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AUDITORY STIMULUS CONTROL IN PIGEONS: JENKINS AND HARRISON (1960) REVISITED[1]

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Pigeons were trained to peck a key in the presence of a 1000-Hz tone on a variable-interval one-minute schedule of reinforcement. One group was trained with an illuminated key; the other was trained in a totally dark chamber. During a generalization test on tonal frequency, subjects trained and tested with the key illuminated produced rather shallow gradients around the training value; subjects trained and tested in the dark produced steeper generalization gradients. These data replicate Jenkins and Harrison's (1960) finding that tone acquires relatively little control over responding and demonstrate that this absence of control is a function of the presence of the keylight.

Key words: auditory control, overshadowing, keylight, key peck, pigeons

The amount of stimulus control, as measured by the slope of a generalization gradient, may be markedly affected by apparently minor procedural changes. Key-peck training in the presence of a tone produces relatively little control by tonal frequency (Jenkins and Harrison, 1960), whereas similar training in the presence of a key illuminated with a spectral value produces considerable control by that spectral value (Guttman and Kalish, 1956). In discussing this discrepancy, Jenkins and Harrison (1960) stated: "Since the training procedures appear to be the same in all important respects it may be concluded that the difference lies in the use of a visual—as compared with an auditory stimulus." Furthermore, they noted that "the visual stimulus appeared directly on the response key, whereas the auditory stimulus was diffuse and probably unlocalized" (p. 252). Heineman and Rudolph (1963) tested this hypothesis that stimulus control is a function of the degree of localization. They trained pigeons to peck an illuminated disc, which varied in size for different groups, and found that the amount of stimulus control on the visual-intensity dimension was inversely related to the size of the stimulus. Thus, greater localization did produce more stimulus control.

Some evidence, however, indicates that localization of color on the key is not a necessary condition for obtaining stimulus control on the spectral dimension. Rudolph (1971) obtained spectral control with a localized monochromatic light off the key; Mackintosh (*personal communication*) also obtained spectral control with a diffusely illuminated overhead Plexiglas panel. Certainly the lights in these studies were not as diffuse as the tones in the Jenkins and Harrison (1960) experiment. Nevertheless, these results with rather diffuse stimuli cast doubt on an explanation based entirely on the degree of localization of the training stimulus.

Another possible interpretation of the discrepancy between Jenkins and Harrison (1960) and Guttman and Kalish (1956) is based on the phenomenon of overshadowing. Overshadowing occurs when the presence of one stimulus reduces the amount of control obtained by another stimulus (Miles, 1965). Van Houten and Rudolph (1972) tested this notion indirectly. Pigeons were trained to peck a key in the presence of an airflow that emerged from the key. Different groups of subjects were trained with a back-illuminated key, a houselight, or with no light. Generalization gradients obtained on the dimension of airflow velocity were steep in the no-light condition but were relatively flat in both the houselight and illuminated-key conditions. These results indicated that the presence of a light during train-

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ing and testing reduced control by airflow. Van Houten and Rudolph (1972) suggested that a similar overshadowing effect might have been present in the Jenkins and Harrison (1960) experiment, *i.e.*, that the keylight may have overshadowed control by tones.

The purpose of the present experiment was to test this overshadowing hypothesis by training pigeons to peck a key in the presence of a tone, with the key illuminated for some subjects but not for others. The amount of tonal stimulus control was assessed by giving the subjects a generalization test on the tonal-frequency dimension.

METHOD

Subjects

Ten, six-month-old experimentally naive Silver King Pigeons were maintained at 80% of their free-feeding weights.

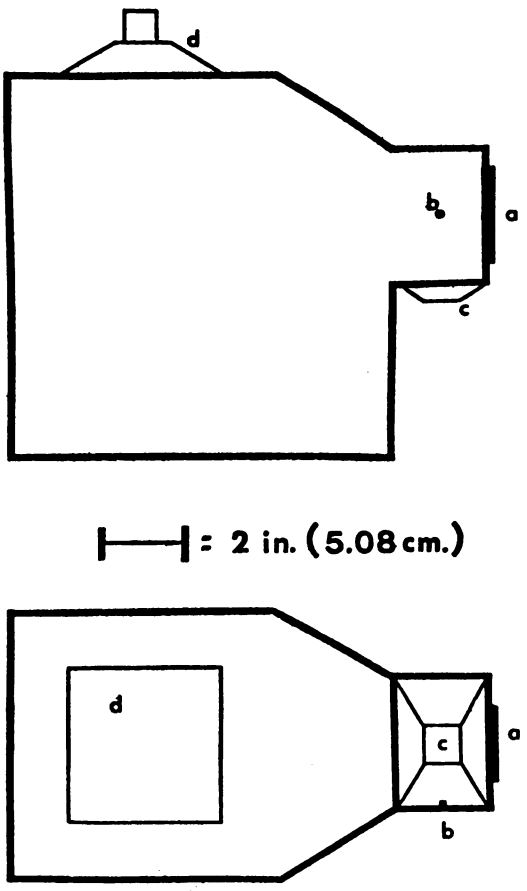

Fig. 1. A side and top view of the apparatus, "a" is the key, "b" is the magazine light, "c" is the magazine aperture, and "d" is the speaker.

