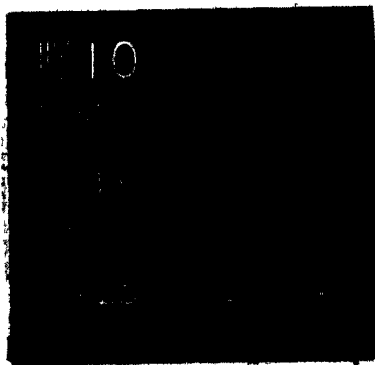


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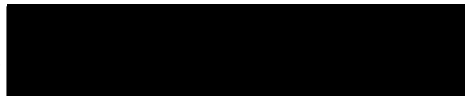
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OVERSHADOWING AND STIMULUS CONTROL

BY

a Ronald Van Houten

A thesis submitted to the Faculty of Graduate Studies
in partial fulfilment of the requirements for the
degree of Doctor of Philosophy.

Psychology Department

Dalhousie University

Halifax, Nova Scotia

September, 1971.

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OVERSHADOWING
AND
STIMULUS CONTROL

DALHOUSIE UNIVERSITY
FACULTY OF GRADUATE STUDIES

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled, Overshadowing and Stimulus Control, submitted by Ronald Van Houten in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Psychology.


Supervisor


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ABSTRACT

This research was designed to investigate the role played by overshadowing in stimulus control research. Overshadowing is said to occur when one stimulus prevents another stimulus from acquiring control. One of the major problems encountered when employing pigeons in such research is their tendency to be controlled primarily by visual stimuli. Hence, it was first necessary to discover a stimulus which would prove nearly as salient as visual stimuli. Airflow was thought to be such a stimulus. The results of the first experiment indicated this assumption was correct. In the second experiment subjects were trained to discriminate the presence of an airflow-tone compound from its absence. Different groups were trained with different airflow velocities. They were then tested with the individual elements of the compound presented alone. The results of the test showed that the amount that airflow overshadowed tone was directly proportional to the velocity of the airflow. In a second section of this experiment tonal intensity was varied while airflow velocity was held constant. The results of this manipulation indicated that the extent to which tone overshadowed airflow was directly proportional to tonal intensity. With these results in hand it was possible to conclude that the overshadowing process is symmetrical.

In the third experiment an attempt was made to demonstrate the importance of an illuminated key constantly present during

nondifferential training with airflow. The results of this study showed that the presence of light during training allowed visual stimulation to overshadow some of the control that would have otherwise been acquired by the airflow. In the fourth experiment subjects were trained on a difficult airflow discrimination with or without a keylight present. The results of this experiment clearly demonstrated that the presence of the irrelevant keylight during discrimination training slowed discrimination acquisition.

In the final chapter the implications of these findings were discussed and some possible explanations for the easy to hard effect and the effect of early vs late introduction of S^A were proposed.

CHAPTER I

1

INTRODUCTION

Pavlov (1927) reviewed the work conducted in his laboratory on what has now come to be known as the classical conditioning paradigm. Many of the functional relationships reported in this paradigm have been found in past years also to apply to the operant conditioning paradigm. One such principle which has just recently attracted the attention of operant investigators is that of overshadowing.

Overshadowing is said to occur when the control over responding exhibited by one stimulus following training is reduced by the presence of a second stimulus during training. Studies on overshadowing generally employ the following procedures. Subjects are assigned to one of two conditions: in the first condition they are trained to respond to a compound of stimulus A and stimulus B and tested during extinction with stimulus A; in the second condition subjects are trained for the same length of time with only stimulus A present. If stimulus A acquires more control in the second condition than in the first, it is said that stimulus B overshadowed stimulus A.

There are two procedures for regulating the amount of overshadowing obtained. The first method involves the manipulation of the intensity of either of the two stimuli. Zeliony (reported by Pavlov, 1927), working in Pavlov's

laboratory, explored the overshadowing phenomena using different stimuli within the same modality (auditory). He found that two stimuli gained equivalent control if they were of the same apparent intensity. However, if they were of different intensities, the one with the higher intensity primarily controlled the response.

Pavlov concluded from the above experiment that the "stronger" of two stimuli presented together gains primary control over the response. Additional studies indicated that this conclusion may be valid even when the two stimuli are from different modalities.

However, when two stimuli differ in modality it is difficult to state which is perceived as more intense. For example, there is no clear rule for equating brightness to loudness. However, it is possible to manipulate the intensity of either stimulus and hence, one can either increase the intensity of the overshadowed stimulus or decrease the intensity of the overshadowing stimulus. With both of these manipulations it is possible to reverse the effect with new subjects. That is, the previously ineffective stimulus now gains primary control over the response.

A second method of regulating the overshadowing effect was demonstrated by another of Pavlov's co-workers, Palladin (reported by Pavlov, 1927). He found that the "weaker" element of the compound could be made to control the response if the "stronger" element was presented alone without reinforcement. This method is essentially discrimination training

with the "stronger" of the two stimuli being irrelevant.

Although the above procedures for attenuating the overshadowing effect appear to be distinct, they can in fact be shown to be closely related. In classical conditioning experiments inter-trial intervals may be viewed as extinction correlated periods. One way of decreasing the intensity of the "stronger" stimulus is to increase the background noise level on its dimension from 0 to some fixed value during the inter-trial interval (ITI). Functionally this increase in background noise is equivalent to a decrease in absolute stimulus intensity. Clearly the limiting case exists when the stimulus is present at full intensity during both positive periods (CS) and negative periods (ITI). This is essentially equivalent to the second method of attenuating overshadowing by making the "stronger" stimulus irrelevant. This is not to say, however, that the two procedures yield identical results.

The Extension of Overshadowing to Operant Stimulus Control

In recent years operant researchers investigating stimulus control have discovered the relevance of overshadowing to their subject matter (Babb, 1957; Johnson and Cumming, 1968; Lovejoy and Russell, 1967, Miles and Jenkins, 1965; Newman and Baron, 1965; Sutherland and Andelman, 1967). In such experiments discriminative stimuli signal the availability of reinforcement (conditional upon a response) in much the same way that a CS in a classical conditioning experiment signals

the delivery of reinforcement.

Overshadowing has been demonstrated in an experiment by Newman and Baron (1965). After training subjects to respond to a white vertical line on a colored background they found that line orientation failed to gain stimulus control.¹ Baron (1965) suggested that the results were due to color overshadowing the presence of line since line orientation easily gained control when pigeons were trained on lines in the absence of color cues. Johnson and Cumming (1968) confirmed the overshadowing effect of color over line orientation and also found that pre-training on line increased its percentage of control.

Perhaps the most complete work done to date on overshadowing within the operant paradigm was reported in a Ph.D. thesis by Miles (1965). Much of this work has also been published in a paper with Jenkins (Miles and Jenkins, 1965). Miles and Jenkins (1965) ran a series of studies in which pigeons were trained to discriminate the presence of a stimulus compound from one of six stimulus conditions. Later, subjects were tested in order to determine which of the stimuli in the compound gained control of responding.

¹ Newman and Baron tested subjects with the colored background present. Freeman and Thomas (1967) obtained sloping line orientation gradients following similar training procedures when they tested without the colored background. However, the degree of control obtained here was still less than that exhibited by subjects trained without color.

Basically, all pigeons were trained to peck a key in the presence of a compound consisting of a tone and a lighted key (positive trials). All groups received the same intensity tone and key light during positive trials. However, the stimulus which signalled the absence of reinforcement (negative trials) was different for each of the six groups. It consisted of either no tone and no light or of no tone and one of five light intensities. The highest light intensity was the same as that present during positive trials.

After each subject had learned the discrimination he was tested during extinction of key pecking with each of the stimuli which made up the reinforced compound. It was found that the tone acquired almost all of the control when the light intensity was the same in both positive and negative trials and that the light acquired almost all of the control when the light was off during negative trials. In general, it was observed that greater light intensity during negative trials produced less control by light and more control by tone. Since increasing light intensity during negative trials is equivalent to decreasing the light intensity during positive trials, it may be concluded that lower relative light intensity during positive trials produces less control by light and more control by tone.

Another interesting result reported by Miles and Jenkins (1965) was that subjects trained in no-tone control groups gave sharper gradients on the light intensity dimension than did subjects trained with the tone present. Thus, they concluded that "each feature exerted some overshadowing effect on the other".

Although a good deal of research has been done on overshadowing within the operant paradigm, relatively little attention has been paid to its implications for discrimination learning. There are, in fact, some quite interesting implications which can be drawn from the above research. However, before drawing them it will be necessary to review a few fundamental experiments on discrimination learning.

