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THE DEVELOPMENT OF STIMULUS CONTROL WITH AND WITHOUT A LIGHTED KEY[1]

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In two experiments, the effect of an illuminated response key on the acquisition of stimulus control by an airflow stimulus was assessed. In the first experiment, pigeons were given nondifferential training with airflow emerging from behind the response key in one of three conditions of illumination: trained to peck a lighted key, trained to peck an unlighted key with a houselight present, trained to peck a key in total darkness. After 10 days of training on a variable-interval schedule of reinforcement, all subjects were given a generalization test on airflow velocity. The gradients for subjects trained in the dark were sharp, while those for subjects trained in lighted conditions were shallow. In the second experiment, the effect of an irrelevant keylight on the acquisition of an airflow velocity discrimination was assessed. Two groups of pigeons were trained to discriminate two airflow velocities. One group was trained with a lighted response key and the other was trained to peck the response key in total darkness. The dark-trained subjects acquired the discrimination more rapidly. The results demonstrate that the acquisition of stimulus control by airflow with either a differential or nondifferential training procedure can be overshadowed by keylight.

Following key-peck training in the presence of a single tonal frequency, there is little stimulus control on the tonal frequency dimension (Jenkins and Harrison, 1960). This finding was of particular significance because animals trained to peck a key illuminated by monochromatic light yielded a gradient along the wavelength continuum (Guttman and Kalish, 1956). Why rather similar training procedures yielded dissimilar results with respect to different stimulus continua is an unanswered question.

One possible explanation for these results is that the visual stimuli in the chamber, particularly the lighted key, overshadowed control by the tone in the Jenkins and Harrison (1960) experiment. Overshadowing is said to occur when the control over responding exhibited by one stimulus is reduced by the presence of a second stimulus (Miles, 1965). Thus, overshadowing of the tone by keylight in the Jenkins and Harrison (1960) experiment would be said to occur if training on the tone alone produced more tonal control than training on the tone-keylight compound. In the Guttman and Kalish (1956) experiment, overshadowing by the keylight was not likely because the training stimulus was presented on the key. The degree of control obtained by a nonvisual stimulus might therefore be inversely related to the degree of control inadvertently obtained by visual stimuli.

One method of testing the plausibility of this explanation is to demonstrate that the degree of control obtained along a non-visual dimension is a function of the presence or absence of visual stimulation in the chamber. Animals trained to peck a key in a totally dark chamber should show much better control on a non-visual dimension than animals trained to peck in an illuminated chamber.

Ideally, the non-visual dimension employed should provide cues to the location of the key in order to ensure a substantial response rate in a dark chamber. Airflow emerging from behind the response key should produce differential cues as to the key's location (Van Houten, Seraganian, and Rudolph, 1972).

Therefore, the purpose of the present experiment was to determine the degree of control acquired by airflow as a function of the presence or absence of illumination.

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EXPERIMENT I

METHOD

Subjects

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

Apparatus

The experimental chamber was 12 in. high, 12 in. wide and 12 in. long (30 by 30 by 30 cm). A transparent response key 1 in. (2.5 cm) in diameter was located 8.25 in. (21 cm) from the floor of the chamber directly above the feeder aperture. The key was back-illuminated by white light from an IEE projector mounted 1.25 in. (3 cm) behind the key. Reinforcers consisted of 4-sec access to grain.

The airflow, which was produced by a Lau model DD9-9A direct-drive blower (Lau Blower Co., Dayton, Ohio), was directed into a retaining chamber. The operation of solenoid-driven valves permitted air to flow from the retaining chamber through a 1.55 in. (4 cm) diameter tube to an airtight box that contained the projector. The air then emerged from behind the slightly recessed pigeon key into the experimental chamber. The air was evacuated through holes in the right wall and through the magazine aperture.

The velocity of the airflow was measured by a Dwyer wind speed indicator (F. W. Dwyer Mfg. Co., Michigan City, Ind.) that consisted of a pitot tube and a fluid manometer. This device was calibrated against a national Physical Laboratory elipsoidal pitot tube with an electronic manometer in a wind tunnel. All airflow velocity measurements were taken 1 in. (2.5 cm) from the key at key level. The houselight was a 24-v bulb on the wall opposite the key. The effective voltage across the bulb was reduced to 16 v with a potentiometer.

