1973

# Generalization gradients along the angularity dimension in pigeons following differential training with one or two salient features.

Dennis W. Ferenc
*University of Windsor*

# GENERALIZATION GRADIENTS ALONG THE ANGULARITY DIMENSION IN PIGEONS FOLLOWING DIFFERENTIAL TRAINING WITH ONE OR TWO SALIENT FEATURES

by
Dennis W. Ferenc
B.A. (Hons.), University of Windsor, 1971

A Thesis
Submitted to the Faculty of Graduate Studies through the
Department of Psychology in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts at the University
of Windsor

Windsor, Ontario, Canada
1973

## ABSTRACT

Four groups of pigeons were tested to compare the effects, on the slope of generalization gradients, of utilizing one stimulus or two stimulus cues during discrimination training. All Ss received discrimination training on the presence-absence of a vertical line; key peck responses were reinforced on a VI 60 sec. schedule. Two groups were trained with chroma (green) on the line as S+ and S- was a green key for one of these groups and a white key for the other group. Two other groups were trained with chroma on the surround as S+ and S- was a green key for one of these groups and a white key for the other group. After training, all Ss received generalization testing along the angularity dimension under extinction conditions for two test sessions. Significant differences in the slope of the generalization gradients occurred only on the second day of testing. The group consisting of colour on the line and two stimulus cues produced the steepest gradient. The results of the present investigation cast doubt on the perceptual attending hierarchy theory and indicate the need for further experimentation on the variables affecting the attending hierarchy.

## PREFACE

I am initially grateful to Dr. Theodore T. Hirota, Chairman of my Thesis Committee, who aroused my interest in this area of experimental research. His early help in the formulation of this study, his encouragement, criticism and patient guidance through the many stages of the paper were greatly appreciated.

I would like to thank Dr. Jerome Cohen for his encouragement and guidance in the preparation of the paper. I would also like to express my thanks to Dr. Allan Okey for acting as my outside reader. My sincerest thanks go to Miss Carol Small and Mr. Jeffrey Price who aided me in the compiling of the final copy of the manuscript. Without the help of all these people this paper could never have materialized.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES (cont.)

## LIST OF FIGURES

# CHAPTER I

## Introduction

The purpose of the present investigation was to replicate Baron and Vacek's (1967) study, controlling for the number of stimulus features present during the training session and omitting the wavelength generalization test. The need for such a studv mav perhaps become evident after a review of some of the current problems.

### Background of Related Research

Several studies have shown that the different properties of a complex stimulus may individually control differential responding (Lashley, 1938; Reynolds, 1961; Newman and Baron, 1965). Since the relation between a stimulus and a response may vary from one instance to another during training, the aspects of the stimulus situation present when a reinforced response occurs may not subsequently lead to that response. Such findings have been interpreted as meaning that subjects can "attend" selectively to the different aspects of the stimulus situation. This has led some researchers to study attention through the concept of stimulus control (Jenkins, 1964; Terrace, 1966; and Honig, 1970).

Stimulus control is often demonstrated using discrimination and generalization paradigms. A stimulus correlated with a response, by itself does not demonstrate control, unless it is also possible to show that the absence of the stimulus is correlated with the absence of that response (Mostofsky, 1970). A common way in which to look at attention is to examine stimulus generalization gradients. Generalization occurs when an organism responds to stimuli which are similar to a stimulus that had been initially conditioned. Generalization gradients have been used to demonstrate the consistent decrease in response strength that occurs with increased differences between training and test stimuli. A gradient with a steep slope and a peak at the training stimulus implies that the organism has attended to the training dimension, while flat gradients imply little or no stimulus control by the test dimension.

Newman and Baron (1965) provided evidence for stimulus control along the dimension of line orientation using generalization tests. Four groups of pigeons were given independent discrimination problems. All groups were presented with a white vertical line on a green background as the reinforced positive stimulus (S+). The nonreinforced stimulus (S-) for Group 1 was a green background with the line absent, for Group 2 S- was a red background with the line absent, and for Group 4, S- was a red background with the white vertical line present. Group 3 received S+ only training.

During generalization along the angularity dimension, Group 1 showed a steep generalization gradient, whereas Group 2 showed a flat gradient. Group 3 and 4 also produced flat gradients. But during training, Group 2 learned the discrimination faster than Group 1. It may be possible to conclude that pigeons in Group 2 found it easier to differentiate on the basis of colour rather than on the presence – absence of the vertical line. Baron (1965) explained these results in terms of a perceptual "attending hierarchy". Baron proposed that colour was higher on this scale than line tilt and therefore was attended to more readily. However, Newman and Baron were not able to show that pigeons in Group 2 exclusively attended to colour. In fact, the pigeons may have attended to the line during training, but the presence of the more dominant cue, colour, may have masked any responding to the line during testing.

Newman and Benefield (1968), using two groups of pigeons, showed that if the coloured background is removed and replaced by a black background during generalization testing, steeper gradients along line tilt are possible. Thus, the pigeons attended to colour rather than to the line during generalization testing, and thereby showed a flat gradient. But, when the coloured background was removed, attention to the line was demonstrated. These results tend to support Baron's (1965) proposal that colour is a more salient cue than line tilt.

One of the implications of the Newman and Baron (1965) study explored by Baron and Vacek (1967) was that if colour is a dominant cue, since it is high on the attending hierarchy, then attention to the line should be greater if the line was coloured rather than the background.

