; (b) the distinctive feature (D stimulus)—this appeared only in positive displays in the "feature-positive" case, and only in negative displays in the "feature-negative" case.

Sainsbury and Jenkins (1967) found that subjects learned the discrimination only when the distinctive feature was a part of the posi-

tive display. Furthermore, pigeons pecked the site of the distinctive feature when it appeared in positive displays but not when it appeared in negative displays. Later experiments (Jenkins, 1973; Jenkins and Sainsbury, 1969; Sainsbury, 1971a, b; Siegel, 1970) replicated the initial feature-positive findings, showing birds learning a discrimination on the basis of a distinctive feature and converging on the distinctive feature.

All these experiments used a pair of displays with the same general composition as those used by Sainsbury and Jenkins (1967); that is, a display with simultaneous CD stimuli *versus* a display with C stimuli. In contrast with the conventional simultaneous presentation of C and D stimuli, Farthing (1971) presented common and distinctive features successively, by alternating 0.75-sec presentations of the common feature with 0.75-sec presentations of the distinctive feature in a 30-sec CD display. The key was darkened for 0.2 sec between successive stimuli within a display. The 30-sec C display consisted of successive 0.75-sec presentations of the common stimulus separated by 0.2 sec of unlighted key. The results of Farthing's feature-positive procedure were consistent with those of experiments using simultaneous C and D presentations; feature-positive birds learned the discrimination and most of the pecks were made on the distinctive feature.

Jenkins and Sainsbury were unable to assess stimulus control in their experiments, as their

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training stimuli could not be altered to produce the necessary stimuli for a generalization test. Hearst (1969) used a vertical line as the distinctive feature, and obtained generalization gradients by recording responses to various line orientations presented in extinction. He obtained decremental gradients for the distinctive feature when it appeared on the positive display, but was unable to vary the common element, a white key. Farthing (1971), using successive presentations of the distinctive and common elements, used groups of birds that received different discrimination training displays, and so was able to use a vertical line as either the common or distinctive feature. The stimulus complementary to the vertical line (*i.e.*, the common feature when the line was the distinctive feature, and *vice versa*) was a white key. On test day, the orientation of the line was varied, while displays were presented in extinction. Farthing obtained decremental gradients for the distinctive feature, and incremental gradients for the common feature.

The present experiment used the conventional feature-positive procedure in which C and D elements were presented simultaneously on CD trials, in an attempt to assess the excitatory or inhibitory stimulus control by the common and distinctive features. Common and distinctive features were on different stimulus dimensions, and thus we could determine stimulus control by both the common and distinctive features, within one discrimination.

METHOD

Subjects

Six experimentally naive White King pigeons, of varying ages, were kept at 80% of their free-feeding weights.

Apparatus

A 36 cm by 27 cm by 30 cm operant-conditioning chamber was equipped with two rectangular 3.5 cm by 5 cm response keys, located side by side, separated by a 0.85 cm-wide metal strip, and backed by a common slide-viewing screen of translucent Plexiglas. Both keys were situated above and to the right of a food magazine located in the bottom left-hand corner of the front panel. Stimuli were made from Cinemoid color filters (numbers 24, 33, 5A, 6, 14, and 60), with the exception of straw, which was produced by Edmund Scientific Co., filter

#809. Stimuli were rear-projected onto the screen by a Kodak Carousel projector containing a General Electric ENH 120-V 300-W Quartzline lamp. The slides were prepared so that only a single circle of light (2.75 cm in diameter) fell on the center of either key (or, if required, both keys).

Recording equipment was kept outside the experimental room. Background masking noise was provided by the projector fan and a white-noise generator.

Procedure

The experiment was conducted in three phases. In Phase 1, subjects were trained to respond to the stimuli that were later used in a go/no-go discrimination. In Phase 2, discrimination training was carried out. In Phase 3, the stimuli were varied and generalization gradients were obtained, allowing assessment of the excitatory or inhibitory control exerted by the original training stimuli.

Phase 1. Shaping and preliminary training: a subject was trained by the method of successive approximations to peck the key illuminated by a circle of white light, which was the output of the projector viewed through three layers of grey filter. Reinforcement, 3-sec access to grain, was given for each response. After every 10 responses, the circle was transferred to the other key. This first session was terminated when 30 responses had been made on each illuminated key.

On the second day of training, a variable-interval 15-sec (VI 15-sec) schedule of reinforcement was instituted. Subjects were trained on both keys with both stimuli that were to be used in subsequent discrimination training—white and amber circles. Only one key was illuminated at a time, and thus four situations were presented: an amber circle on the right key, an amber circle on the left key, a white circle on the right key, and a white circle on the left key. Each of the four stimulus situations was presented an equal number of times, and an equal number of reinforcements was given in each situation. A presentation of one situation was termed a trial. A block consisted of one trial of each of the four different situations; the order of trials in each block was randomly determined. Two blocks of trials were presented on Day 2. Each trial continued until the subject received 10 reinforcements. The session began with a trial on which a

white circle was presented (this was the only time the order of trials in a block was not random). Two blocks of trials were presented on Day 3. Sessions 4 and 5 also consisted of two blocks of trials. Trial length became the time used to obtain five reinforcements, and the schedule of reinforcement was changed to VI 30-sec. Session 6 was a test for possible bias towards either stimulus. No reinforcements were given. Trial length was fixed at 30 sec, and six blocks of trials were given.

