AIRFLOW AS A DISCRIMINATIVE STIMULUS¹

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In one experiment, pigeons were taught to discriminate airflow by having availability of reinforcement signalled by its presence and extinction signalled by its absence. After they reached criterion, some were trained on a discrimination reversal. Others were trained on an intradimensional discrimination with a low airflow velocity associated with reinforcement and a higher airflow velocity associated with extinction. All discriminations were learned rapidly, indicating that airflow velocity can function as a discriminative stimulus. In the second and third experiments, naive pigeons were trained to discriminate the presence of a compound stimulus (one of three tonal intensities paired with one of three airflow velocities) from its absence. These pigeons were subsequently given a component stimulus test during extinction on four stimulus values; the two training values, the tone alone, and the airflow alone. High or moderate velocity airflow controlled more responding than any of the three tone intensities. However, low velocity airflow controlled more responding only when a low intensity tone was employed.

One of the problems encountered in using pigeons for psychological research is that their behavior appears to be controlled primarily by visual stimulation. This creates difficulties whenever one employs an experimental paradigm that requires stimuli from two or more modalities. The typical solution used with other organisms is to employ auditory stimulation. However, it is difficult to develop auditory control in pigeons unless very high intensity tones are utilized (Blough, 1969; Heise, 1953).

The purpose of the first experiment was to determine the efficacy of airflow velocity as a discriminative stimulus. Since pigeons probably use airflow cues for flight, it may be possible to use such cues as effective discriminative stimuli in the laboratory.

EXPERIMENT I

METHOD

Subjects

Twelve 6-month-old experimentally naive Silver King Pigeons were maintained at 80% of their free-feeding weights.

Apparatus

The experimental chamber was 12 by 12 by 12 in. (30 by 30 by 30 cm). A transparent response key 1 in. (2.5 cm) in diameter was located 8.5 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 to the experimental chamber. Three different valves controlled three modes of presentation, which were called Key, Side, and Diffuse; a diagram of the three modes is shown in Figure 1.

Key-source airflow was presented by operating a valve that allowed air to flow through a

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Fig. 1. A schematic representation of the pigeon chamber viewed from above. The three modes of presentation, Diffuse, Key, and Side are represented with vectors indicating the airflow direction.

1.5 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.

Side-source airflow was presented by operating a valve that allowed air to flow through a 1.5 in. (4 cm) diameter tube attached to the right wall of the pigeon chamber at key level. This allowed side flow across the key.

Diffuse-source airflow was presented by operating a valve that allowed air to fill a box adjacent to the pigeons' chamber. The air then flowed through holes on the left wall of the pigeon chamber. With all airflow modes, 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., Mich. City, Ind.), which consisted of a pitot tube and a fluid manometer. This device was calibrated against a National Physical Laboratory ellipsoidal pitot tube with an electronic manometer in a wind tunnel. All measurements were taken 1 in. (2.5 cm) from the key at key level. Fan speed was measured with a Jaquet model 39772-251 1000 rpm gauge (R. H. Nichols Co. Ltd., Toronto).

Procedure

Preliminary key-peck training consisted of approximately 50 reinforced key pecks on Day 1. During the next four days, the schedule was changed from variable interval 10-sec (VI 10-sec) to VI 30-sec. Then, all subjects received

five 30-min sessions on a Catania and Reynolds (1968) constant probability VI 30-sec schedule. The schedule remained in effect throughout the experiment. During all of this training, airflow was not present though the blower motor was turned on for the last two days of VI 30-sec training.

Discrimination Training

After pretraining, all pigeons were trained on a multiple schedule of reinforcement in which responding in the presence of airflow (S^D) was reinforced on a VI 30-sec schedule; responding in its absence (S^A) was extinguished (*mult* VI 30-sec EXT). The fan was running at 1125 rpm for all conditions. This produced an airflow velocity of 29 mph from the Key source, 25 mph from the Side source and 4 mph from the Diffuse source. Airflow velocities were not equated because we wished to employ the most discriminable stimuli that the apparatus was capable of producing. Therefore, the maximum fan speed was utilized in each condition.

The source of the airflow was the key for Subjects 1 to 4, the side for Subjects 5 to 8, and diffuse for Subjects 9 to 12. These three groups of subjects were called the Key, Side, and Diffuse groups respectively.

On the first 11 days of discrimination training all pigeons received six 4-min S^D periods and six 4-min S^A periods per day. Two orders of stimulus presentation were alternated every day. The stimulus orders were random with the restriction that no more than two periods of either stimulus could occur in a row. Each period was separated from the next by a 10-sec timeout during which the keylight and airflow were off.

After 11 days of discrimination training, the period duration was gradually reduced to 30 sec in order to insure that reinforcement density itself did not gain control over behavior as a discriminative stimulus. All subjects were shifted to two 24 two-minute periods on Day 12, to 24 one-minute periods on Day 15, and to 72 thirty-second periods on Day 17. Throughout these shifts, 10-sec timeouts separated periods and the number of S^D periods remained equal to the number of S^A periods.