Baron and Vacek trained two groups of pigeons on a discrimination task. The experimental group received discrimination training with a green vertical line on a white background as S+ and a white key as S-. The control group received discrimination training with a white vertical line as S+ and a green key with the line absent as S-. The control group was identical to Group I of the Newman and Baron (1965) study. The results of the Baron and Vacek study showed that the experimental group produced a steeper gradient than the control group, supporting their hypothesis that colour would facilitate control. Furthermore, the control group in this study produced a flat gradient, whereas in the Newman and Baron (1965) study a similar group produced a steep gradient. Baron and Vacek concluded that pigeons attended to the more dominant cue, colour.

However, Baron and Bresnahan (1969a) questioned whether chroma on the line increased attention to the line. Their experiment tested the possibility that chroma on the surround may have in fact decreased attention to the line. They trained four groups of pigeons. Two groups were trained on a discrimination with a white vertical line on either a green or black surround, and two groups received single stimulus training on a green or black surround. Examining the groups which received discrimination, it was found that the group trained with the black surround produced a steeper gradient than the group with the green surround along the angularity dimension. However, the group trained with single stimulus training with the white vertical line on the black surround produced a flat gradient compared to the group which received single-stimulus training with a green surround. Their results thus showed an interaction effect of location of the colour and kind of training. Therefore, their results did not present clear evidence against the fact that colour on the line may have increased attention to the line as suggested by Baron and Vacek (1967).

The possibility that colour on the line may have increased attention to the line was further examined by Hirota, Milam and Ferenc (1973). Whereas Baron and Bresnahan (1969a) tried to show that colour on the surround may have decreased attention to the line, the Hirota et al. study tested the effect of placing colour on the line. The experimental group in the Hirota et al. study was trained to discriminate a green vertical line on a white background (S+) and a plain white key (S-). The control group learned the discrimination with a black vertical line on a white background as S+ and a white background as S-. In short, the experimental group was trained with chroma on the line and the control group trained with a black line. During generalization testing along the angularity dimension, both groups produced equally steep gradients. Hirota et al. concluded that the addition of chroma on the line does not increase attention to the line.

Baron and Vacek (1967) inferred that chroma increased attention to the line by examining the difference in slopes between their experimental and control groups during the generalization test. The group trained on the presence-absence of a white line on a green surround (Group 2) produced a flat gradient compared to the group trained on the presence-absence of a green vertical line on a white surround (Group 1). However, studies utilizing differential training of the presence-absence of a white vertical line on a green surround generally produce steep gradients (Newman & Baron, 1965; Newman & Benefield, 1968; Baron & Bresnahan, 1969a). A possible explanation for the discrepant results by Baron and Vacek (1967) is that the test data for their study was confounded by the presence of a wavelength generalization test at the same time as the line-tilt generalization test (see Hirota et al., 1973). The experimental group of the Baron and Vacek study received three orientations of the line in three wavelengths on a white background. The control group received three orientations of the white line paired with three wavelengths of the surround. Thus, two dimensions were varied simultaneously during testing.

Another possible shortcoming of the Baron and Vacek (1967) study was that each group was not equated for the number of salient features to be discriminated during training. The experimental group, which received discrimination training on presence-absence of a green vertical line on a white background, could learn the discrimination in two ways. Pigeons in this group could have attended to colour and thus learned the discrimination on the basis of green versus the absence of green. The other way in which the discrimination could be learned was if the pigeons attended to the line and discriminated the presence-absence of the line. The control group, trained to discriminate the presence-absence of a white vertical line on a green background, could have learned the discrimination on the basis of the amount of green present. That is, the two green areas separated by the white line as the S+ may have been discriminated from the negative stimulus which consisted of a solid green area. However, from the work of Newman and Baron (1965) and Newman and Benefield (1968), it is more likely that the birds use the white vertical line as the discriminative stimulus, thus having one cue available to learn the discrimination. The differences in the generalization gradients produced by the two groups may be due to the possible confounding wavelength generalization test, or it may be attributed to the possibility that each group learned the discrimination in a different number of ways. When groups are equated for number of features to discriminate, equally steep gradients may occur. Hirota, Milam and Ferenc (1973) trained one group of pigeons to discriminate the presence-absence of a green vertical line on a white background, and trained a second group to discriminate the presence-absence of a black vertical line on a white background. During generalization along the angularity dimension, Hirota et al. obtained equally steep gradients. It should be noted that their study equated the two groups for the number of features to be discriminated and that the wavelength generalization test was omitted.

So far, the previous studies have examined attention through stimulus control and the inspection of generalization gradients along some specified dimension. The approach to attention by S-R learning theorists involves the number of training trials required during a discrimination session and an examination of the errors made to complex stimulus components (Skinner, 1938; Hull, 1943). Examining the role of perceptual dominance of cues in discrimination learning has led S-R learning theorists to predict that learning occurs more rapidly when relevant stimuli are presented in more than one modality (Blodgett, McCutchan & Mathews, 1949; Eninger, 1952; and Warren, 1953). Eninger (1952) following Hull's (1943) implications, trained rats in a maze using an auditory, a visual, and a combined auditory-visual discrimination. The efficacy of the combined group proved superior to either of the two single components. Eninger explained these results in terms of a summation hypothesis, in which the habit strengths of the individual modalities yielded a greater overall associative strength for the combined modalities. Warren (1953) concerned himself with the lack of evidence to support theoretical implications of adding cues from different stimulus dimensions within the same modality. Seven rhesus monkeys were tested over a large number of discrimination problems. The relevant cues which differed over a series of problems were colour (C), form (F), size (S), and their possible combinations (CF, CS, FS, and CFS). Warren found that colour was a dominant cue in the learning situations; colour categories differing in ease of solution. However, the number of errors for the problems did not significantly decrease when either form or size were added to colour. In a similar experiment (Warren, 1954), it was again found that colour was a dominant cue but the monkeys were capable of learning the other relevant cues. Thus, Warren's studies tend to support Baron's (1965) proposal that colour is high on the attending hierarchy. The experiments by Eninger (1952) and Warren (1953, 1954) were designed mainly to test Hullian summation theory, which proposed that the compounding of modalities results in more rapid learning than a single component in discrimination problems. Another implication of these studies was that summation of the individual associative strengths accurs when stimulus elements are added. Therefore, it was concluded that animals often learn discrimination problems more quickly when multiple stimulus cues are available.