Procedure

Subjects were trained to peck a key under one of three conditions. The first group (Subjects 1 to 4) pecked a lighted key with no other source of illumination. The second group (Subjects 5 to 8) pecked an unlighted key with a houselight on. The final group (Subjects 9 to 12) pecked a dark key with no light source available. *In all three conditions a 30-mph airflow was present.*

Trained with Keylight On

The only source of illumination in this condition was the keylight. Preliminary key-peck training for Subjects 1-4 consisted of approximately 50 reinforced key pecks on Day 1. There were then 40 additional reinforcements a session according to the following schedules: Day 2, CRF (each response produced reinforcement); Days 3 and 4, variable interval 15-sec (VI 15-sec). During the next 10 days, all subjects received training on a VI 1-min schedule of reinforcement. Each session consisted of 15 identical 2-min periods, with each period separated from the next by a 10-sec timeout period during which both the keylight and airflow were terminated.

Trained with Houselight On

The only source of illumination in this condition was the houselight. During the timeout periods, the houselight and airflow were off. In all other respects, these subjects were trained identically to the subjects in the keylight condition.

Trained in Dark

Subjects in this condition (9 to 12) were first trained to peck the key in the presence of the houselight. Toward the end of the session however, the houselight intensity was gradually decreased until the pigeon was pecking in complete darkness. If the subjects did not respond in the dark at the onset of the second or third session, the houselight was turned on at reduced intensity until a response occurred. Then, the houselight was quickly faded out. All subjects started responding in the dark after the third session was completed. In all other respects, these subjects were trained identically to the subjects in the keylight condition.

Generalization Testing

After 10 days on the VI 1-min schedule, all subjects were given a generalization test on the airflow velocity dimension. Subjects in the keylight condition were tested with the keylight on; subjects in the houselight condition were tested with the houselight on, and subjects in the dark condition were tested in a dark chamber. Therefore, all the lighting conditions during the test were identical to those during training. All pigeons were tested during extinction of key pecking. The test stimuli, airflows of 0, 10, 15, 20, and 30 mph, were randomized within blocks and were presented for 10 blocks. Test stimulus presentations lasted 1 min and were separated from each other by a 10-sec timeout period as in training.

Results and Discussion

Subjects in all conditions learned to key peck and rarely responded during timeout. The total number of responses to the training valve on the last day of training and during the generalization test are presented in Table 1. It is apparent that there is considerable overlap among the groups in responding to the training stimulus both before and during the generalization test. Thus, the slope differences described below cannot be attributed to rate differences among these three groups.

Table 1

The total number of responses emitted to the training valve during the generalization test and on the last day of training.

KEYLIGHT			*HOUSELIGHT*			*DARK*		
	Train	*Test*		*Train*	*Test*		*Train*	*Test*
S1	408	298	S5	713	230	S9	1018	80
S2	1008	427	S6	1675	543	S10	1143	316
S3	1292	266	S7	1155	383	S11	1098	374
S4	1802	512	S8	1023	147	S12	767	494

In Figure 1, the number of responses that each subject emitted to each stimulus is expressed as a percentage of the total responses emitted to all stimuli. All of the subjects trained in the dark condition gave sharp gradients while the gradients of all but one subject (Subject 1) in the key and houselight training conditions were relatively shallow.

