The effect of localizing the stimulus at the response key on generalization along the hue dimension in the pigeon

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After training with a variable-interval schedule of positive reinforcement, pigeons were tested for stimulus generalization along the hue dimension. For one group, the stimulus was located on the response key. For a second group, the stimulus was located on a surface adjacent to the response key. The stimulus-on-key group produced the typical steep gradients normally found with hue stimuli; the stimulus-off-key group produced flat gradients. After discrimination training between the presence and absence of the hue stimulus, both groups produced decremental gradients. In a second experiment, naive pigeons were trained to peck a transparent key with the stimulus surface located approximately 3.8 cm behind the key. When tested for generalization, the hue gradients were decremental. The results suggest that location of the stimulus in the line of sight with pecking is a necessary condition for stimulus control by hue after nondifferential training.

Guttman and Kalish (1956) trained pigeons to respond to a key transilluminated by a colored light for food reinforcement delivered according to a variable-interval (VI) schedule. A subsequent stimulus-generalization test showed that rate of pecking was a function of light color with the response rate highest to the stimulus that had been present during training. Response rate was proportionally lower to other hues as a function of the difference between the test hue and the training hue.

Jenkins and Harrison (1960) performed a similar experiment using frequency of a tone as the stimulus-generalization dimension. In contrast to the Guttman and Kalish study, little control by tonal frequency was found after nondifferential training; the stimulus-generalization gradient was almost flat. A second group in the Jenkins and Harrison study was given discrimination training with a tone as the positive stimulus and the absence of the tone as the negative stimulus. After this discrimination training, the postdiscrimination gradient was decremental with the mode located at the frequency of the training stimulus, a gradient similar in form to the hue gradient obtained by Guttman and Kalish.

Jenkins and Harrison concluded that the failure to find stimulus control after nondifferential training was due to the use of tonal frequency, since the stimulus dimension, as all other aspects of their study, were comparable to the Guttman and Kalish study. As stimulus control was found for tonal frequency after discrimination training, the failure to find stimulus control after nondifferential training was not due to a lack of physiological capacity to discriminate among the different tonal frequencies. Jenkins and Harrison noted

that visual stimuli play a more important role in the normal activities of pigeons than do tonal frequencies, a possible basis for the difference. Terrace (1966) suggested that differential reinforcement with respect to hue could have occurred in the preexperimental environment of the pigeons where different hues are present and may be pecked by the pigeons. Pure tones, not normally found in the preexperimental environment, would not have this preexperimental history. Thomas, Mariner, and Sherry (1969) investigated this possibility by giving pigeons experience with a tone prior to experimental training. The results of the Thomas et al. study showed stimulus control by tonal frequency after nondifferential training by the experimental subjects but not by the control subjects which had no history of experience with the tone.

Jenkins and Harrison (1960) noted a second difference between the auditory and visual stimuli. The hue was located as a discrete stimulus on the response key while the tone was diffused through the test chamber. This distinction can be expanded: first the hue was localized, and second, the point of localization was on the response key. The purpose of the present study was to determine if either or both of these variables contribute to stimulus control after nondifferential training with a hue stimulus.

EXPERIMENT I

Method

Subjects. Four adult naive White King pigeons were maintained at 75% of their free-feeding weight.

Apparatus. Two identical chambers measured 52 cm long, 37 cm wide, and 35 cm high. One of the walls contained two holes, 2.5 cm in diam, centered 25 cm above the floor and 2.5 cm to either side of the vertical midline. Translucent Plexiglas paddles, painted flat black on the rear side except for a 1-cm circle, were centered behind the holes. The left paddle served as the response key requiring a force of 18-22 g (.18-.22 N) through an excursion of .1 cm to operate; the right paddle served merely as a stimulus surface and was not

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depressible. Both paddles could be transilluminated by Industrial Electronics Engineers, Inc. in-line display cells equipped with Wratten hue filters (see Lyons & Klipec, 1971). Reinforcement consisted of a 3-sec access to an illuminated mixed-grain hopper, delivered through a rectangular hole located below the key in the center of the wall. Diffuse light was provided in each chamber by two 28-V incandescent bulbs located behind a Plexiglas screen across the top of the response-key wall. A fan provided ventilation and masking noise. Contingencies were programmed via solid state programming equipment located in the room containing the chambers, and responses were recorded by electromechanical counters.