Sutherland and Holgate (1961) attempted to explain how a discrimination is learned when two relevant cues are present, in terms of an attentional model. If two relevant cues are present, some animals may attend to one particular dimension while other animals may attend to the other dimension. Whichever dimension the animal attends to, the problem can be solved in terms of that dimension. Thus, group performance would show quicker learning when two cues are relevant than when only one cue is relevant. When only one cue is relevant, some animals may be attending to an irrelevant dimension. The time it takes to switch to the appropriate dimension results in slower learning for the group. It is clear from the experiments done by Warren (1953, 1954) that his data fit more exactly with the attentional model proposed by Sutherland and Holgate (1961) than with Hullian theory. The addition of cues of form and size did not aid in the learning of the discrimination, colour had a more dominant effect in determining what was attended to in the tasks.

In summary, it has been suggested that when pigeons are differentially trained to discriminate the presence-absence of a green vertical line they produce steep gradients (Baron & Vacek, 1967, and Hirota, Milam & Ferenc, 1973). It is not apparent whether colour on the surround may in fact decrease attention to the line during generalization testing (Baron & Bresnahan, 1969a). Since training pigeons in a discrimination task on the presence-absence of a white vertical line on a green surround has produced reliable gradients (Newman & Baron, 1965, and Newman & Benefield, 1968) the case for the attenuation of attention to the line by the surround may be unwarranted. It has also been suggested that when more than one stimulus cue is available in the discrimination task, learning is facilitated. It remains to be seen whether varying the number of stimulus cues in a discrimination task, with stimuli which consist of colour either on a vertical line or on the background, affects the slope of stimulus generalization gradients.

Because of the possible confounding wavelength generalization test in the Baron and Vacek (1967) study, and because of the differences in the number of stimulus features in both groups, it seems appropriate to replicate their experiment controlling for these variables. This would be advantageous for two reasons. First, it would provide further information for the effects of placing colour on the line during discrimination training, and secondly, it would provide a clear indication of the effects of different number of cues on the slope of stimulus generalization gradients.

## Purpose of the Present Investigation

The present study, therefore, was designed to replicate the Baron and Vacek (1967) study without the generalization test along the wavelength dimension and to examine generalization gradients across a greater number of stimuli. Baron and Vacek used vertical (0°), 22.5° and 45° left of vertical as their test stimuli. This study explores those stimuli of 22.5° and 45° right of vertical as well as those stimuli reported by Baron and Vacek. It was also the aim of this study to examine the effects of using different number of cues in a discrimination task, having colour on the vertical line or on the response key surround. Four groups of pigeons were used. Two of these groups were identical to the two groups used by Baron and Vacek (1967), and the other two groups acted as controls. With the additional two control groups, it was possible to divide the four groups in such a way that two groups were equated for two salient features, two groups for one salient feature, two groups trained with chroma on the line as S+, and two groups trained with chroma on the surround as S+. All four groups received discrimination training, with S- being either a coloured (green) or a white key. Generalization testing was along the angularity dimension with stimuli 0° (vertical), 22.5° and 45° left or right from vertical.

It was hypothesized that:

1. Groups containing two salient features will produce steeper gradients than groups containing only one salient feature.

2. Groups having colour on the line were expected to give steeper gradients than groups with a coloured surround.

3. The group containing two salient features and having colour on the line should produce the steepest gradient.

The independent variables in this investigation were the number of salient features and the location of the colour, either on the line or on the surround. The dependent variable was the number of responses made to the generalization test stimuli.

## CHAPTER II

## Method

### Subjects

The Ss were 30 male adult White Carneaux pigeons and 2 adult male White King pigeons. All birds were experimentally naive. They were reduced to approximately 75% (± 10 g.) of their body weight by food deprivation, and maintained at this level throughout the experiment. Water was available in Ss' home cages at all times.

### Apparatus

Two Lehigh Valley experimental chambers for rats (Model 1417) were used. The 10.5 inch by 9.5 inch rat panel in each chamber was replaced by a panel containing a single 1-in. diameter key, 8.75 in. above the floor. A 2-in. square feeder opening was located 5 in. below the key. The stimuli were lines about 3/16th in. wide projected on the response key by Grason Stadler In-Line Digital Display Units. Colour was produced on either the background or the line by the addition of a green Kodak Wratten Filter No. 13 (537-nm.) to each display unit. The lines were projected at five different angular orientations ranging from 45° counterclockwise to 45° clockwise from vertical (0°) in 22.5° steps. White noise was continuously presented in the chambers via a speaker mounted on the wall. The feeder light replaced the houselight and the keylight during 3 sec. presentations of a grain mixture.

Procedure

Initial training. On Day 1, Ss were randomly assigned to one of four groups. Magazine and key-peck training were established by successive approximations. For each group, the stimulus designated as S+ for that group appeared continuously on the key. Each S was allowed to make 100 continuously reinforced responses, 50 on Day 1, and 50 on Day 2.