Problems in Stimulus Control

There are two methods of producing stimulus control: nondifferential (single stimulus training) and differential. Training under the nondifferential method consists solely of periods in which the response is reinforced on some schedule in the presence of an unchanging environment. Differential training involves reinforcing responding in the presence of one stimulus situation and not reinforcing responding in a second stimulus situation. The two stimulus situations may differ in one or more stimulus elements. Thus differential reinforcement may occur with respect to a single stimulus change or with respect to a compound stimulus change.

The best known example of a stimulus developing control as the result of nondifferential training is found in the work of Guttman and Kalish (1956) where pigeons were trained to peck a key illuminated by monochromatic light of one of four wavelengths. On a subsequent generalization test all subjects exhibited stimulus control along the wavelength continuum.

If one were hasty he might conclude that nondifferential training on a stimulus is sufficient to guarantee the acquisition of stimulus control. However, a later study by Jenkins and Harrison (1960) destroyed this simple formulation. Here pigeons were trained to peck a key in the presence of a 1000 Hz tone. On a subsequent generalization test subjects failed to show good stimulus control along the tonal frequency dimension. Jenkins and Harrison did, however, manage to obtain good control by giving their subjects discrimination training with the presence of tone signalling reinforcement availability and its absence signalling extinction. Jenkins and Harrison (1960) speculated that the difference between their results and those of Guttman and Kalish (1956) might be due to the difference between their diffuse and Guttman and Kalish's localized stimulus. Heinemann and Rudolph (1963) have made a similar suggestion. Although this is possible, it could be pointed out that there are cases where diffuse stimuli have resulted in sloping gradients (Hearst, 1962).

As a result of these studies two principles were added to the stimulus control literature: First, that some stimuli

develop control as the result of nondifferential training while others do not, and second, that stimuli that gain little or no control as the result of nondifferential training may develop control as the result of explicit differential training (Miles, 1965). Just why rather similar training procedures yielded dissimilar results with respect to different stimulus continua remains something of a puzzle.

Nondifferential Training and Overshadowing

A possible answer to the above question emerges as an implication of Miles and Jenkins (1965) research. It will be recalled that they demonstrated that keylight was capable of overshadowing tone if it was presented along with the tone during positive trials and neither stimulus was presented during negative trials. If keylight can overshadow tone following differential training with both stimuli signalling reinforcement, it would seem reasonable that keylight could also overshadow tone following nondifferential training with both stimuli signalling reinforcement. Since Jenkins and Harrison (1960) trained subjects to peck a lighted key in the presence of a tone, it is possible that the keylight tended to overshadow the tone. If this explanation is correct, it would follow that subjects given nondifferential training in the absence of a keylight should show very sharp control on the tonal frequency continuum. The fact that tone acquired control following differential training with the keylight present during both positive and negative trials in the Jenkins and Harrison study is in agreement with this interpretation since this is equivalent to

Miles and Jenkins (1965) group which received training with the key light irrelevant.

In the Guttman and Kalish (1956) experiment overshadowing was not as likely since the hue of the keylight was the training stimulus. Thus Guttman and Kalish obtained spectral stimulus control since control by hue was not overshadowed; whereas, Jenkins and Harrison failed to obtain tonal stimulus control because it may have been overshadowed.

One method of testing the plausibility of this explanation is to demonstrate that the degree of control obtained along a non-visual dimension is inversely related to the salience of the visual stimulation in the chamber. Pigeons 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 the presence of a lighted key.

Differential Training and Overshadowing

If the above experiment yields the predicted results it would be interesting to further investigate the effect of a constant or irrelevant cue, like key light, on differential training on a non-visual dimension. One possible outcome would be that the irrelevant cue would have no effect on the rate with which the relevant cue gained control. This was in essence implicitly assumed by Miles and Jenkins (1965) when they reasoned that increasing the intensity of the keylight

in the negative trials was equivalent to decreasing the intensity of the key light during positive trials. However, it is quite possible that this assumption is incorrect.

It is also possible that a very salient stimulus might overshadow a much less salient one even though nondifferential reinforcement is provided on the former and differential on the latter. If the light is a sufficiently salient stimulus, it may acquire control early during discrimination training before the differential reinforcement contingency takes effect. If this occurs the tone will then have to gain control back from the keylight. It would be expected that such a discrimination might take longer than one in which the keylight was not present during training.

In fact, in most discrimination studies responses are reinforced in the presence of the positive stimulus for the first few days of training. This would allow keylight to gain control prior to the introduction of the negative stimulus. A number of studies have demonstrated that pretraining on one stimulus can block control by another stimulus when both stimuli are later presented together during training (Kamin, 1968; 1969; Miles and Jenkins, 1965; Seraganian and vom Saal, 1969). These studies are closely related to studies on overshadowing, since the latter show that if two stimuli together predict an event the more salient of the two will acquire the bulk of control. Pretraining on a particular stimulus can increase its control

over responding. Johnson, Kinder and Scarborough (1969) made use of this when they found that they could prevent color from overshadowing line orientation by pretraining on line orientation. By increasing the control by line orientation through pretraining it was possible for line orientation to overshadow color. Hence, the pretraining in blocking studies enables the cue to overshadow other stimuli in later training. This might possibly explain why Terrace (1963) found that subjects learned a discrimination more rapidly if negative periods were introduced early rather than late in training.

Research Exploring Control by Irrelevant Cues

A number of studies indicate that the control acquired by an irrelevant cue is dependent on the ease with which relevant cues can be distinguished (Haberlandt, 1971; Perkins, Hershberger and Weyant, 1959). Perkins, Hershberger and Weyant (1959) found that an irrelevant cue (a buzzer) acquired more control when it accompanied a difficult light intensity discrimination than when it accompanied an easy light intensity discrimination.

In a more recent classical conditioning experiment Haberlandt (1971) demonstrated that rabbits pretrained on an easy discrimination performed better on a more difficult discrimination than did subjects pretrained on that difficult discrimination. In all cases an incidental cue was present on both positive and negative trials. It was found that the irrelevant cue exhibited more control in the latter group than in the group that was pretrained on the easy discrimination. It was assumed by the author that the animals trained on the

difficult discrimination throughout the experiment performed more poorly because of the control acquired by the irrelevant cue.

It is possible that the irrelevant cues might have increased the time required to acquire the discrimination. However, Haberlandt (1971) did not run a control group trained on the difficult discrimination with the irrelevant cue absent. Such a control group would be necessary in order to conclude that the presence of irrelevant cues may overshadow relevant cues during the acquisition of a difficult discrimination.

The Development of a New Stimulus Dimension

Many of the studies proposed in the introduction of this thesis involved conditions in which pigeons were trained to peck in the dark. At the time this thesis was conceived it was believed that a pigeon would not peck a key in the absence of discriminative stimuli signalling its location. With this in mind, an attempt was made to develop an alternative directional stimulus to keylight. Airflow was one such stimulus which seemed to hold promise. It was thought that if it emerged from behind a key it would provide directional stimuli to signal the key's location.²

Before utilizing airflow as a discriminative stimulus it would be necessary to demonstrate its comparability to other

² The research was presented in this order for clarity. At the time the airflow studies were run the idea of overshadowing had not yet been considered. This thesis is a good example of how hindsight can fit data into established modes of organization.

more commonly used stimuli. This would involve a demonstration that pigeons could form airflow on-off discriminations and intradimensional discriminations (a discrimination between two airflow velocities). It might also be interesting to establish whether subjects could perform discrimination reversals and would yield orderly gradients of generalization.

Summary of Proposed Experiments

This thesis is divided into four sections. The first section is concerned with the development of airflow as a viable discriminative stimulus for pigeons. The second section contains a replication of Miles's research on overshadowing employing airflow and tones rather than keylight and tones. The primary difference between these studies and those by Miles was that the intensity of both stimuli were varied. Hence, it was possible to demonstrate the symmetrical nature of the overshadowing effect. The third section tests the hypothesis that a nonvisual stimulus will gain less control if a keylight is present than if it is absent. The final section investigates the role played by irrelevant stimuli during discrimination learning.

CHAPTER 2
EXPERIMENT 1

In order to examine the role keylight plays in the overshadowing of other stimuli it will first be necessary to develop a stimulus which would enable pigeons to peck a key in the dark. Such a stimulus should provide cues as to the location of the response key. The traditional alternative to visual stimuli are auditory stimuli. However, it is difficult to develop auditory control in pigeons unless very high intensity tones are utilized (Blough, 1969; Heise, 1953). Furthermore, it is unlikely that pigeons could use auditory cues to reliably locate the key. Hence, the development of a new stimulus dimension was necessary before further studies could be undertaken.

The purpose of the first experiment was to determine the efficacy of airflow velocity as a discriminative stimulus. Since pigeons must utilize discriminative stimuli provided by airflow for flight it might be expected that stimulation provided by airflow might be a salient stimulus which could easily acquire control over other behaviors. Furthermore, it seemed likely that a pigeon could localize the source of an airflow. If so, airflow emerging from behind a response key would provide cues to the key's location and could, therefore, control responding in a totally dark chamber.