Procedure. During five preliminary sessions, the birds were adapted, magazine trained, and shaped to peck the response key. The birds were given three sessions of 15-sec VI training, two sessions of VI 30 sec, and were then placed on a VI 60-sec schedule. At the beginning of VI training, sessions were divided into a series of 47-sec working periods separated by 10-sec blackouts. The VI 60-sec sessions typically were concluded after 40 working periods. Responses during blackouts produced no programmed consequences.

Nondifferential phase. Two groups were trained according to stimulus condition. Group 1 (P 1 & P 2) was trained with a green (555 nm) stimulus on the key and a white stimulus off the key on the adjacent stimulus surface. Group 2 (P 3 & P 4) was trained to the converse with a white stimulus on the key and a green (555 nm) stimulus off the key. Twenty-one sessions of VI 60-sec were given, followed by a generalization test in which several hues were presented on the surface which was green during training, i.e., the test stimuli were presented on the key for Group 1 and off the key for Group 2.

Generalization test. The test consisted of 47-sec stimulus presentations separated by 10-sec blackouts. After three presentations of S+ during which several reinforcements occurred, extinction was scheduled. Seven wavelengths (501, 538, 549, 555, 559, 574, and 606 nm) were then presented according to seven restricted randomized blocks.

First discrimination phase. Each group was placed on a multiple VI 60-sec extinction schedule. The 555-nm stimulus (S+) was present when the VI 60-sec component was in effect; a dark stimulus surface (S-) signaled the extinction component. S- was chosen as a parallel to Jenkins and Harrison's (1963) study in which discrimination training between the presence and absence of a tone resulted in steep tonal frequency gradients in contrast to the flat gradients obtained after nondifferential training. S+ and S- were each presented 20 times per session in a random order with the restriction that neither stimulus could occur more than three times consecutively and that each stimulus must occur five times in each successive block of 10 presentations. Each bird was trained to the criterion of 90% of the total responses to S+ for each of three consecutive sessions. The number of working periods per session was increased to a total of 80 for P 4 after his discrimination performance stabilized below the criterion level. A generalization test identical to the first one was given to each bird on the day following attainment of criterion.

Cue-switch phase. The location of the white and green stimuli were reversed: For Group 1, the response key was white and the adjacent surface green; for Group 2, the response key was green and the adjacent surface white. Discrimination training between the presence and absence of the green stimulus again was continued to the 90% criterion. Both birds in Group 1 required reshaping because they pecked exclusively at the green off-key stimulus surface instead of the white response key during the first three sessions of this phase. The session length was increased to a total of 80 working periods of P 1 after his discrimination performance stabilized below the criterion level.

Figure 1. Relative generalization gradients for individual birds after nondifferential training (Test 1), discrimination training (Test 2), and discrimination training with the stimulus location reversed (Test 3). The top panels present Group 1, the bottom panels present Group 2. Each point represents the number of responses made in the presence of that stimulus divided by the number of responses made to the modal stimulus times 100.

Following the attainment of criterion, each bird was again tested for generalization to different hues projected on the stimulus surface which had been green during this phase.

Results

Figure 1 presents the relative generalization gradients for individual birds after each of the three phases. Responding at each stimulus value is expressed as a percentage of the number of responses to the modal stimulus.

The gradients obtained after nondifferential training are shown in the left panel. Birds trained with the hue on the response key (Group 1) produced the steep gradients normally found with hue. However, birds trained with the hue off the response key produced flat gradients.

The gradients obtained after the first green-ON/green-OFF discrimination phase (center panel) are all decremental; Group 1 showed little change from the first test while Group 2 went from flat to steep gradients. All gradients obtained after the cue-switch phase (right panel) were also decremental.

The discrimination criterion was immediately attained (three sessions) by both birds in Group 1 in the first discrimination phase with the hue located on the response key. Group 2 required a large number of sessions to reach criterion (37 for P 3 and 54 for P 4) in the same phase with the hue located off the response key. In the cue-switch phase, the same relationship between the location of the hue and sessions to criterion

was found. That is, Group 1 birds trained a large number of sessions to criterion with the hue located off the key (24 for P 1 and 47 for P 2), while both birds in Group 2 attained criterion in three sessions with the hue located on the response key.