Phase 2. Discrimination training: a session consisted of 24, 90-sec trials separated by 10-sec intertrial intervals. A trial consisted of the presentation of a display made up of either a white circle on one key and an amber one on the other, or amber circles on both keys. Consequently, as amber was on both displays, and white appeared on just one of the two, the white circle was termed the "distinctive feature". Each session included 12 trials containing the distinctive feature (the CD display) and 12 trials of amber on both keys (the C display). In CD displays, the distinctive feature was randomly varied from key to key across trials, but was constant within a trial. The distinctive feature was shown on each key an equal number of times in a session.

During discrimination training, CD displays occurred on positive trials, and the C display on negative trials. Reinforcement was arranged on a VI 30-sec schedule during positive trials, contingent upon pecks on either key. Extinction was in effect during negative trials.

Discrimination training was terminated when, after five days of training, a subject reached a criterion of two consecutive days with at least a 0.8 "convergence" ratio (responses on distinctive feature/total responses to CD display; Siegel, 1970). Consequently, before a bird was tested, 80% or more of its pecks during the positive display were on the distinctive feature. Table 1 summarizes the first two phases of the procedure.

Phase 3. Generalization testing: a subject was given one of two different generalization tests, conducted in extinction. In both tests, only CD displays were presented. As during discrimination training, the key on which the distinctive feature appeared was randomly varied from trial to trial. In a given generalization test, either the common or distinctive stimulus was varied, while the other remained constant at the training value. The intensity of the white circle was varied, with 1, 2, 3, 4, 5, and 6 thicknesses of grey filter (Cinemoid No. 60) presented (the training stimulus was three thicknesses). For the common feature, the variations were green, straw, amber (the training stimulus), orange, red, and dark red.

Trials 30 sec long were randomly presented in blocks of six; a block consisted of trials containing the six possible variations of one stimulus (as outlined above), with the complementary part of the display remaining constant. Ten blocks per test session were presented.

For any bird, either the common stimulus or the distinctive feature was varied in a general-

Table 1
Summary of Phases One and Two

Session Number	Stimulus Situation		Schedule of Rft.		Trial Duration	No. of Trials (or Blocks)
	Left Key	Right Key	Left Key	Right Key		
1	white	—	CRF	—	10 rfts	3
	—	white	—	CRF	10 rfts	3
2	These, in random order, are a block	amber	VI 15 sec	—	10 rfts	2
		—	—	VI 15 sec	10 rfts	2
		white	VI 15 sec	—	10 rfts	2
		—	—	VI 15 sec	10 rfts	2
3		a block	as above		10 rfts	2
4		a block	VI 30 sec		5 rfts	2
5		a block	VI 30 sec		5 rfts	2
6		a block	EXT		30 sec	6
7 — criterial session						
	amber	white	VI 30 sec	VI 30 sec	90 sec	6
	white	amber	VI 30 sec	VI 30 sec	90 sec	6
	amber	amber	EXT	EXT	90 sec	12

ization test. The test given to a bird was randomly determined, until one kind of generalization test had been given to three birds; then, all remaining birds were given the other test.

RESULTS

All birds were responding at a steady rate after five days of preliminary training (Phase 1). During the "bias" test of Session 6, three birds (P-11, P-12, P-17) responded more to the amber circle than to the white circle; the other subjects (P-18, P-19, P-20) made more pecks on the white circle.

The birds took a median of seven days of discrimination training to reach criterion in Phase 2, with five birds being tested after the minimum number of seven training sessions (five days of discrimination training plus two consecutive days with a convergence ratio of at least 0.80). The sixth bird, P-11, required 10 days to reach criterion. Discrimination ratios (total pecks on positive trials/total pecks on positive and negative trials) for final training sessions had a median of 0.884, with a range of 0.808 to 0.988.

Birds P-11, P-17, and P-20 were presented test displays in which the intensity of the distinctive feature (white light) was varied while the common feature was held constant. The data from this generalization test are presented in Figure 1. Pecks at both the distinctive feature and the common feature were included in the count of responses to a given display; P-11, P-17, and P-20, made 91.2%, 73.8%, and 98.6% of total test-session responses on the distinctive feature. Number of responses to a given display was converted to a percentage of N, the total number of test responses (excluding intertrial responses), and plotted on the y-axis against the different stimulus-intensity values along the x-axis. All three birds gave decremental generalization gradients; P-17 (N = 771) pecked most at the training value of the distinctive feature (stimulus 3) and responded less as intensity moved further away from the original value. Stimulus 4 (one step less intense than the training value of the distinctive feature) was the point of most responding for both P-11 and P-20 (N = 282 and N = 971, respectively). Responding was progressively reduced as the intensity of the distinctive feature differed from this value.