Subjects

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

Apparatus

The experimental chamber was 30 cm high, 30 cm wide and 30 cm long. A transparent response key 2.5 cm in diameter was located 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 3 cm behind the key. Reinforcers consisted of a four 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 of airflow presentation is shown in Figure 1.

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

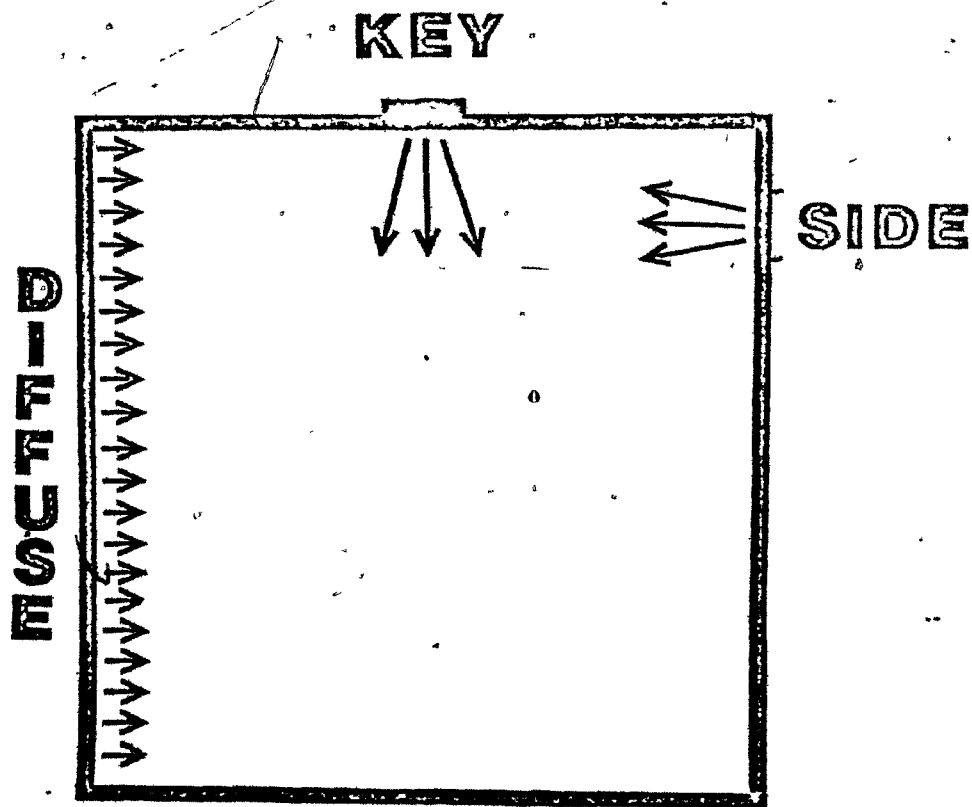


Fig. 1. A schematic representation of the top view of the conditioning apparatus illustrating the three modes of airflow presentation.

that allowed air to flow through a 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 110 equally spaced 6 mm diameter holes on the left wall of the pigeon chamber. With all airflow modes, the air was evacuated through 110 equally spaced 6 mm diameter holes in the right wall and through the magazine aperture.

Air flowing into the chamber made no noise that was detectable by human observers. However changes in fan speed did produce easily discriminable changes in loudness and pitch. Therefore, in all experiments in which the presence and absence of airflows served as discriminate stimuli fan speed was held constant and the valve controlling airflow was simply opened and closed. There are, however, two instances in this thesis where fan speed was varied in order to produce an intradimensional airflow velocity discrimination learning situation. In these instances it is possible that the tonal intensities produced by the different fan speeds acquired some control. The first instance occurs in a portion of the present experiment; the other instance occurs in experiment 4.

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 2.5 cm from the key at key level. Fan speed was measured with a Jaquet model 39774-251 1000 rpm gauge (R.H. Nichols Co. Ltd., Toronto).

Procedure

Preliminary key peck training consisted of approximately 50 reinforced key pecks on day one. 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 & 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

Following 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 while responding in its absence (S^Δ) 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, since we wished to employ the most discriminable stimuli that our 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 1-4, the Side for subjects 5-8, and Diffuse for subjects 9-12. 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 6 four-min S^D periods and 6 four-min S^A periods per day. There were two orders of stimulus presentation; these 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 key light 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 did not exhibit control. All subjects were shifted to 24 two-minute periods on day 12, to 24 one-minute periods on day 15, and to 72 30-sec 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 19th 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 subjects in their groups on the original discrimination. The remaining four subjects in these two groups were discarded. All reversal subjects received 24 two-min periods for 10 days.

Second Discrimination

On the 19th day of discrimination training Key subjects 1, 2 and 3 were shifted (subject 4 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-min 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 twelve 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. The gradual shift to shorter stimulus periods did not appear to disrupt the birds' performances markedly, with the possible exception 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

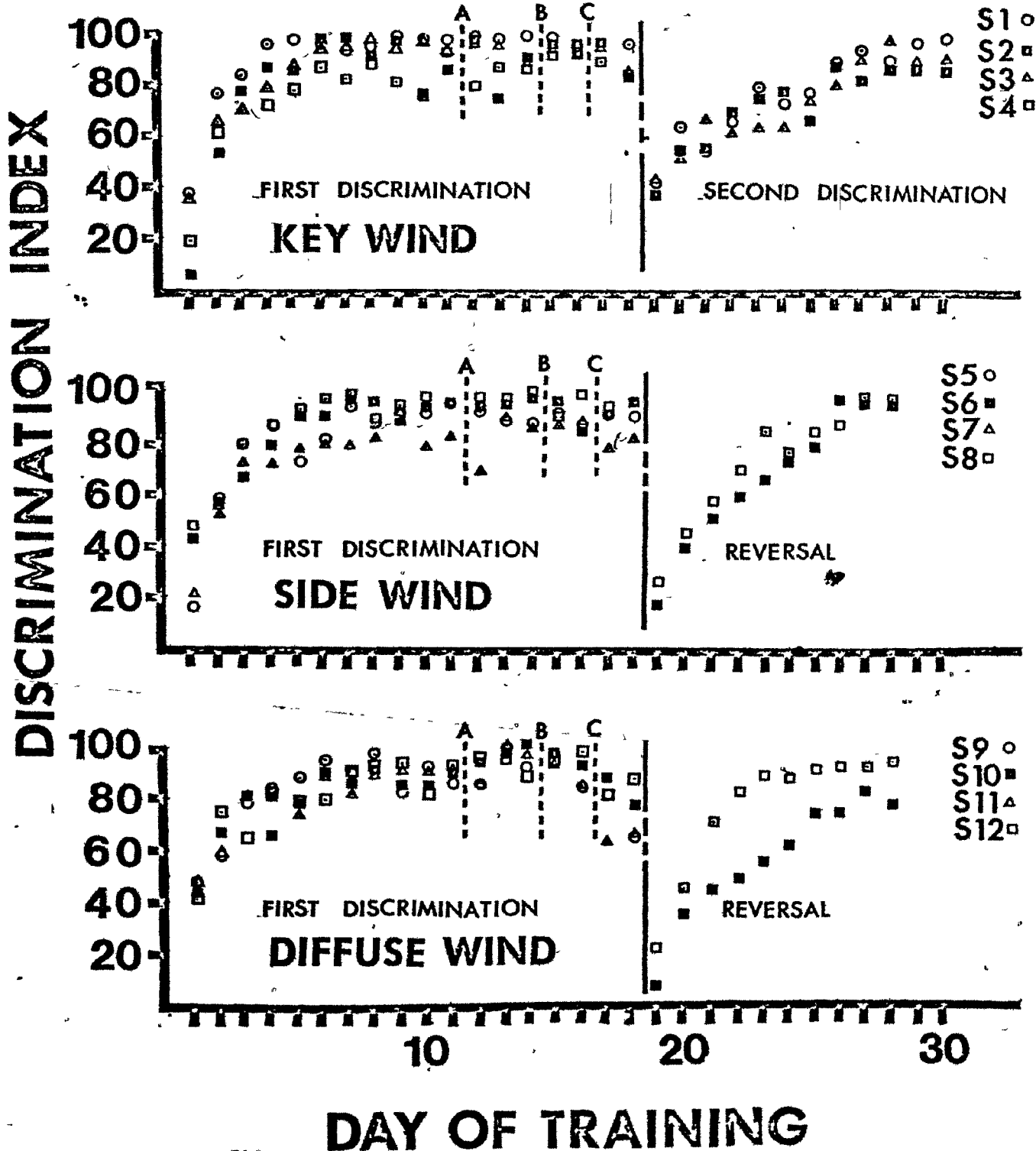


Fig. 2. Percentage of responding to reinforced stimulus for each subject in each condition over days of training. At A the period duration was decreased from 4 min to 2 min. At B it was decreased to 1 min, at C the period duration decreased to 30 sec. Period duration was increased to 2 min in the second discrimination or reversal.

higher velocity airflow as S^A was acquired by all birds. Following 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.