Apparatus

The apparatus is presented schematically in Figure 1. The chamber was designed to facilitate responding in the dark, and thus differed from a standard pigeon chamber in three ways. (1) The response key was larger than the standard key, measuring 5.08 by 6.35 cm. (2) The response key was located in a small (8.89 by 6.35 by 8.89 cm) recessed "alcove", which could provide tactual cues to the key's location. (3) The magazine was also located in this small alcove directly below the key, so that when the magazine cycle terminated the subject was in position to respond again.

Tones were produced by a 10-cm speaker mounted on top of the chamber. Intensity of the 1000-Hz stimulus used in training varied from 65 to 95 dB depending on the area of the chamber in which the measurement was taken. The large range of tonal intensities was presumably a function of standing waves produced in the small aluminum chamber. Though a precise integration of intensity over area was not performed, a number of readings taken at various locations in the chamber indicated that the average tonal intensity was approximately 85 dB. The average intensities of the 300-, 670-, 1500-, and 3500-Hz test stimuli were approximately 95, 90, 75, and 85 dB, respectively.

Procedure

All subjects were trained to peck a lighted key in the absence of tone and were presented with 4 sec of access to mixed grain for each of 30 key pecks on the first day of training. Throughout the experiment, grain presentation was signalled by a magazine light for all subjects. On the second and third days of training, each of 30 key pecks was reinforced. During the first 15 reinforcements on the second day, the 1000-Hz tone was faded in. When this was accomplished, the keylight was faded out for five of the subjects (No-Keylight group). Fading was continued on the third day and was completed by the end of that day.

During the next 10 days of training, subjects were given 30 reinforcements per day. The reinforcements were delivered on a variable-interval 15-sec (VI 15-sec) schedule, in which the first response after an average interval of 15 sec was reinforced, for the first five days, and then on VI 30-sec. When the No-Keylight subjects were placed in the chamber it was

dark. If they failed to start responding in the dark, the keylight was dimly illuminated until the subject started responding; then it was quickly faded out (generally within about five reinforcements). On the final 10 days of training, responding was reinforced on a VI 1-min schedule for 30 min each day. Throughout all phases of training the 1000-Hz tone was on when the subjects were put into the chamber and when they were taken out. The five Keylight subjects were treated just like the No-Keylight subjects, except that the key was always illuminated for these subjects.

After a 5-min warmup on the training conditions, a tonal-frequency generalization test was administered in extinction, with the key illuminated for the Keylight group and not illuminated for the No-Keylight group. The test stimuli were 300, 670, 1000, 1500, 3500 Hz, and No-tone. These six test conditions were presented in a counterbalanced order over 10 blocks of trials, with each stimulus occurring for 30 sec in each block.

RESULTS AND DISCUSSION

Acquisition

Little difficulty was encountered in training the No-Keylight subjects to respond in the dark. These five subjects all responded in the dark during the third day of continuous reinforcement training. On the first day of VI 15-sec training, none of the subjects started responding when placed in the dark chamber, and thus the keylight was dimly illuminated for a few reinforcements. However, four of the five subjects began responding in the dark on the second day of VI 15-sec training and the fifth subject began responding in the dark on the fourth day of VI 15-sec training. Subjects in the No-Keylight group tended to emit fewer responses than subjects in the Keylight group, particularly early in training. For example, on the first two days of VI 30-sec training, the lowest number of responses emitted by a Keylight subject was greater than the highest number emitted by a No-Keylight subject. This difference decreased with continued training, and on the last day of VI 1-min training the number of responses emitted by the No-Keylight group (Subjects 1 to 5) was 599, 1321, 471, 836, and 1165; the Keylight group (Subjects 6 to 10) emitted 1514, 1138, 1418, 401, and 1067, respectively.