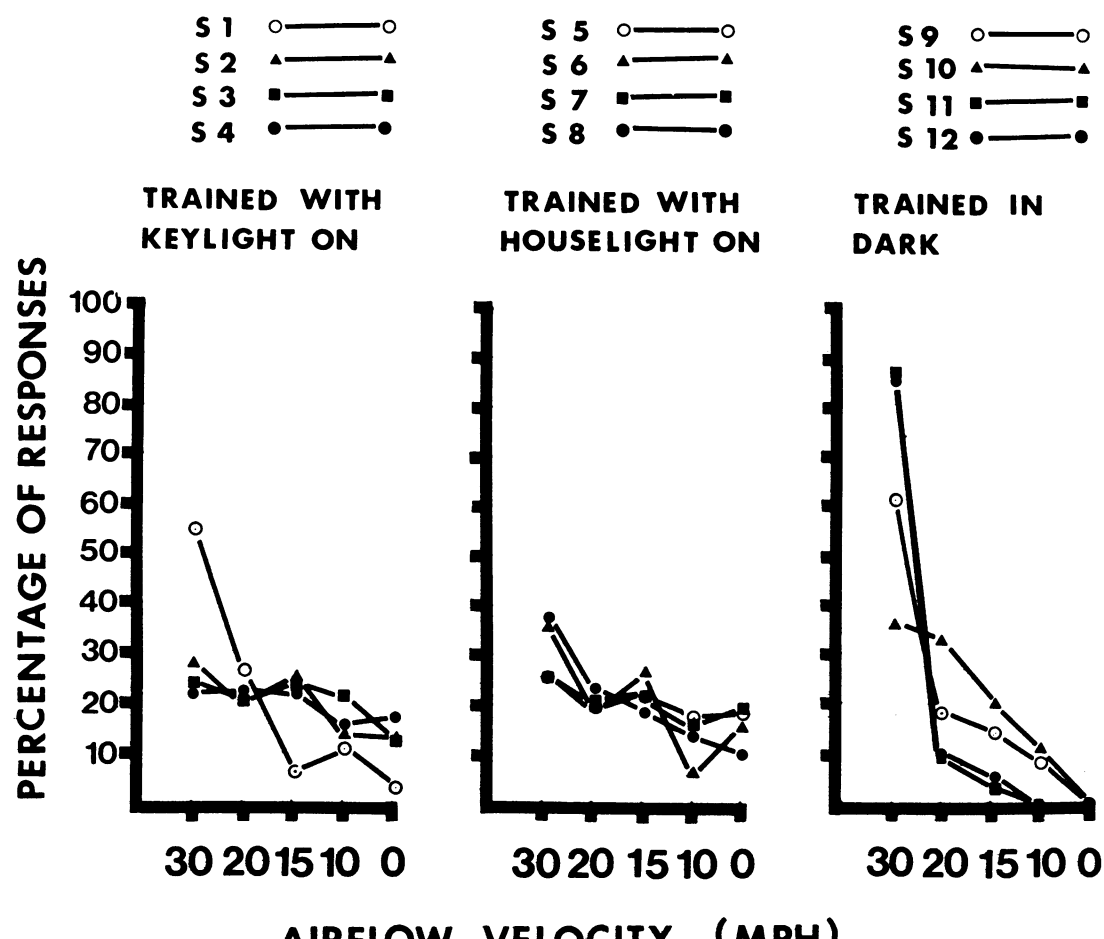

Fig. 1. Percentage of total responses given to each of the airflow velocities during the generalization test.

The results indicate that the presence of light reduced the control acquired by the airflow; thus, by definition, light overshadows airflow. It is plausible, therefore, that other nonvisual stimuli (*e.g.*, tones) might more readily acquire control over behavior if pigeons were taught to peck in the absence of visual stimulation.

Since visual stimulation overshadows stimulus control with a non-differential training procedure, it may also retard the acquisition of stimulus control with a differential training procedure. The following experiment was designed to investigate the role played by visual stimuli in differential training.

EXPERIMENT II

The previous experiment demonstrated that a stimulus present in almost all stimulus control research employing pigeons—the keylight or houselight—is capable of overshadowing what would otherwise be a very effective stimulus—airflow. Therefore, in discrimination training on a non-visual dimension, it is possible that irrelevant visual stimulation might gain some control over behavior early in training. The control gained by the irrelevant visual stimulation could retard the acquisition of the discrimination. As training progressed, however, the relevant cue should eventually regain this control because it more reliably predicts reinforcement.

The purpose of the present experiment was to determine whether subjects trained on a difficult airflow velocity discrimination would learn more slowly if an irrelevant keylight was present during training.