It should be noted that the second discrimination performance of these subjects may have been controlled in part by the differential auditory stimulation provided by the fan motor. It seems unlikely, however, that this source of stimulation, as opposed to the different airflow velocities, was primarily responsible for the observed discrimination performance. Support for this assertion comes from the facts that (1) subjects learned presence vs. absence of airflow discriminations and their reversals quite rapidly in a situation where differential auditory cues were not present (fan motor speed held constant) and that (2) it is part of the folklore among pigeon runners and occasionally reported (e.g., Heise, 1953) that auditory discriminations are difficult to develop in pigeons.

In Table 1 the number of responses that each 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

TABLE 1
 Percentage of total responses emitted by each
 bird to each of the stimulus conditions.

<u>Subject Number</u>	<u>Test Stimuli in mph</u>					<u>Total Number of Responses</u>
	<u>7</u>	<u>11 (S^D)</u>	<u>15</u>	<u>25 (S^Δ)</u>	<u>29</u>	
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

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 .

There are three aspects of the present data that 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 intradimensional discriminations were also acquired rapidly. Finally, orderly post-discrimination gradients were obtained.

In the next two chapters airflow will be utilized as a stimulus to examine overshadowing and its effect on stimulus control.

CHAPTER 3EXPERIMENTS 2A AND 2B

In a series of experiments reported by Miles and Jenkins (1965) pigeons were trained to discriminate positive trials signalled by a keylight-tone compound from negative trials signalled by the absence of tone and one of six light intensities - namely no keylight, keylight at the intensity present on positive trials, or keylight at one of four intermediate intensities. When the individual elements comprising the positive compound were presented alone, the results suggested percentage of control acquired by the tone was inversely related to the intensity of the light during negative trials. Hence, it was concluded that keylight over-shadowed tone to an extent directly proportional to the relative intensity of the keylight during positive trials.

Experiment 2A

The present experiment attempts to replicate Miles and Jenkins by employing tone and airflow as the elements of the compound. The major procedural difference between these experiments lies in the way in which one of the elements of the compound is varied. In Miles and Jenkins experiment one of the elements (light intensity) was present on both positive and negative trials. The intensity of the light during negative trials was different for each group. In the present experiment

the intensity of one of the stimuli (airflow) will be varied during positive periods. Neither tone nor airflow will be present during negative periods. It is hypothesized that the amount of overshadowing will be directly proportional to the intensity of the overshadowing stimulus (airflow).

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 2.5 cm in front of the key.

Procedure

(a) Over three sessions the subjects were shaped to peck an illuminated key on continuous reinforcement and were then gradually shifted to a VI 1 min schedule. Tone 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 mph³ for

³ Modification of the blower transformer made it possible to present higher velocities than were previously obtainable.

pigeons 1-3, 16.0 mph for pigeons 4-6, and 7.8 mph for pigeons 7-9. On the first four days of discrimination training all pigeons received 12 four-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 keylight, tone, and airflow were off.

On day 5 of discrimination training the period duration was reduced to two 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 in 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 test block. The test stimuli were the S^D present during training, the tone, the airflow and S^A . Each stimulus presentation was 1 min in duration and was separated from the next stimulus by a 10 sec timeout period. Each subject was tested until it did not respond to an entire block of stimuli or for fifteen 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. Though there is some suggestion that speed of acquisition was directly related to airflow velocity, an ANOVA on percentage correct over the first four days of discrimination training was not significant, $F(2,6) = 1.28, p > .05$.⁴

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; S^A = absence of airflow and tone) is expressed as a percentage of the total test responses. The results indicated that the proportion of test responses to the airflow decreased as airflow velocity decreased, $F(2,6) = 15.45, p < .01$. More importantly, the proportion of test responses to tone concurrently increased, $F(2,6) = 19.34, p < .01$. Thus, the results replicated Miles and Jenkins' (1965) finding that the amount of overshadowing is directly proportional to the intensity of the overshadowing stimulus. One might object to this conclusion since the number of training sessions was not equated for the two groups. Thus it might be argued that subjects which receive more training had more opportunity to come under the control of tones, and amount of training, not intensity of the airflow, was the critical variable. An inspection of the training data, however,

⁴ The Anova on the percentage data in this and all other experiments was performed by transforming the percentage data to arc sin.

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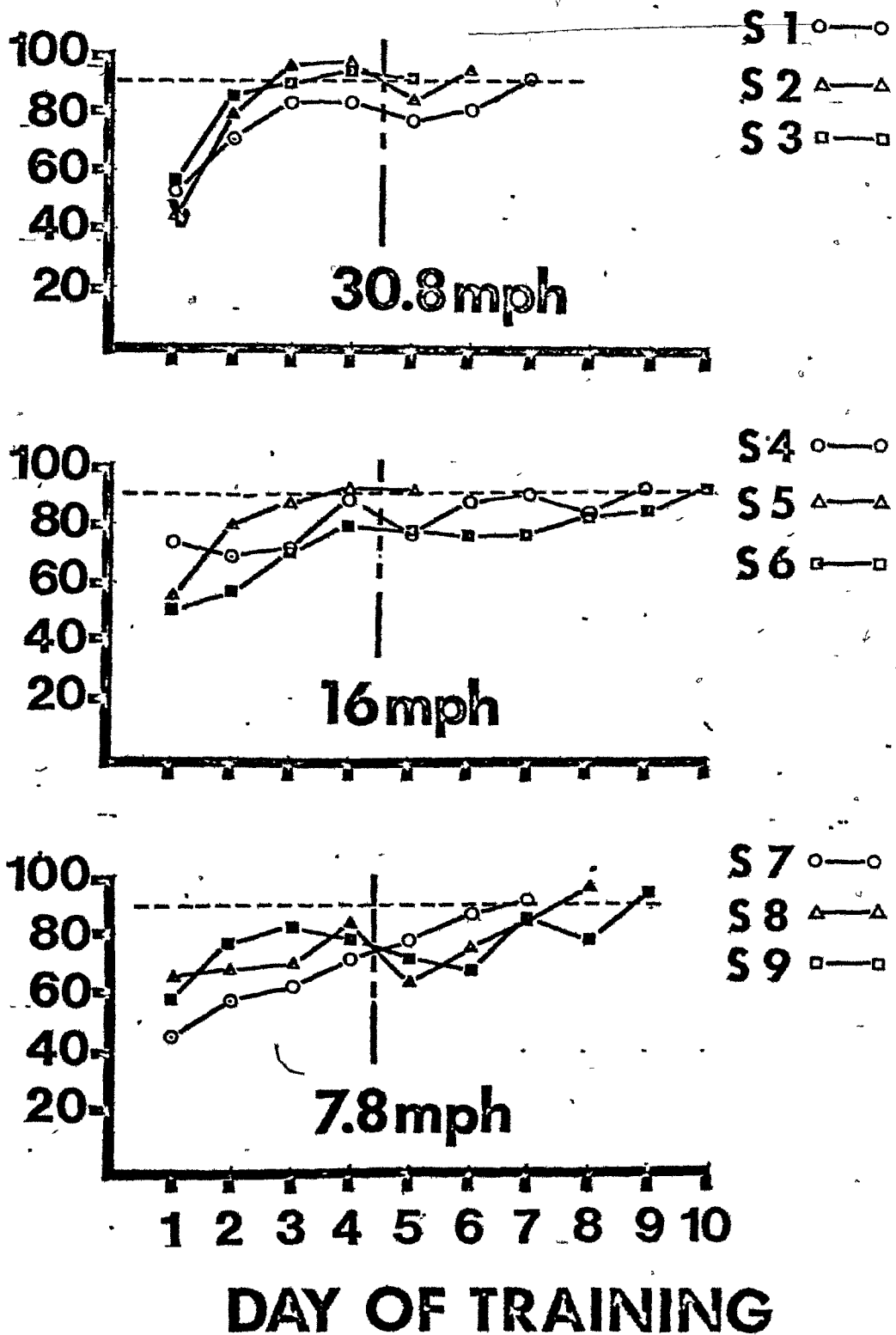


Fig 3. Percentage of responding to the reinforced stimulus during training. The broken vertical line indicates the transition from 1/4 min to 2 min periods.