EXPERIMENT II

In the previous experiment, only those birds trained with the hue located on the response key showed stimulus control after nondifferential training; birds trained with the hue located off the key yielded flat gradients. The purpose of this experiment was to determine if it is a necessary condition that the stimulus surface be the same surface which is pecked or if locating the stimulus surface behind the operandum (a transparent key) in the line of sight with pecking is sufficient to produce stimulus control by hue after nondifferential training.

Method

Subjects. Three adult naive White King pigeons were maintained at 75% of their free-feeding weight during the experiment.

Apparatus. A transparent response key 2.5 cm in diam was used. The translucent paddle used as the response key in the previous experiment was fastened to the face of the display cell unit which was recessed 3.8 cm behind the response key. Thus, the stimuli were the same as in the previous experiment except they were located behind the key. No other changes were made in the apparatus.

Procedure. The birds were trained nondifferentially for 21 sessions according to the procedures in the first experiment. A green (555 nm) stimulus was located behind the response key. The off-key stimulus surface was white. Next, a generalization test was given with the test stimuli located behind the response key.

Results

Figure 2 presents the relative generalization gradients for each bird, all of which are clearly decremental.

DISCUSSION

It appears that it is necessary to locate the stimulus on or near the line of sight with the operandum to produce stimulus control by hue after nondifferential training, since only those birds trained with the stimulus on or behind the key produced decremental hue gradients. This indicates that localization of the stimulus so that it is in the visual field of the subject while responding is not a sufficient condition for stimulus control by the hue to result. Furthermore, the property of being visual does not in itself provide the key to stimulus control by hue, since only a limited portion of the visual field exerted control over the birds' behavior after nondifferential training. It should be noted that localization, though not sufficient, may be a necessary condition for nondifferential training to result in stimulus control by hue. Training a bird to peck at an

Figure 2. Relative generalization gradients for individual birds after nondifferential training with the stimulus located behind the response key. Each point represents the number of responses made in the presence of that stimulus divided by the number of responses made to the modal stimulus times 100.

enlarged stimulus surface, though it obviously falls in the line of sight with the manipulandum, may not result in control by hue (Heinemann & Rudolph, 1963).

The establishment of stimulus control by wavelength with respect to the stimulus off the key by training on the light-ON/light-OFF discrimination is parallel to the result of Jenkins and Harrison's (1963) study where birds trained on a tone-ON/tone-OFF discrimination showed good control by tonal frequency. This is further evidence that discrimination training need not be along the explicit dimension tested in order to obtain stimulus control on that dimension.

The cue-switch phase showed that stimulus control could be established by discrimination training regardless of the order of training to the two stimulus arrangements, i.e., the hue stimulus located first on the key or off the key. All birds produced decremental gradients in this phase. Switching the hue stimulus from on-key to off-key results in a marked loss of discriminative control. This is contrasted to the control that was maintained in switching from the off-key location to the on-key location.

Studies which transilluminate the entire response key with the hue stimulus provide the opportunity for discrimination training during the nondifferential procedure, which could explain stimulus control by hue after nondifferential training (Terrace, 1968). Birds often peck the area around the key which is not illuminated by the hue stimulus. These responses are not reinforced; thus, there is discrimination training between the hue and the absence of the hue. In the present study, only the center of the key was transilluminated with the hue stimulus, the remainder of the key was black, so responses to the black area could result in reinforcement. Observation revealed that the birds often pecked the black area of the key, rather than the central-hue area. This arrangement ruled out unintended

differential training between the presence and absence of the hue during nondifferential training as reinforcement was received for pecks to the black area of the key. Unintended differential training may have occurred between the key and nonkey surfaces if the birds pecked the nonkey surfaces but, if so, the stimulus dimension on which the discrimination was based was not hue.

Pecks to surfaces other than the response key were not measured. Frequent observation revealed that pecks to the off-key stimulus surface did occasionally occur. However, these pecks would not be expected to affect the results, at least not beyond the effects of other off-key pecking typically observed in such experiments.

In summary, the use of a localized hue as the stimulus dimension does not mean that stimulus control will occur after nondifferential training under a VI 60-sec schedule. Also, it is possible that stimulus control would occur after nondifferential training with tonal frequency as the stimulus dimension if the tone was perceived as emanating from the response key.

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