METHOD

Subjects

Eight eight-month old experimentally naive Silver King pigeons were maintained at 80% of their free-feeding weights.

Apparatus

The apparatus was the same as that employed in the previous experiment.

Procedure

Subjects were trained to peck a key in the presence of one of two conditions. The first group (Subjects 1 to 4) was trained to peck in the presence of an airflow-keylight compound and the second group (Subjects 5 to 8) was trained to peck a dark key in the presence of an airflow with no source of illumination in the chamber. All subjects were then trained on an airflow discrimination with either a 10-mph airflow signalling the availability of reinforcement (S^D) and a 20-mph airflow signalling extinction (S^Δ), or *vice versa*.

Subjects Trained to Peck a Lighted Key

Subjects in this group were trained to peck the key in the presence of a keylight-airflow compound. Half the subjects (Pigeons 1 and 2) were trained to peck the lighted key in the presence of a 10-mph airflow and the remaining half (Pigeons 3 and 4) were trained to peck in the presence of a 20-mph airflow. Preliminary training consisted of 50 reinforced key pecks on Day 1 followed by variable-interval training with progressively longer variable-interval schedules. On Day 6, all subjects were on a VI 30-sec schedule. After three more days on VI 30-sec, all subjects began training on the airflow discrimination.

Subjects Trained to Peck in the Dark

Subjects in this group were trained to peck the key in the presence of a houselight-airflow compound. Half the subjects (Pigeons 5 and 6) were trained to peck in the presence of a 10-mph airflow and the remaining half (Pigeons 7 and 8) were trained to peck in the presence of a 20-mph airflow. During the first two sessions, the intensity of the houselight was gradually decreased until the pigeons were pecking in complete darkness. Preliminary training was in every other respect identical to that of the subjects in the other condition.

Discrimination Training

After four days on the VI 30-sec schedule, the last two of which contained 10-sec timeout periods, all subjects began training on an airflow velocity discrimination. The airflow velocity present during initial training was designated as the stimulus that signalled reinforcement availability; the other airflow signalled extinction. All subjects received thirty-min periods per day. Responses were reinforced during half of the periods and were extinguished during the other half. Period order was random with the restriction that no more than two periods of the same stimulus could occur in succession. Each period was separated from the