Discrimination training. On Days 3-13, all Ss underwent differential training. On Day 3, reinforcements were programmed on a variable interval reinforcement schedule with a mean interval of 30 seconds (VI 30 sec.). On Day 4, Ss were shifted to a VI 60 sec. schedule and remained on this schedule for the remaining ten days of training. For each group, daily sessions of training consisted of thirty-two 55 sec. periods of S+ and thirty-two 15 sec. periods of S- in an ABBA BAAB sequence. Reinforcement did not occur for S-.

For Group 1, S+ was a green vertical line on a white surround, and S- was a white surround; for Group 2, S+ was a white vertical line on a green surround, and S- was a green surround; for Group 3, S+ was a white vertical line on a green surround, and S- was a white surround; and for Group 4, S+ was a green vertical line on a white surround, and S- was a green surround.

Generalization testing. On each of Days 14 and 15, all Ss received a warm-up session followed by a generalization test. The warm-up session consisted of 6 alternations of S+ and S-. The test stimuli consisted of the five line orientations of vertical and 22.5° and 45° on either side of the vertical of the training stimulus for each group. Each stimulus of 45 sec. duration appeared 10 times during each day of testing. The vertical line never appeared first during the test days, and the stimuli were presented in an incomplete counterbalanced order. Testing was carried out under extinction conditions.

Statistical Analysis

To provide answers to the hypotheses posed at the beginning of this investigation, the analysis of variance was utilized to assess differences for the main variables and the interaction effects. In total, one three-factor analysis of variance with repeated measures and 24 two-factor analyses of variance with repeated measures were undertaken. The three-factor analysis was performed on the discrimination data; the factors being treatment group (A), stimuli (B), that is, S+ and S-, and days (C). The 24 two-factor analyses represent all possible combinations of the four groups for each of the two days of testing. The analyses were performed on the overall absolute generalization gradients as well as on the left side of the generalization gradients. The left side was examined independently to provide a comparison between the present study and the Baron and Vacek (1967) study, which provided information for 0°, 22.5° and 45° left of vertical. In each of the 24 analyses, the factors were treatment group (A) and stimuli (B), representing the various line orientations during generalization testing. The interaction effect of Treatment x Stimuli (A x B) represented the slope of the generalization gradients and was the major effect examined.

The analyses were performed by a computer programme which requtred the use of equal N's. The programme was the University of Windsor version of the University of Illinois "Balanova 5." This programme handles repeated measures analyses of variance.

# CHAPTER III

## Results

### Initial Training

Four birds required an additional day of training. Birds 1228 and 9065 from Group 1 and birds 5664 and 3065 from Group 2 received magazine training only on Day 1 of training. On the second day, these Ss received keypeck training and 50 CRF. On Day 3, these four birds received 50 CRF while all other Ss of Group 1 and Group 2 rested. Discrimination training began on Day 4 for all birds in Group 1 and 2 only. Ss in Groups 3 and 4 were run as presented in the method section of this paper.

### Discrimination Training

All the Ss acquired the discrimination. Appendix A presents the order of S+ and S- for each day of training for each bird. The acquisition data for the four groups for the ten days of discrimination training are contained in Appendix B. The mean response rates to S+ and S- for discrimination training are represented graphically in Figure 1. A discrimination ratio (total pecks to S+ divided by the total pecks to S+ and S-) was calculated for the last day of discrimination for all birds (see Table 1). These ratios ranged from 0.94 to perfect discrimination (1.00). The mean ratio value for each group was 0.99 except for Group 1 which produced a mean discrimination ratio of 0.98.

Table 2 presents the results of a 3-factor repeated measures analysis of variance carried out on the total number of responses made to S+ and S- during training. An inspection of Table 2 reveals that there were three significant F ratios, two for the main effects of Stimuli (B) ($F=396.24$, $df=1/28$, $p<.01$) and Days (C) ($F=26.32$, $df=9/252$, $p<.01$), and one for the interaction effect of Stimuli x Days (A x B) ($F=27.73$, $df=9/252$, $p<.01$). The lack of a significant Group (A) main effect indicated that the four groups did not differ in overall number of resposnes made during discrimination. The absence of a significant interaction effect of Group x Days (A x C) ($F=0.71$, $df=27/252$, $p>.05$) indicated that the groups did not differ in response rates over the training sessions. Thus, this data suggests that the four groups responded during discrimination training equally well.

## Generalization Test

The order of presentation of the five test stimuli for each day of testing is presented in Appendix C. The mean total responses to the five test stimuli were calculated for all four groups. Appendix D contains the means for the four groups for Day I of testing and Appendix E contains the means for Day 2 of testing. The means were also represented graphically for the two test days. Figure 2 represents the absolute generalization gradients for Day 2 of testing.

TABLE I

Mean Discrimination Ratios for the Four Training Groups for the Last Day of Discrimination Training

| Group | Ratio |
|---|---|
| 1 | 0.98 |
| 2 | 0.99 |
| 3 | 0.99 |
| 4 | 0.99 |

A separate analysis of variance with repeated measures was performed on toal number of responses of all four groups to all generalization test stimuli for both Day 1 and Day 2 of testing (Table 3 and 4, respectively), and for the stimuli on the left side of the gradient (Table 5 and 6, respectively). The mean square error ($MS_{B \times subj. w. groups}$) for each analysis was utilized to calculate the main effect of Stimuli (B) and the interaction effect of Group x Stimuli (A x B) for all corresponding analyses of variance for all possible combinations of pairs of groups on each test day. This mean square error term was used because it is a better approximation of the population mean square error (Winer, 1962, p. 209).