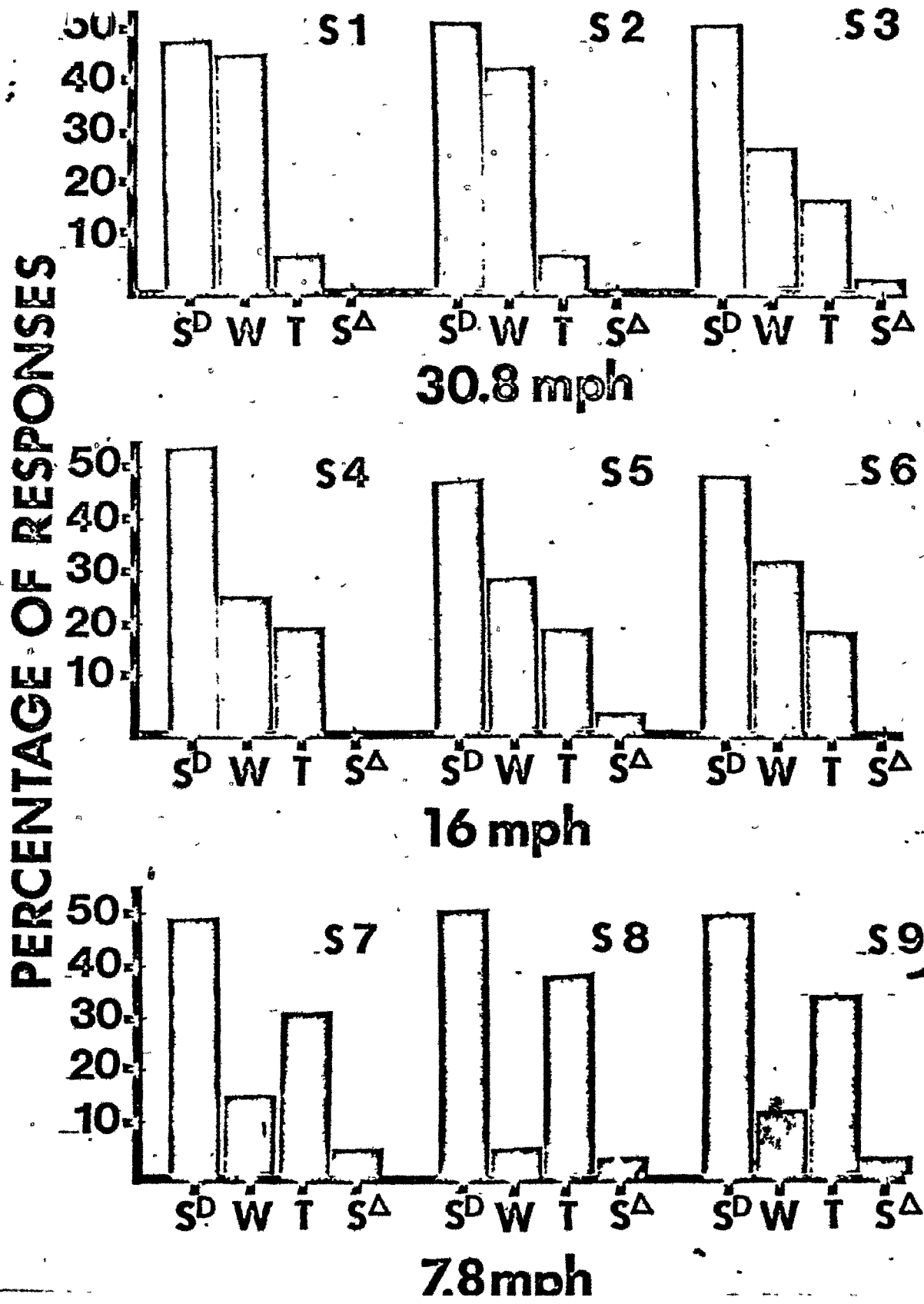


Fig 4. Percentage of responding to each of the test stimuli during the stimulus composite test. S^D is the stimulus which signalled reinforcement availability during training, i.e. the compound of the tone and airflow. W is the wind or airflow, T is the tone and S^Δ is the absence of both the tone and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

shows that there is considerable overlap between these groups in the number of training sessions received, and that in spite of considerable variability within each group in the number of training sessions, the test results within each group were remarkably similar.

In the present experiment changing the airflow velocity produced different amounts of control by a constant tonal stimulus. This raises the question of whether or not changes in tonal intensity will influence the degree of control acquired by a constant airflow stimulus. In order to determine whether this symmetrical overshadowing relationship exists, the following experiment was performed.

Experiment 2B

Method

Subjects

Six 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.

Procedure

The procedure employed was identical to that used in Experiment 2A with the exception that in the present experiment two different tonal intensities were compared to the 7.8 mph airflow from the key. Subjects 1-3 were trained with the airflow-80 db compound as S^D ; while subjects 4-6 were trained with the

airflow-70 db compound as S^D . As 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 rapidly over the first four days than the 70 db group, $F(1,4) = 30.97$, $p < .01$. 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. The results indicated that the proportion of test responses to the tone decreased as tonal intensity decreased, $F(1,4) = 57.89$, $p < .01$. More importantly the proportion of test responses to airflow concurrently increased, $F(1,4) = 80.73$, $p < .01$.

The results of this study indicate that the overshadowing process is symmetrical. That is, stimulus A will overshadow stimulus B where A is an intense stimulus and B is a weak stimulus, while stimulus B will overshadow stimulus A where B is an intense stimulus and A is a relatively weak stimulus.

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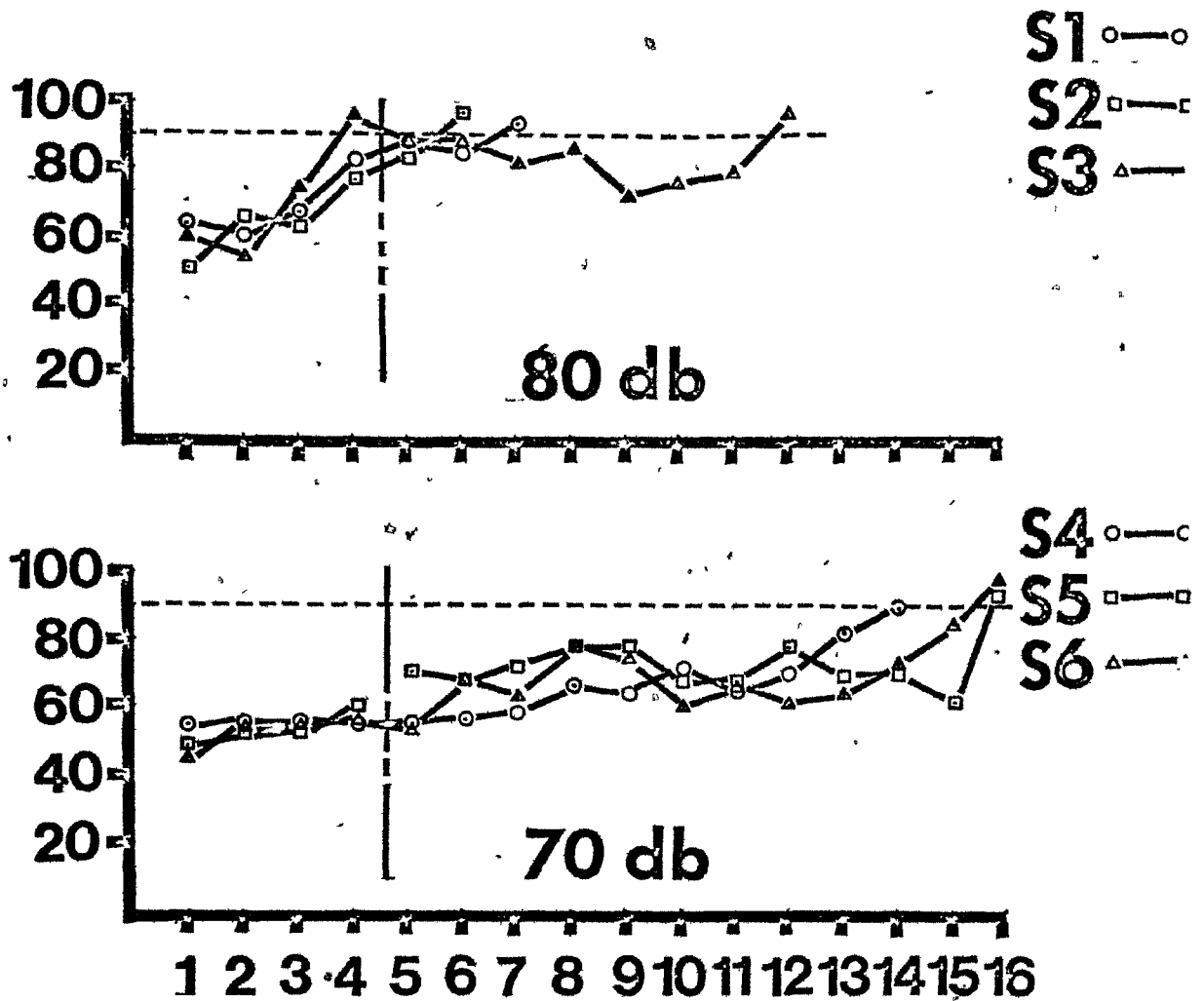


Fig. 5. Percentage of responding to the reinforced stimulus during training. The broken vertical line indicates the transition from 4 min to 2 min periods.