P-12, P-18, and P-19 were shown test displays

Fig. 1. Generalization gradients obtained for birds tested with CD displays in which the intensity of the distinctive feature was varied, while the common feature was held constant. Number of responses to each stimulus display was converted to a percentage of responses to all displays, and plotted against intensity of the distinctive feature. Numbers along the x-axis represent the number of layers of grey filter used in presenting that value of the distinctive feature; the training value of the distinctive feature was "3".

in which hue, a dimension of the common feature, was varied, while the distinctive feature (white light) was held constant. Test data are plotted in Figure 2. As in Figure 1, number of responses to a given stimulus display was converted to a percentage of N, and percentage was plotted against different test values of the stimulus. The count of responses to a stimulus display included pecks at both the distinctive feature and the common feature; P-12, P-18, and P-19 made 98.7%, 86.2%, and 72.7% of test responses on the distinctive feature. All gradients were decremental. P-12 and P-19 (N = 2104 and N = 1274) responded most to the training value of the common stimulus (amber), and responded less as the hue of the common feature departed from amber. P-18 (N = 340) made most pecks to orange and

fewer pecks to hues differing progressively from this value.

Some birds (P-11, P-12, and P-17) were given a second generalization test with the stimulus that had been previously held constant varied, and the former variant held constant at its training value. In all cases, decremental generalization gradients were obtained.

DISCUSSION

On the basis of early results from feature-positive and feature-negative experiments, Sainsbury (1971*b*, p. 348) stated "... it would seem that the location of the pigeon's peck may be indicative of the feature he is 'attending to'." This view is contradicted by Jenkins' (1973) feature-positive experiment, which forced responding to the common feature by reinforcing only pecks to this feature during

the CD display. While pecking was directed at the C stimulus, the excitatory value of the distinctive feature was nonetheless affected by reinforcement. Jenkins concluded that it was unsafe to assume that common features acquired no excitatory control from the reinforcer when the distinctive feature was pecked. Indeed, the present experiment demonstrates that the common feature does acquire excitatory control even when the distinctive feature is pecked almost exclusively. Where a pigeon pecked the food-correlated display did not indicate which elements of the display were controlling responding. During the generalization test in which the common element was varied, birds made about 80% of total responses on the distinctive feature, yet decreased responding (at the distinctive feature) when the common element was changed from its training value. One bird, P-12, made 98.7% of all responses to the distinctive feature, yet showed decremental gradients for the common feature.

The decremental generalization gradients obtained for both common and distinctive features restrict the generality of Farthing's (1971, p. 336) statement that "the common feature acquires an inhibitory or excitatory function opposite that of the distinctive feature". Farthing's statement was based on the results of generalization testing after discrimination training in which a positive display consisted of successive alternations of common and distinctive features, whereas the present procedure presented C and D stimuli simultaneously, making up an unchanging positive complex. Perhaps the successive presentation of C and D stimuli in Farthing's positive complex prevented the subjects from perceiving the two features as a unitary complex, and so birds did not associate the common feature with food. Indeed, Farthing reported that subjects responded most to the distinctive part of the positive display, *i.e.*, reinforcement thus usually occurred in the absence of the common feature, preventing the common feature from becoming food-associated. Though subjects in the present experiment also usually received reinforcement while pecking on the distinctive feature, the common feature was always present at the time of the reinforced response, and functionally it appears to have become food-associated (excitatory).

The decremental gradients obtained for the common feature in the positive display suggest

Fig. 2. Generalization gradients obtained for birds tested with CD displays in which wavelength of the common feature was varied, while the distinctive feature was held constant. The number of responses to each stimulus display was converted to a percentage of responses to all displays, and plotted against wavelength of the common feature. Training value of the common feature was amber.

that a stimulus can take on different control functions, depending upon the context in which it is presented. That is, a stimulus might be excitatory in the positive display, and neutral or inhibitory in the negative display. It was not possible, however, to obtain interpretable generalization gradients for the common elements in the negative display because of the very low rate of responding to the negative display—the result of overtraining on the discrimination. Nonetheless, the occurrence of few pecks to any part of the negative display demonstrates that the stimuli comprising it are not excitatory.

An important implication of the finding that both the common and distinctive features of the positive display yield decremental generalization gradients, indicative of excitatory control, is that food reinforcement in the presence of a stimulus complex causes the entire complex to become excitatory, although some parts of the complex may be more reliable cues for reinforcement than others. Though such findings imply that all features of a nonreinforced complex will be inhibitory, whether all features of the nonreinforced complex in a feature-negative discrimination do become inhibitory remains to be demonstrated.

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