On Day 1 of generalization testing, analyses of variance with repeated measures performed between all possible combination of the

TABLE 2

Analysis of Variance of Mean Number of Responses Per Minute to S+ and S- During Discrimination Training

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 902.50 | 3 | 300.68 | 0.24 |
| Subj. w. groups | 34412.57 | 28 | 1229.02 | |
| Within subjects | | | | |
| B (Stimuli) | 417358.81 | 1 | 417358.81 | 396.24 ** |
| AB | 1849.18 | 3 | 616.39 | 0.58 |
| B X subj. w. groups | 29492.12 | 28 | 1053.29 | |
| C (Days) | 11309.89 | 9 | 1256.65 | 26.32 ** |
| AC | 915.70 | 27 | 33.91 | 0.71 |
| C X subj. w. groups | 12028.86 | 252 | 47.73 | |
| BC | 10988.43 | 9 | 1220.93 | 27.73 ** |
| ABC | 1109.12 | 27 | 41.07 | 0.93 |
| BC X subj. w. groups | 11093.50 | 252 | 44.02 | |

** $p < .01$

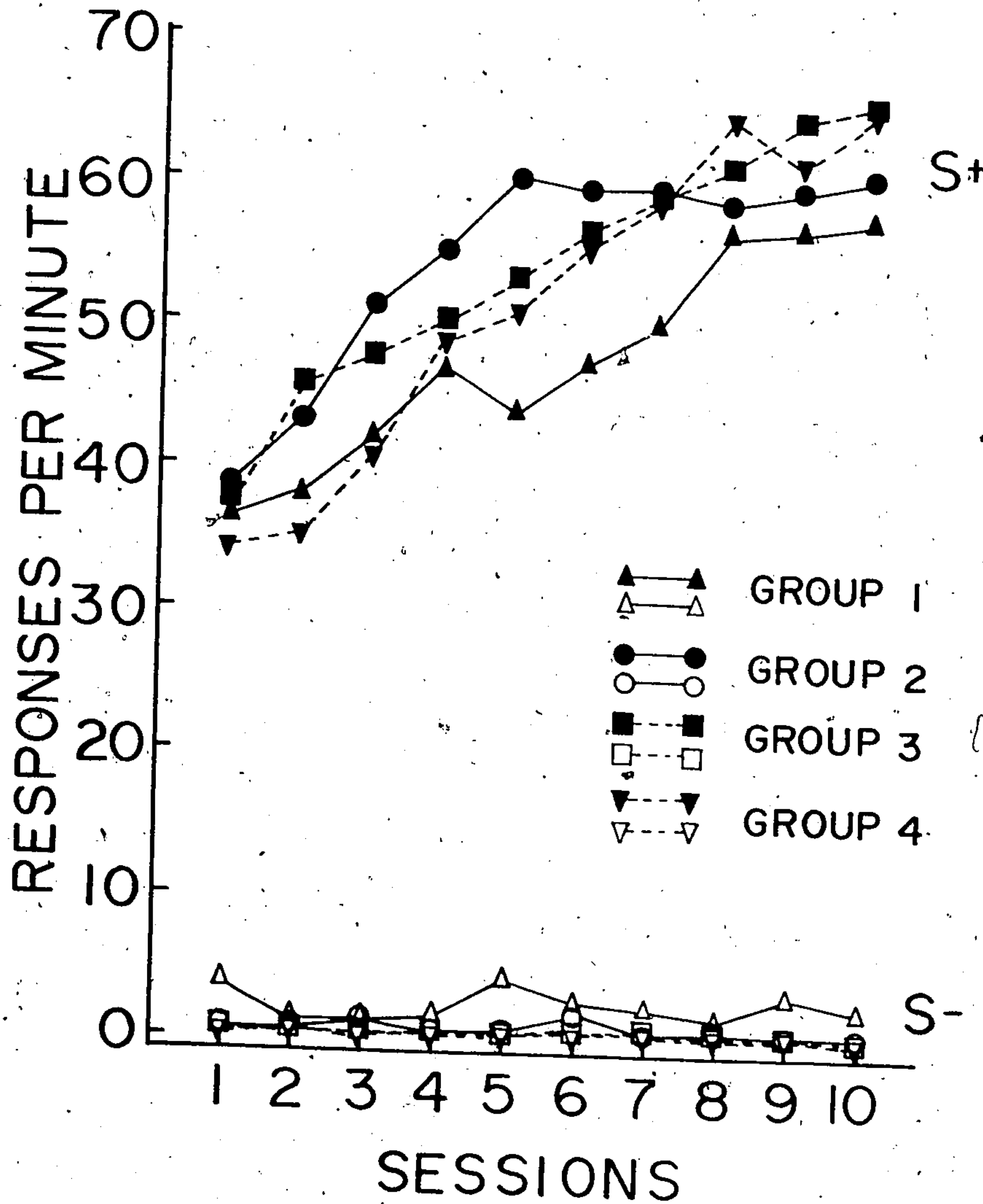


Fig. 1. Mean number of responses per minute to S+ and S- during discrimination training.