PERCENTAGE OF RESPONSES

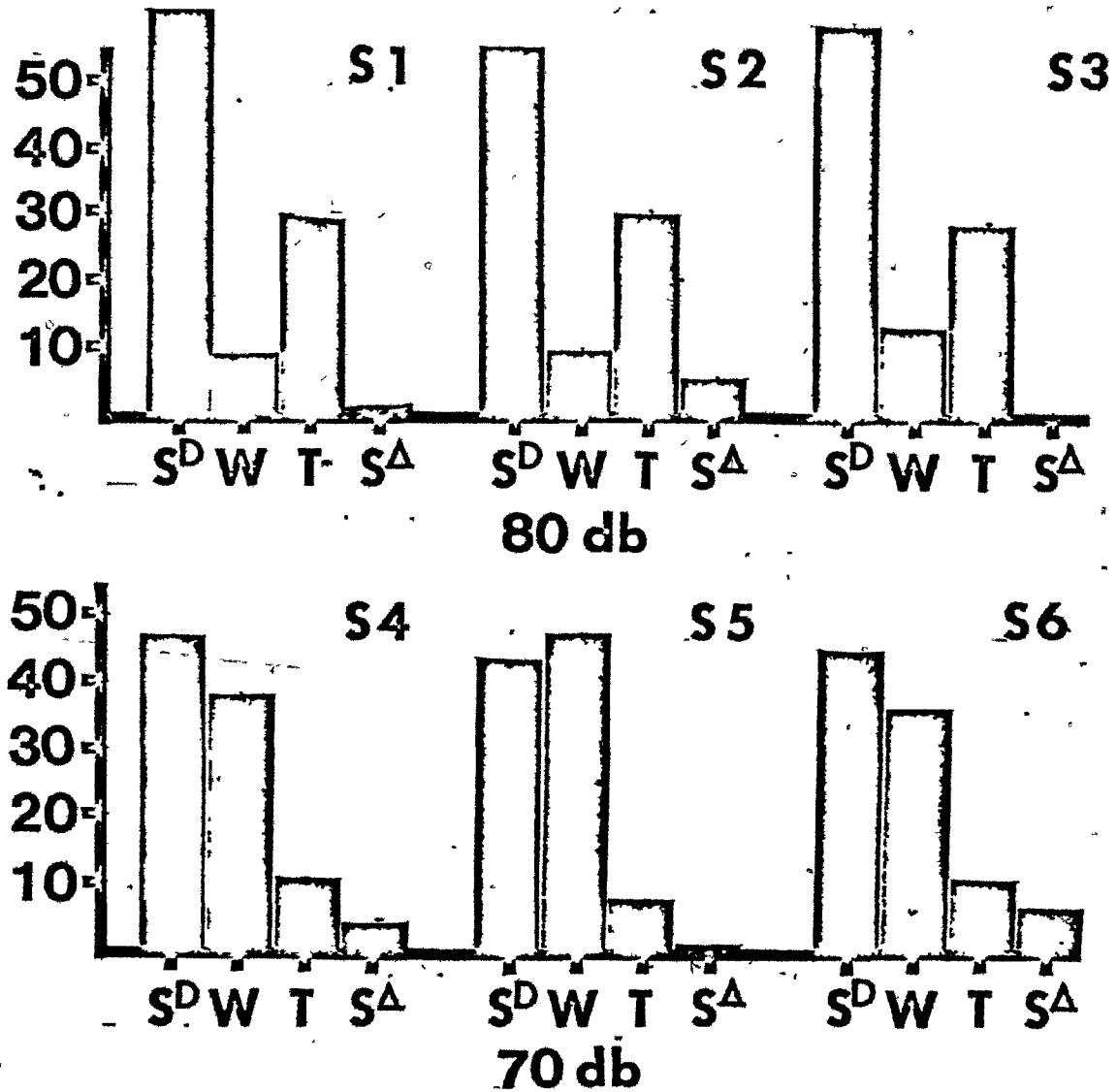


Fig. 6. Percentage of responding to each of the test stimuli during the stimulus composite test. SD is the stimulus which signalled reinforcement during training, i.e., the compound of the tone and airflow. W is the wind or airflow, T is the tone, and S Δ is the absence of both the tone and airflow.

CHAPTER 4EXPERIMENTS 3 AND 4

Following key peck training in the presence of a single tonal frequency, pigeons exhibit little stimulus control on the tonal frequency dimension (Jenkins and Harrison, 1960). This discovery was of particular significance since 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 opposite results with respect to different stimulus continua remains 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. However, in the Guttman and Kalish (1956) experiment overshadowing was not likely since the training stimulus was visual. The degree of control therefore which is obtained by a nonvisual stimulus might 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 inversely related to the salience of the 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 the presence of a lighted key.

Ideally, the non-visual dimension employed should provide cues to the location of the key in order to insure a substantial response rate in a dark chamber. Airflow emerging from behind the response key should produce differential cues as to the keys location (Experiment 1).

Therefore, the purpose of the present experiment was to attempt to show differences in the degree of control acquired by airflow as a function of the relative salience of visual stimuli in the chamber.

Experiment 3

Method

Subjects

Twelve six-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 experiments except that a houselight was occasionally employed. The house-light was a 24 volt bulb mounted on the wall opposite the key. The effective voltage across the bulb was reduced to 16 volts with a potentiometer.

Procedure

Subjects were trained to peck a key under one of three conditions. The first group of subjects (1-4) pecked a lighted

key with no other source of illumination. The second group of subjects (5-8) pecked an unlighted key with a houselight on. The final group of subjects (9-12) pecked a dark key with no light source available. In all three conditions a 30 mph Key source airflow was also present.

Trained with Keylight On

The only source of illumination in this condition was the keylight. Preliminary key peck training consisted of approximately 50 reinforced key pecks on day one. Subjects 1-4 then received 40 additional reinforcements a session according to the following schedules: day two, CRF; days three and four variable interval 15 sec (VI 15 sec). During the next 10 days all subjects received half hour sessions with a VI 1 min schedule of reinforcement in effect. Period duration was two min with each period separated from the next by a 10 sec time-out period during which both key light and airflow were terminated.

Trained with Houselight On

The only source of illumination in this condition was the houselight. During the time-out 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 (9-12) 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 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. During all other sessions the chamber was completely dark. In all other respects, these subjects were trained identically to the subjects in the keylight condition.

Generalization Testing

Following 10 days on the VI 1 min schedule of reinforcement all subjects were given a generalization test on the airflow velocity dimension. Subjects in the key light 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 time-out period as in training. These various airflow speeds were produced by

varying the speed of the blower. The 0 mph stimulus was presented in two different ways; the airflow valve was closed and the blower motor was either not running or was running at the speed that would produce a 30 mph airflow if the valve was open.

Results

Subjects in all conditions learned to keypeck and rarely responded during time-out. The mean response rates for the last two days of training for each subject are presented in Table 2. It is apparent that there is considerable overlap in response rate between these three groups. Therefore, the results of the generalization test cannot be attributed to the minor differences in rate.

Results of these subjects on the generalization test are expressed as a percentage of the total responses emitted to each stimulus in Figure 7. All of the subjects trained in the dark condition gave sharp gradients while the gradients of all but one subject in the key and houselight training conditions were relatively shallow. Responding in the presence of the 0 mph stimulus was not influenced by whether the blower motor was running or not. This result indicates that responding was not controlled by the auditory stimulation produced by the blower motor. In order to determine whether or not there were significant differences in airflow control, responses to the

TABLE 2

Average response rate over last two days of training in responses per minute.