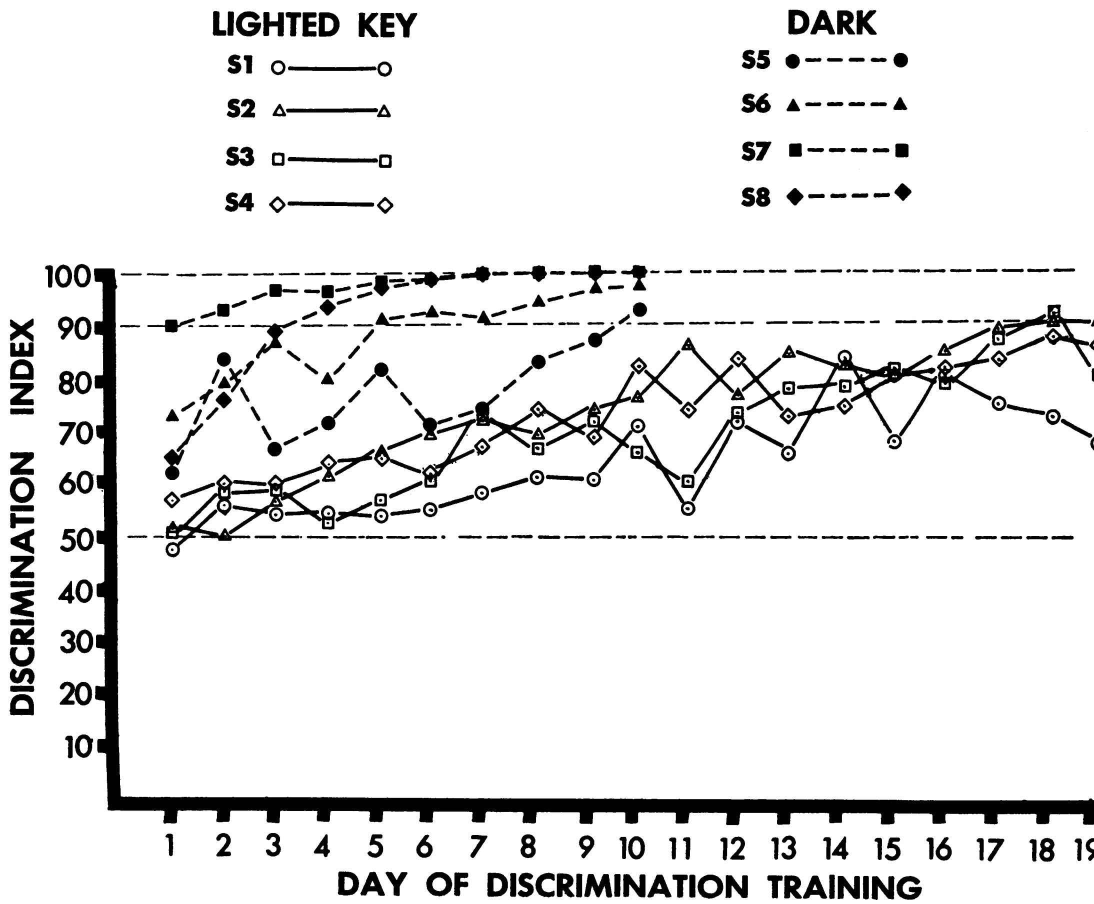

Fig. 2. Percentage of correct responses for each subject in each condition.

next by a 10-sec timeout period. Timeout periods consisted of the absence of both the keylight and the airflow. Responding was reinforced on a VI 30-sec schedule throughout discrimination training.

Results and Discussion

Results for the discrimination acquisitions are presented in Figure 2. All of the dark-trained subjects performed better on the first day of discrimination training than did the keylight-trained subjects. Furthermore, all subjects trained in the dark condition obtained discrimination ratios of 90% or better by Day 10, while none of the subjects in the keylight condition reached 90% until Day 18. There were no points of overlap between any of the subjects in either group, although one subject in the dark condition (Pigeon 5) performed almost as poorly as the better keylight subjects on Days 6 and 7.

The total number of responses emitted during S^D and S^Δ periods for the first and tenth day of discrimination training is presented in Table 2. Considerable overlap is apparent in

Table 2

Total number of responses emitted in the presence of the S^D and S^Δ on the first and tenth day of discrimination training for all subjects.

	KEYLIGHT					*DARK*			
	Day 1		*Day 10*			*Day 1*		*Day 10*	
	S^D	S^Δ	S^D	S^Δ		S^D	S^Δ	S^D	S^Δ
S1	729	802	1177	750	S5	536	330	902	71
S2	2093	1991	2398	750	S6	427	160	353	12
S3	665	645	796	414	S7	849	95	1397	2
S4	677	505	1322	283	S8	558	304	896	1

responses emitted in the presence of the S^D between these two groups throughout training. Therefore, the differences in rate of discrimination acquisition cannot be attributed to differences in response rate.

The discrimination performance on Day 1 of the subjects in this experiment may be viewed as systematic replication of the result of Experiment 1. In the present experiment, all subjects were given nine days of training in the presence of the positive stimuli before discrimination training. Thus, the first day of discrimination training may be viewed as a generalization test in which responses to the original training value were reinforced and responses to a generalized stimulus were extinguished. The fact that all subjects trained in the dark had substantially higher discrimination ratios (steeper generalization gradients) on Day 1 than any of the subjects trained in the light is in agreement with the results of Experiment 1.

The results of this experiment clearly suggest that the presence of a strong irrelevant cue during discrimination training retards discrimination acquisition. This finding may explain why Terrace (1963) noticed that subjects trained on a discrimination after prolonged VI training acquired the discrimination more slowly than subjects that received little VI training. It is probable that the exposure to prolonged VI training allowed other irrelevant stimuli to acquire control over behavior. Thus, when discrimination training was started, the relevant cues had to regain control from these irrelevant cues.

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