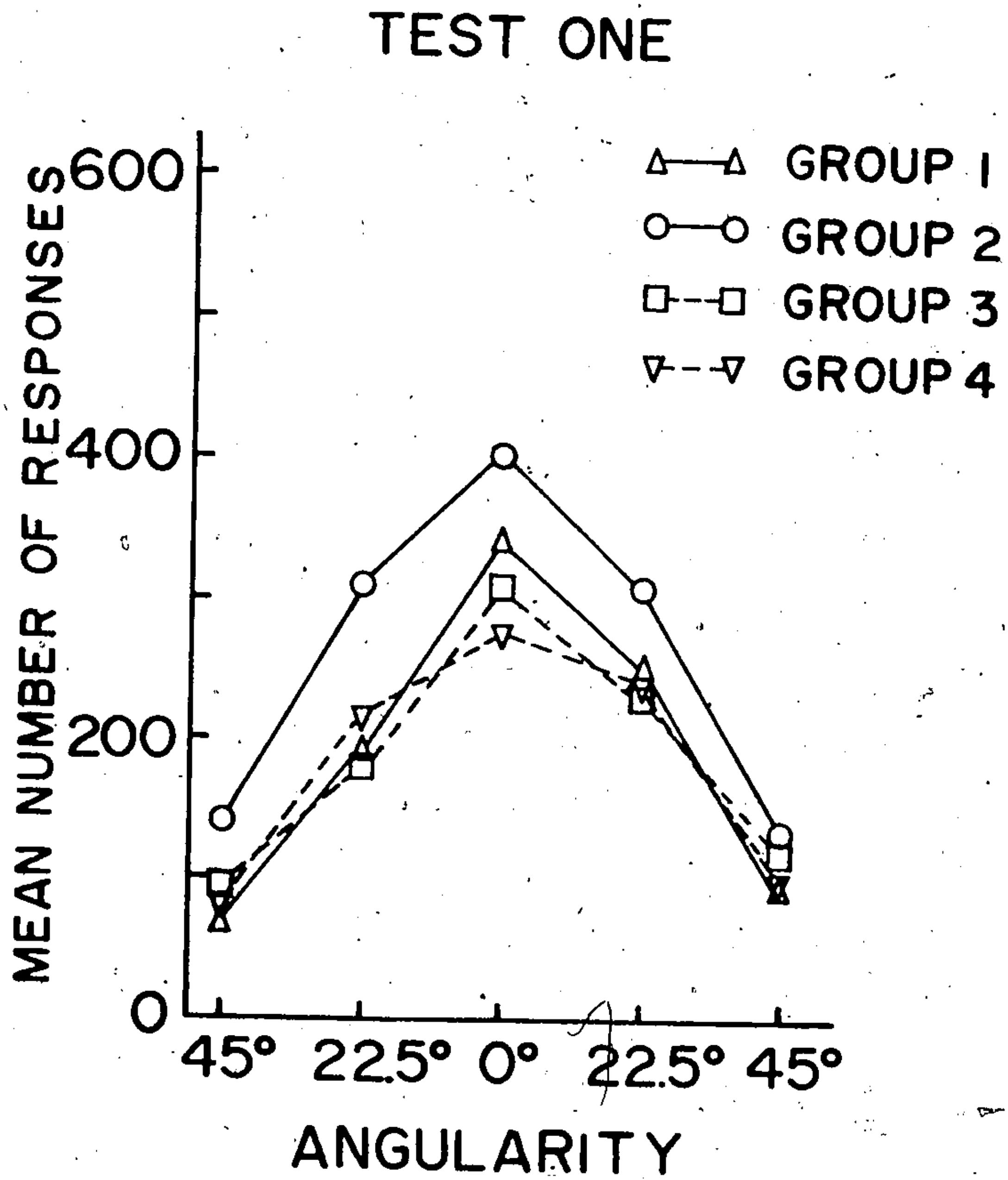


Fig. 2. Absolute generalization gradients for the four training groups for the first day of generalization testing.