KEYLIGHT	HOUSELIGHT	DARK
S1 16.2	S5 23.0	S9 22.2
S2 22.2	S6 51.4	S10 35.4
S3 41.4	S7 36.3	S11 34.9
S4 58.8	S8 34.3	S12 28.1

S 1 ○ — ○
 S 2 ▲ — ▲
 S 3 ■ — ■
 S 4 ○ — ○

TRAINED WITH
 KEYLIGHT ON

S 5 ○ — ○
 S 6 ▲ — ▲
 S 7 ■ — ■
 S 8 ○ — ○

TRAINED WITH
 HOUSELIGHT ON

S 9 ○ — ○
 S 10 ▲ — ▲
 S 11 ■ — ■
 S 12 ○ — ○

TRAINED IN
 DARK

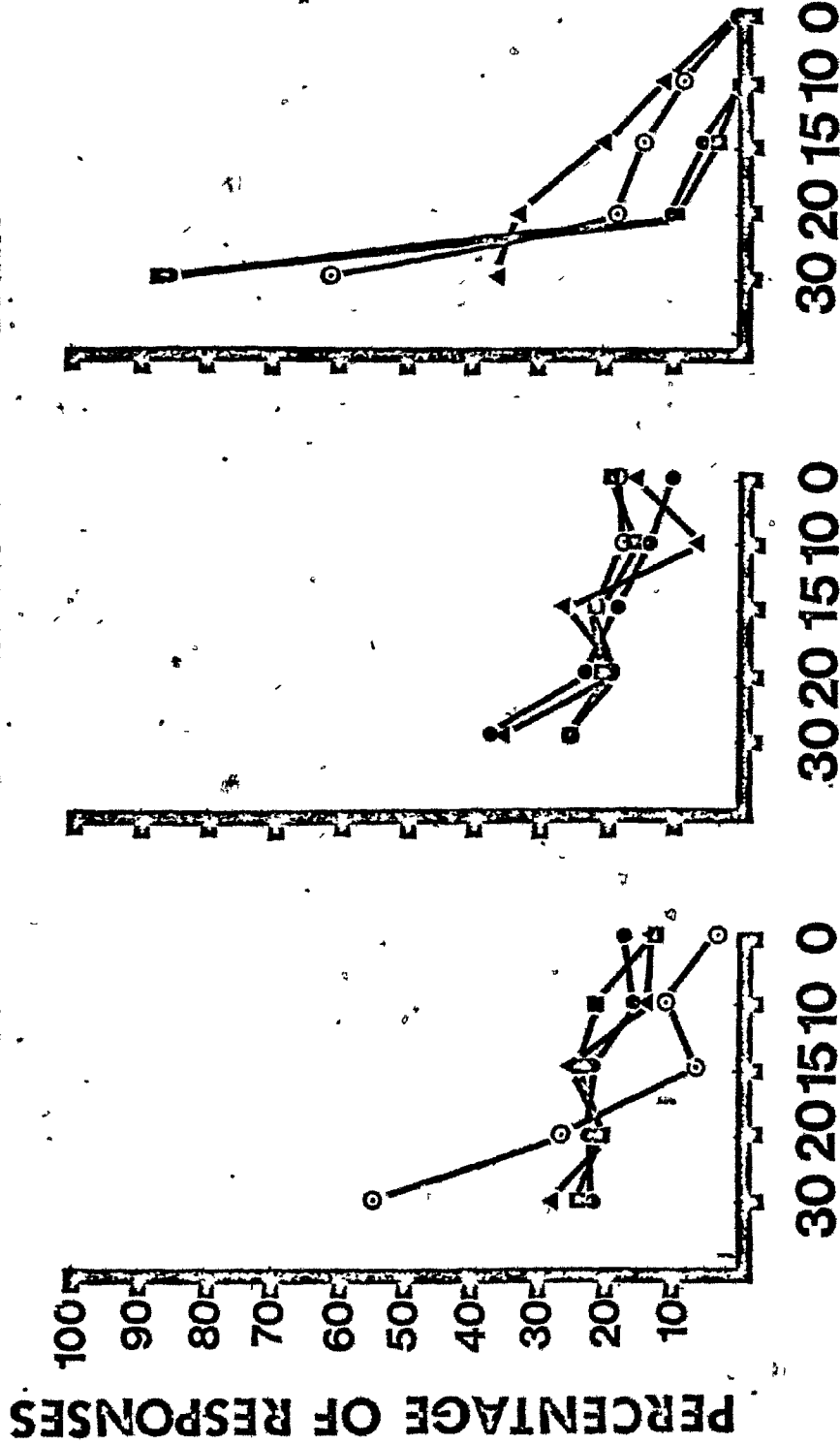


Fig. 7. Percentage of total responses given to each of the air flow velocities during the generalization test.

training value were expressed as a percentage of responses to the training value plus responses to no airflow. An analysis of variance on these data indicated significant differences, $F(2,9) = 19.39, p < .01$. Pairwise comparisons of the three groups indicated that the dark trained group yielded significantly steeper gradients than either of the light trained groups, and that the latter trained groups were not significantly different.

Discussion

The results indicated that the presence of light during training and testing allowed visual stimulation to overshadow some of the control that would otherwise have acquired by the airflow. It is plausible, therefore, that other nonvisual stimuli (e.g., tones) might gain control over behavior if pigeons were taught to peck without any visual stimuli.

Since visual stimuli are important in nondifferential training, they might also be important during differential training. The following experiment was designed to investigate the role played by visual stimuli in differential training.

EXPERIMENT 4

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 salient stimulus - airflow. Therefore, if a discrimination is difficult it is possible that a strong irrelevant stimulus might gain some control early in training. As training progressed it would be likely that the

relevant cue would gradually regain this control since it more reliably predicts reinforcement.

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

Method

Subjects

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

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 of subjects, 1-4, were trained to peck in the presence of an airflow-keylight compound while the second group of subjects, 5-8, were 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 and a 20 mph airflow signalling extinction, or vice versa. The different airflows were produced by changing the speed of the blower.

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 Key source airflow while 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 one followed by variable interval training with progressively longer variable interval (VI) schedules. On day 6 all subjects were on a VI 30 sec schedule. Following 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 Key source airflow while 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.

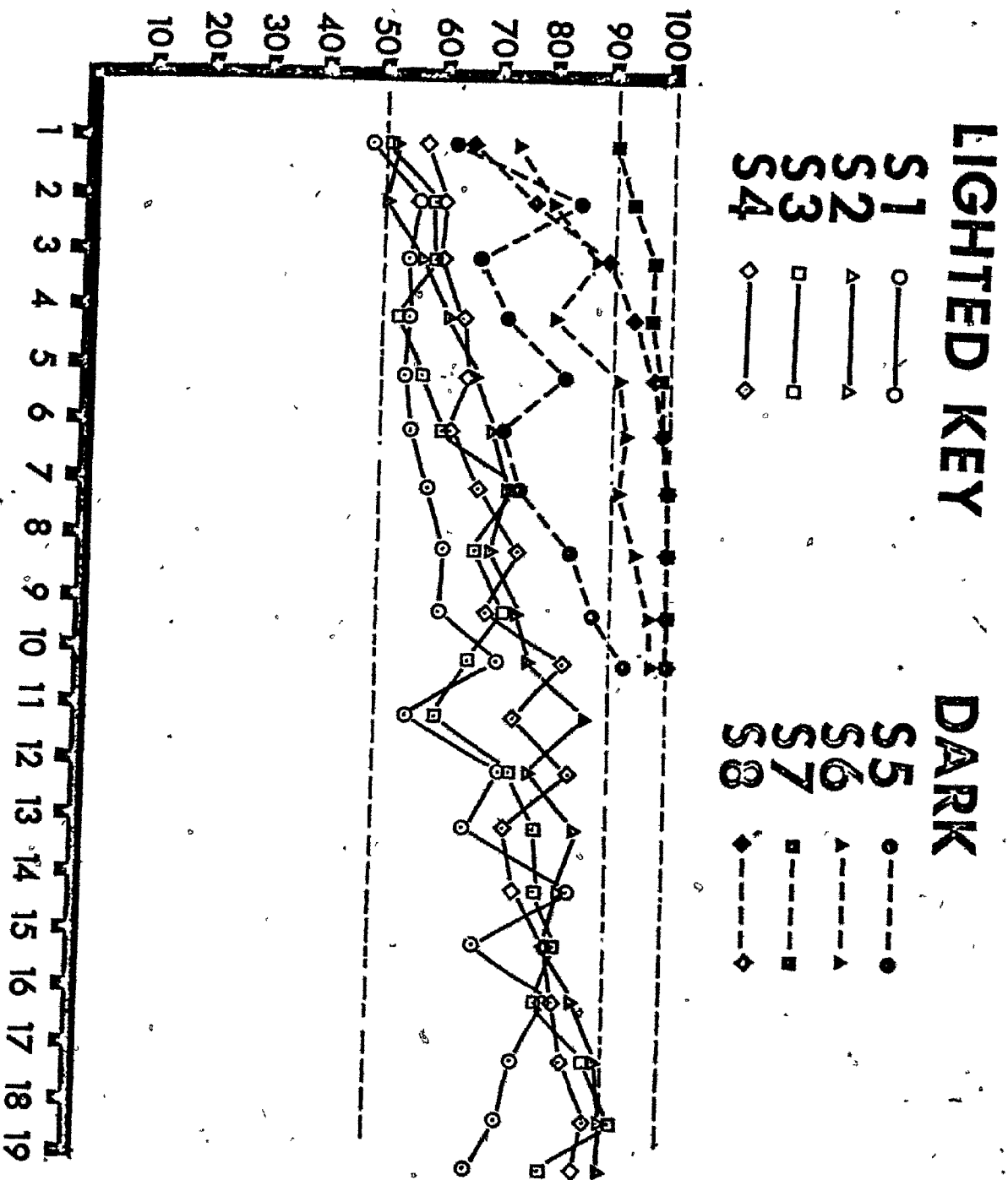
Discrimination Training

Following four days on the VI 30 schedule, the last two of which contained 10 sec TO periods, all subjects began training on an airflow velocity discrimination. The airflow velocity present during initial training was designated as the stimulus which signalled reinforcement availability while the other airflow signalled extinction. All subjects received 30 two-min periods per day. Half of the periods signalled the availability of reinforcement while the other half signalled extinction. 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 next by a 10 sec time-out period. Time-out 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

Results for the discrimination acquisitions are presented in Figure 8. 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. An ANOVA on the percentage correct over the first 10 days of discrimination training was significant, $F(1,6)=21.48, p<.01$. There were no points of overlap between any of the subjects in either group although one subject in the dark condition

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DAY OF DISCRIMINATION TRAINING

Fig 8. Percentage of responding to reinforced stimulus for each subject in each condition.