Discrimination Reversal

On the nineteenth day of discrimination training two subjects from both the Side and

Diffuse conditions were given training with the values of S^D and S^A reversed. Subjects 6 and 8 were shifted to the new discrimination with no airflow as S^D and a 25-mph airflow from the Side source as S^A . Subjects 10 and 12 were shifted to no airflow as S^D and a 4-mph airflow from the Diffuse source as S^A . These four subjects were chosen because they were the best two in their groups on the original discrimination; the remaining four subjects in these two groups were discarded. All reversal subjects received 24 two-minute periods for 10 days.

Second Discrimination

On the nineteenth day of discrimination training, Key Subjects 1, 2, and 3 were shifted (Subject 4 was discarded because of illness) to a more difficult intra-dimensional discrimination with responses reinforced in the presence of an 11-mph airflow and extinguished in the presence of a 25-mph airflow. Thus, the S^D velocity was lower than the S^A velocity, whereas the reverse was true during the original discrimination. All subjects received 24 two-minute periods each day for 12 days. On the following day, each pigeon was given a generalization test during extinction of key pecking. The test stimuli, airflows of 7, 11, 15, 25, and 29 mph, were randomized within blocks and were given until the subject ceased to respond for one complete block. Test stimulus presentations lasted 30 sec and were separated from each other by a 10-sec timeout.

RESULTS AND DISCUSSION

Results for the acquisition of all of the discriminations are presented in Figure 2. The airflow velocity discriminations with the presence of airflow as S^D and the absence of the airflow as S^A are presented on the left-hand side of Figure 2. All 12 animals acquired the discrimination and reached near-asymptotic performance in six days. The different methods of presentation did not greatly influence the speed of acquisition. However, two birds in the Key condition, Subjects 1 and 3, maintained asymptotes of 94% or greater for the last six days of training with 4-min stimulus periods. Birds in the Diffuse and Side wind conditions did not sustain such high asymptotes. The gradual shift to shorter stimulus periods did not appear to disrupt the birds' performances markedly, with the possible ex-

ception of Subjects 9 and 11 in the Diffuse condition on the shortest duration.

Discrimination Reversal

The four birds in the discrimination reversal condition initially performed below 50% correct but rapidly learned to suppress responding in the presence of the airflow and to respond in its absence. The levels of performance attained in this task were similar to those observed in original acquisition.

Second Discrimination

The intra-dimensional velocity discrimination with the higher velocity airflow as S^A was acquired by all birds. After nine days of training the three birds maintained discrimination performances of 85% or better. These asymptotes appeared to be slightly lower than the asymptotes of the initial discrimination, presumably reflecting the greater difficulty of the second discrimination.

In Table 1, the number of responses that each Key subject emitted to each airflow value on the generalization test is expressed as a percentage of the total responses emitted. All subjects emitted the major portion of their responses to the 7-mph stimulus and to the 11-mph stimulus (S^D). The fact that all three subjects emitted somewhat more responses to 7 than to 11 mph is mildly suggestive of a peak shift effect. There was very little responding to 25 mph (S^A) and to 29 mph and an intermediate level of responding to 15 mph, the velocity between S^D and S^A .

Table 1

Percentage of total responses emitted by each bird to each of the stimulus conditions.

Subject Number	Test Stimuli in mph					Total Number of Responses
	7	11(S^D)	15	25(S^A)	29	
1	38.9	37.1	21.8	0.7	1.5	1171
2	42.9	37.9	16.4	2.9	0.0	140
3	41.7	36.4	17.8	2.7	1.4	1083

Three aspects of the present data support the conclusion that airflow velocity can be a discriminative stimulus. First, the initial discriminations with airflow as S^D were acquired rapidly. Second, reversals of these discriminations and intra-dimensional discriminations were also acquired rapidly. Finally, orderly post-discrimination gradients were obtained.

Fig. 2. Mean discrimination index per training session. The discrimination index was calculated by dividing the number of responses during S^D by the total number of responses during S^D and S^A . At A, the period duration was decreased from 4 min to 2 min. At B, the period duration was decreased to 1 min, and at C, the period duration was decreased to 30 sec. Period duration was increased to 2 min in the second discrimination or reversal.

EXPERIMENT II

Given that airflow can function as a discriminative stimulus, the practical question for the experimenter who wishes to employ a non-visual stimulus with pigeons becomes: which is more discriminable, tones or airflow? One

way to assess the relative discriminability of two stimuli is to train animals on a discrimination with the presence of both stimuli signalling the availability of reinforcement and the absence of both stimuli signalling extinction. The animals can then be presented with the individual stimuli that makes up the com-

pound stimulus in order to determine the amount of control that each acquired (Reynolds, 1961).

The purpose of the present experiment was to compare the relative discriminability of a 90-dB tone to three airflow velocities.

METHOD

Subjects

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

Apparatus

The apparatus was the same as in the previous experiment. Sound level readings were taken with a General Radio model 1551 sound level meter, scale C, with the microphone located 1 in. (2.5 cm) in front of the key.

Procedure

Over three sessions, the subjects were trained to peck an illuminated key on continuous reinforcement and were then gradually shifted to a VI 1-min schedule. Tones and airflows were absent during these three days, though the blower was turned on during the third day.