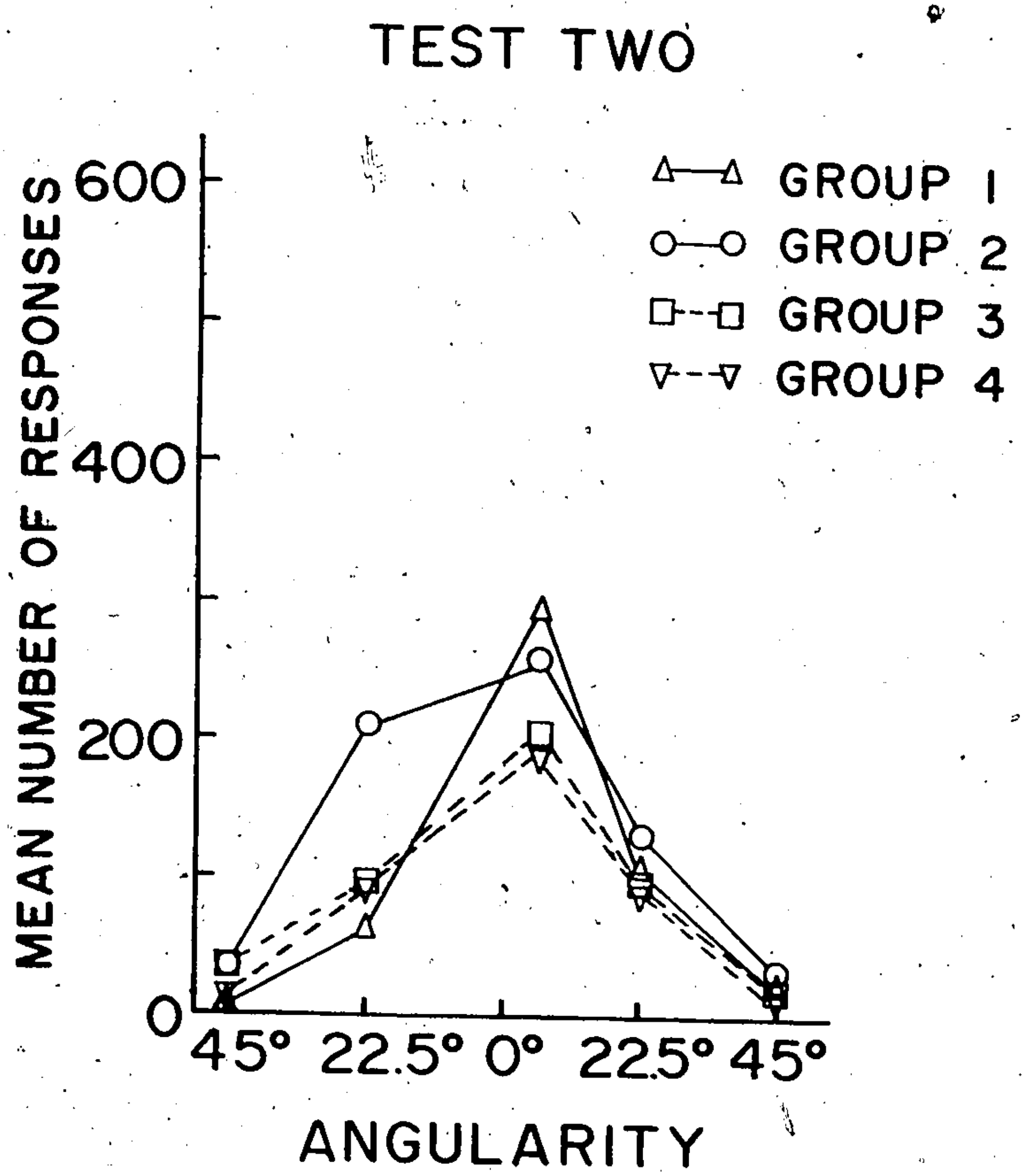


Fig. 3. Absolute generalization gradients for the four training groups for the second day of generalization testing.

TABLE 3

Analysis of Variance of Total Number of Responses for All Training Groups to All Test Stimuli on Day 1 of Generalization Testing

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 161648.38 | 3 | 53882.78 | 2.05 |
| Subj. w. groups | 733797.88 | 28 | 26207.06 | |
| Within subjects | | | | |
| B (Stimuli) | 1266133.00 | 4 | 316533.25 | 73.64 ** |
| AB | 55301.00 | 12 | 4608.41 | 1.07 |
| B X subj. w. groups | 481389.00 | 112 | 4298.11 | |

* $p < .05$

** $p < .01$

TABLE 4

Analysis of Variance of Total Number of Responses for All Training Groups to All Test Stimuli on Day 2 of Generalization Testing

| Source | SS | df | MS | F |
|---|---|---|---|---|
| <u>Between subjects</u> | | | | |
| A (Groups) | 77617.00 | 3 | 25872.33 | 2.70 |
| Subj. w. groups | 267633.94 | 28 | 9558.35 | |
| <u>Within subjects</u> | | | | |
| B (Stimuli) | 1043522.80 | 4 | 260880.69 | 76.89 ** |
| AB | 107276.00 | 12 | 8939,66 | 2.63 |
| B X subj w. groups | 379965.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE 5

Analysis of Variance of Total Number of Responses for All Training Groups to Left Side of Gradient on Day 1 of Generalization Testing

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 144357.63 | 3 | 48119.20 | 3.19 * |
| Subj. w. groups | 421446.69 | 28 | 15051.66 | |
| Within subjects | | | | |
| B (Stimuli) | 885208.75 | 2 | 442604.37 | 94.90 ** |
| AB | 35202.62 | 6 | 5867.10 | 1.25 |
| B X subj. w. groups | 261159.00 | 56 | 4663.55 | |

* $p < .05$

** $p < .01$

TABLE 6

Analysis of Variance of Total Number of Responses for All Training Groups to Left Side of Gradient on Day 2 of Generalization Testing

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 84547.56 | 3 | 28182.52 | 2.94 |
| Subj. w. groups | 268278.88 | 28 | 9581.38 | |
| Within subjects | | | | |
| B (Stimuli) | 778831.13 | 2 | 389415.56 | 90.56 ** |
| AB | 92077.31 | 6 | 15346.21 | 3.56 ** |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

TABLE 7

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 1 of Generalization Testing for Group 1 and Group 2

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 89527.50 | 1 | 89527.50 | 6.05 * |
| Subj. w. groups | 206984.44 | 14 | 14784.60 | |
| Within subjects | | | | |
| B (Stimuli) | 573958.25 | 2 | 286979.12 | 61.54 ** |
| AB | 7713.25 | 2 | 3856.62 | 0.83 |
| B X subj. w. groups | 261159.00 | 56 | 4663.55 | |

* $p < .05$

** $p < .01$

TABLE 8

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 1 of Generalization Testing for Group 2 and Group 3

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 94696.18 | 1 | 94696.18 | 6.19 * |
| Subj. w. groups | 213910.25 | 14 | 15279.30 | |
| Within subjects | | | | |
| B (Stimuli) | 454851.87 | 2 | 227425.94 | 48.77 |
| AB | 14947.93 | 2 | 7473.96 | 1.60 |
| B X subj. wi groups | 261159.00 | 56 | 4663.55 | |

* $p < .05$

** $p < .01$

TABLE 9

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 1 of Generalization Testing for Group 2 and Group 4