(pigeon 1) performed almost as poorly as the better keylight subjects on days 6 and 7.

The response rates during S^D periods for the 10th day of discrimination training are presented in Table 3. It is apparent that there is considerable overlap in response rate between these two groups. Therefore, the differences in rate of discrimination acquisition cannot be attributed to differences in response rate.

Discussion

The results of the study may be viewed as a partial replication of experiment 3 since all subjects in the dark condition performed better on day one of discrimination training. Furthermore, the results 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 likely 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 gain back control from these irrelevant cues.

It should be noted that differential auditory stimulation was perfectly correlated with the two airflow velocities used

TABLE 3

Response rate during S^D periods on the 10th day of
discrimination training in responses per minute.

KEYLIGHT		DARK	
S1	39.2	S5	30.1
S2	79.9	S6	11.8
S3	26.5	S7	46.6
S4	44.1	S8	29.7

in this study and thus the discrimination performance may have been partly controlled by these auditory cues. However, even if these auditory cues did control behavior somewhat, the implications of the results are still the same: the presence of irrelevant visual stimulation retards the acquisition of a discrimination.

CHAPTER 5°GENERAL DISCUSSION

For many years it was theoretically assumed (Hull, 1952) that irrelevant stimuli play an important role in discrimination learning. However, only recently has this question received the experimental attention it merits (Wagner, 1969). The present thesis demonstrated that irrelevant stimuli do play an important role in discrimination learning and that the mechanism by which they do involves stimulus overshadowing.

The experiments which comprise this thesis can be logically divided into three sections. The first section, reported in chapter 2, deals with the development of airflow as an effective discriminative stimulus. The second section, chapter 3, consists of experiments demonstrating overshadowing with airflow and showing the symmetrical nature of overshadowing in stimulus control. The final section, chapter 4, is involved mainly with the role that irrelevant stimuli play in discrimination learning.

Let us examine the results of the experiments which constitute chapter 3 and 4 in greater detail since they deal directly with the most important finding of this thesis -- the role played by irrelevant stimuli in discrimination learning. In experiment 2A subjects were trained to respond to a tone-airflow compound. Subjects in different conditions were

trained on different airflow velocities. The results of this experiment replicated Miles and Jenkins' (1965) findings that the amount of overshadowing is directly proportional to the intensity of the overshadowing stimulus. The primary significance of this experiment was the demonstration that airflow could overshadow loud tones and therefore, could serve as an effective stimulus in subsequent studies.

In experiment 2B, subjects were again trained with a tone-airflow compound. However, in this experiment, the tonal intensity was varied. The results of this experiment indicated that the overshadowing process is symmetrical. That is, varying the intensity of either stimulus affects the amount of overshadowing obtained.

In experiment 3, subjects were given nondifferential training on airflow velocity with and without an illuminated key. The results of experiment 3 indicated that presence of the illuminated key can overshadow control by a second stimulus when subjects are given nondifferential training on the second stimulus. Therefore, it can be concluded that for pigeons, the procedure of nondifferential training with any particular stimulus always involves nondifferential training on one of the most salient stimuli in the chamber: an illuminated key. Furthermore, the process of overshadowing determines which of these stimuli will acquire control.

In experiment 4, subjects were trained on an airflow velocity discrimination with and without a keylight. The

results demonstrated that the presence of a strong irrelevant stimulus, the keylight, during airflow discrimination training will retard the acquisition of that discrimination. This result can be predicted from the findings of experiment 3 since prior to the differential contingency taking effect the stronger irrelevant stimulus may overshadow the weaker relevant stimulus.

Let us examine the implications of the above findings. Generally it is possible to state that if the stimuli an experimenter is concerned with are very salient and the irrelevant cues present are not salient the irrelevant stimuli can be disregarded. However, if the stimuli that the experimenter is interested in are not very salient while the irrelevant cues are salient, the irrelevant stimuli cannot be overlooked.

Examples of experiments which typify both possibilities are those of Guttman and Kalish (1956) and Jenkins and Harrison (1960). In the former experiment animals were given non-differential training with the stimulus of interest -- wavelength -- being very salient. The irrelevant stimuli in the chamber were not salient enough to overshadow the training stimulus. Hence, all of their subjects evidence good stimulus control across a dimension of the training stimulus. However, in the latter experiment animals were given nondifferential training with the stimulus of interest -- tonal frequencies -- being less salient. The irrelevant stimuli in the chamber, presumably the keylight, were sufficiently salient to overshadow tonal

control. Hence, these subjects failed to show good stimulus control on a dimension of the training stimulus.

Similar findings also exist in the discrimination learning literature. For example, it is common knowledge that pigeons are better at visual than auditory discriminations. This result is likely to be partially determined by the fact that constant irrelevant cues of a visual nature may overshadow the relevant auditory stimuli early in training. This may also explain the discrepancy noted by Heise (1953) that pigeons are poor at auditory discrimination learning although they have fairly sensitive hearing as determined by psychophysical methods.

The results of chapter 4 can also be utilized to explain two well known phenomena. The first of these phenomena is the easy-to-hard effect in discrimination learning (James, 1890; Lawrence, 1952). It has long been known that animals pretrained on an easy discrimination do better on a more difficult discrimination along the same dimension than animals pretrained on the difficult discrimination. It will be recalled that Haberlandt (1971) demonstrated that an irrelevant stimulus acquires less control when subjects are pretrained on an easy discrimination than when they are pretrained on the difficult discrimination. Haberlandt assumed that the animals trained on the difficult discrimination throughout the experiment performed more poorly because of the control acquired by the irrelevant cue. This difference in control between the

two groups is probably due to an overshadowing effect. Pre-training on the easy problem enables the relevant stimuli to overshadow the irrelevant stimuli. However, pretraining on the difficult problem may result in the irrelevant stimuli overshadowing the relevant stimuli. The errorless training procedure employed by Terrace (1963) in which the subjects are first trained on an easy discrimination, e.g., green key vs dark key, and then gradually shifted to a harder spectral discrimination may be a special case of the easy-to-hard effect. Thus, this procedure produces errorless discrimination learning because it prevents irrelevant stimuli from acquiring control.

The second phenomenon relevant to the present thesis is the effect of early-vs-late introduction of S^A in discrimination learning (Skinner, 1938; Terrace, 1963). Skinner (1938) demonstrated that a brightness discrimination can be acquired by rats with little responding to S^A if discrimination training begins immediately after bar press training. Terrace (1963) found that subjects which had S^A introduced early during the first session performed in a far superior manner to animals that had S^A introduced after three weeks of pretraining on the S^D .


When subjects are given prolonged pretraining on an S^D they are exposed to many other stimuli in the chamber. Each of these stimuli will acquire some degree of control according to its relative salience. Later when the subjects are given

discrimination training the irrelevant stimuli will block control by the relevant stimuli to the degree that they initially have gained control.

If, however, the subjects are not given pretraining on the S^D , there is not as much opportunity for irrelevant stimuli to acquire control prior to discrimination training. Hence, the relevant stimuli gain control more rapidly since the irrelevant stimuli have less control over responding.

The results of experiment 4 also suggest a possible application for the field of education. Difficult discriminations are often effectively introduced by employing errorless discrimination training procedures (Sidman and Stoddard, 1967). This thesis suggests that this procedure is effective primarily because it prevents irrelevant stimuli from acquiring control over responding early in training. Another method of preventing irrelevant stimuli from acquiring control would be the removal from the training environment of as many irrelevant stimuli as possible. Hence, subjects could be trained in a special environment where the number of irrelevant stimuli has been greatly reduced. When the discrimination was learned to criterion the irrelevant stimuli which were normally present could be systematically reintroduced.

In summary, these results emphasize the importance of taking into account all stimuli present in an experimental environment whenever the researcher is interested in problems in the area of stimulus control. Failure to do so can result in these stimuli confounding the results of the experiment.

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