On Day 4, all pigeons were shifted to a *mult* VI 1-min EXT schedule with the presence of both airflow from the key and a 2000-Hz 90-dB tone as S^D and the absence of both the airflow and the tone as S^A . The airflow velocities were 30.8 mph for Pigeons 1 to 3, 16 mph for Pigeons 4 to 6, and 7.8 mph for Pigeons 7 to 9. On the first four days of discrimination training, all pigeons received twelve 4-min periods a day. During six of these periods, S^D was presented and key pecks were reinforced on VI 1-min; during the remaining six periods, S^A was presented and key pecks were not reinforced. The order of S^D and S^A periods was random with the restriction that no more than two periods of the same kind could occur consecutively. Each period was separated from the next by a 10-sec timeout during which the key-light, tone, and airflow were off.

On Day 5 of discrimination training, the period duration was reduced to 2 min and the number of periods was increased to 16. Following this manipulation, each pigeon was given a component stimulus test on the first day after it emitted at least 90% of its total responses during S^D .

Component Stimulus Test

All subjects were tested during extinction of key pecking with four test stimuli, the order of which was randomized within each stimulus block. The test stimuli were the S^D present during training, the tone, the airflow present during training and S^A . Each stimulus presentation was 1 min in duration and was separated from the next stimulus by a 10-sec timeout. Each subject was tested until it did not respond to an entire block of stimuli or for 15 complete blocks, whichever came first.

RESULTS AND DISCUSSION

Results for the acquisition of the discrimination with each of the three velocities are presented in Figure 3.

Fig. 3. The mean discrimination index per training session. The broken vertical line indicates the transition from 4 min to 2 min periods.

In spite of the fact that a very loud tone was paired with the airflow in all three groups, it appeared that greater airflow speeds produced faster acquisition. However, this observation must be qualified because, there was very little difference between the 30.8- and 16-mph groups on Day 4 and because there was no dif-

ference between the 16- and 7.8-mph groups in terms of days to the 90% correct criterion.

It can also be observed that five of the nine subjects were disrupted when the period duration was decreased from 4 to 2 min. However, all subjects recovered and reached criterion in 10 days or less.

The results of the component stimulus test are presented in Figure 4. In this figure the number of responses emitted to each of the four test stimuli (S^D = airflow and tone; W = airflow; T = tone; and S^A = absence of airflow and tone) is expressed as a percentage of the total test responses. The results indicated that the 30.8 and 16 mph airflow acquired more control over responding than did the 90-dB tone. Furthermore, airflow control appeared to be more complete in the 30.8-mph group than in the 16-mph group. However, the 90-dB tone acquired more control than did the airflow velocity in the 7.8-mph group. The results of the 7.8-mph airflow group raised the ques-

tion of how effective this airflow would be when compared with lower tonal intensities. In order to answer this question, the following experiment was performed.

EXPERIMENT III

METHOD

Subjects

Six 6-month-old experimentally naive, Silver King Pigeons were maintained at 80% of their free-feeding weight.

Apparatus

The apparatus was the same as in the previous experiment.

Procedure

The procedure was identical to that employed in Experiment II, except that in the present experiment two different tonal intensities were compared to the 7.8-mph airflow from the key. Subjects 1 to 3 were trained with the airflow-80 dB compound as S^D ; subjects 4 to 6 were trained with the airflow-70 dB compound as S^D . As the in the previous study, S^A was the absence of the airflow-tone compound.

RESULTS AND DISCUSSION

The acquisition data for the two groups presented in Figure 5 show that the 80-dB tone group acquired the discrimination more

Fig. 4. Percentage of responding to each of the test stimuli during the stimulus component test. S^D is the stimulus that signalled reinforcement availability during training, i.e., the compound of the tone and airflow. W is the wind or airflow, T is the tone, and S^A is the absence of both the tone and airflow.

Fig. 5. The mean discrimination index per training session. The broken vertical line indicates the transition from 4-min to 2-min periods.

Fig. 6. Percentage of responding to each of the test stimuli during the stimulus component test. S^D is the stimulus that signalled reinforcement during training, i.e., the compound of the tone and airflow. W is the wind or airflow, T is the tone, and S^A is the absence of both the tone and airflow.

rapidly than the 70-dB group. Furthermore, acquisition for the 80-dB tone group was similar to acquisition for the 90-dB group with the same airflow (7.8 mph) in the previous experiment.

The results of the component stimulus test are presented in Figure 6. They indicated that

the 80-dB tone acquired more control over responding than did the 7.8-mph airflow while the 70-dB tone acquired less control than the 7.8-mph airflow. The results of the 80-dB tone group were almost identical to the results of the 90-dB tone–7.8-mph airflow condition in the previous experiment. This similarity parallels the similarity noted in the acquisition data of these two groups.

Experiments 2 and 3 demonstrated that the use of airflow as an S^D is an alternative to the use of loud tones as an S^D . Indeed, the results indicated that airflow is relatively more discriminable than loud tones over a wide range of airflow velocities.

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