Testing

Relative generalization gradients for nine of the 10 subjects are presented in Figure 2. (Subject 3 from the No-Keylight group was omitted because it made only four responses during the test, all to 1500 Hz on the first test trial.) In this figure, responses to each of the test stimuli are expressed as a percentage of total responses emitted during the test. Total responses for each subject during the test are presented in Figure 2.

Each subject in the No-Keylight group exhibited a decremental gradient that peaked at 1000 Hz. Two subjects in the Keylight group also exhibited decremental gradients with a peak at 1000 Hz, but neither peak was as high as the peaks of any subject in the No-Keylight group. The other three subjects in the Keylight group exhibited rather flat gradients, with the percentage of responses in 1000 Hz being essentially equivalent to the percentage given in No-tone. The difference in the gradients indicates that the presence of the keylight during training and testing reduced the amount of tonal control, *i.e.*, light overshadowed control by tone. Since the results of the Keylight group are similar to the results of Jenkins and Harrison's (1960) group that received similar training, it may also be concluded that light overshadowed control by tone in their group. Thus, the discrepancy between strong spectral control obtained by Guttman and Kalish (1956), and weak tonal control obtained by Jenkins and Harrison (1960), appears to be resolved by noting that considerable tonal control is obtained if a visual stimulus is not present to overshadow tonal control.

The question remains why control develops with either auditory or visual stimuli when subjects' responding is reinforced in the presence of a stimulus. We would suggest that in both instances, unscheduled sources of differential training produce the observed control. Possible sources of differential training are readily apparent when a visual stimulus is located on the response key, *e.g.*, responses to the stimulus on the key are reinforced, whereas responses to other stimuli off the key are not reinforced. Possible sources of differential training are not so apparent when an auditory stimulus is employed. However, one possible source concerns the fact that responses are re-

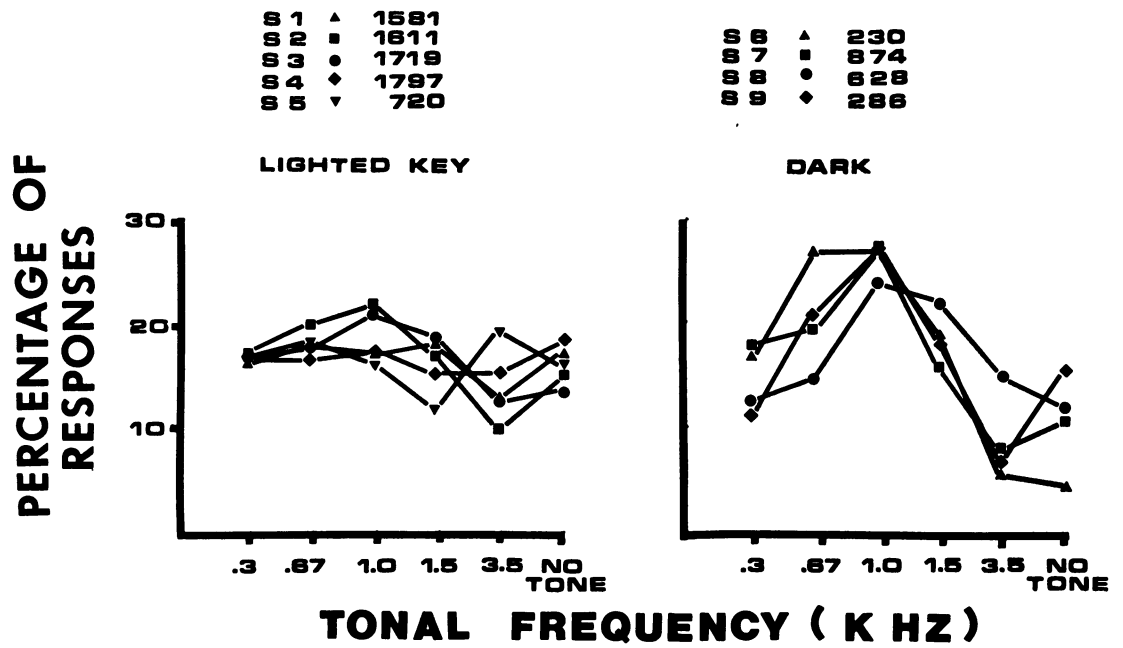

Fig. 2. Percentage of total responses given to each of the tones during the generalization test. Total responses made on the test are presented in the subject legend.

inforced in the chamber in the presence of the tone and are not reinforced outside of the chamber in the absence of the tone. Thus, the tone may inform the subject that the environment containing the possibility of reinforcement is present. Notice that this cue property of the tone might well be overshadowed by visual stimuli, given that a pigeon normally identifies its environment on the basis of visual stimuli.

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