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 103694.88 | 1 | 103694.88 | 7.23 * |
| Subj. w. groups | 200783.19 | 14 | 14341.65 | |
| Within subjects | | | | |
| B (Stimuli) | 425970.44 | 2 | 212985.19 | 45.67 ** |
| AB | 10284.68 | 2 | 5142.34 | 1.10 |
| B X subj. w. groups | 261159.00 | 56 | 4663.55 | |

* $p < .05$

** $p < .01$

TABLE 10

Analysis of Variance of Total Number of Responses to All Test Stimuli on Day 2 of Generalization Testing for Group 1 and Group 2

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 35279.88 | 1 | 35279.88 | 3.61 |
| Subj. w. groups | 136639.69 | 14 | 9759.97 | |
| Within subjects | | | | |
| B (Stimuli) | 754992.69 | 4 | 188748.13 | 55.64 ** |
| AB | 61350.93 | 4 | 15337.77 | 4.52 ** |
| B X subj. w. groups | 379965.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE II

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 2 of Generalization Testing for Group 1 and Group 2

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 38420.05 | 1 | 38420.05 | 4.42 |
| Subj. w. groups | 121628.81 | 14 | 8687.76 | |
| Within subjects | | | | |
| B (Stimuli) | 577261.13 | 2 | 288630.56 | 67.13 ** |
| AB | 54683.87 | 2 | 27341.93 | 6.36 ** |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

TABLE 12

Analysis of Variance of Total Number of Responses to All Test Stimuli on Day 2 of Generalization Testing for Group 1 and Group 2

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 732.04 | 1 | 732.04 | 0.12 |
| Subj. w. groups | 82014.68 | 14 | 5858.19 | |
| Within subjects | | | | |
| B (Stimuli) | 565421.75 | 4 | 141355.44 | 41.67 ** |
| AB | 39255.75 | 4 | 9813.93 | 2.89 * |
| B X subj. w. groups | 379965.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE 13

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 2 of Generalization Testing for Group 1 and Group 3

| Source | SS | df | MS | F |
|---|---|---|---|---|
| <u>Between subjects</u> | | | | |
| A (Groups) | 645.33 | 1 | 645.33 | 0.09 |
| Subj. w. groups | 94149.68 | 14 | 6724.97 | |
| <u>Within subjects</u> | | | | |
| B (Stimuli) | 448961.38 | 2 | 224480.69 | 52.21 ** |
| AB | 39170.68 | 2 | 19585.34 | 4.55 ** |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

TABLE 14

Analysis of Variance of Total Number of Responses to All Test Stimuli on Day 2 of Generalization Testing for Group 1 and Group 4

| Source | SS | df | MS | F |
| --- | --- | --- | --- | --- |
| Between subjects | | | | |
| A (Groups) | 4867.19 | 1 | 4867.19 | 0.60 |
| Subj. w. groups | 112006.56 | 14 | 8000.46 | |
| Within subjects | | | | |
| B (Stimuli) | 548319.13 | 4 | 137079.75 | 40.41 ** |
| AB | 44210.68 | 4 | 11052.68 | 3.26 * |
| B X subj. w. groups | 37796.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE 15

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 2 of Generalization Testing for Group 1 and Group 4

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 5525.39 | 1 | 5525.53 | 0.54 |
| Subj. w. groups | 140954.69 | 14 | 10068.19 | |
| Within subjects | | | | |
| B (Stimuli) | 447796.25 | 2 | 223898.13 | 52.07 ** |
| AB | 42944.75 | 2 | 21472.37 | 4.99 * |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

TABLE 16

Analysis of Variance of Total Number of Responses to All Test Stimuli on Day 2 of Generalization Testing for Group 2 and Group 4

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 66355.12 | 1 | 66355.12 | 5.00 * |
| Subj. w. groups | 185619.88 | 14 | 13258.56 | |
| Within subjects | | | | |
| B (Stimuli) | 511987.87 | 4 | 127996.94 | 37.72 ** |
| AB | 34136.50 | 4 | 8534.12 | 2.51 * |
| B X subj. w. groups | 379965.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE 17

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 2 of Generalization Testing for Group 2 and Group 4

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 73085.81 | 1 | 73085.81 | 5.87 * |
| Subj. w. groups | 174129.56 | 14 | 12437.82 | |
| Within subjects | | | | |
| B (Stimuli) | 362221.94 | 2 | 181110.94 | 42.12 ** |
| AB | 20554.31 | 2 | 10277.15 | 2.39 |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

TABLE 18

Analysis of Variance of Total Number of Responses to All Test Stimuli on Day 2 of Generalization Testing for Group 2 and Group 3

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 46175.92 | 1 | 46175.92 | 4.15 |
| Subj. w. groups | 155627.69 | 14 | 11116.26 | |
| Within subjects | | | | |
| B (Stimuli) | 523895.44 | 4 | 130973.81 | 38.61 ** |
| AB | 34376.68 | 4 | 8594.17 | 2.53 |
| B X subj. w. groups | 379965.00 | 112 | 3392.54 | |

* $p < .05$

** $p < .01$

TABLE 19

Analysis of Variance of Total Number of Responses to Left Side of Gradient on Day 2 of Generalization Testing for Group 2 and Group 3

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (Groups) | 49023.90 | 1 | 49023.90 | 5.39 * |
| Subj. w. groups | 127324.75 | 14 | 9094.62 | |
| Within subjects | | | | |
| B (Stimuli) | 353871.06 | 2 | 176935.50 | 41.15 ** |
| AB | 26296.25 | 2 | 13148.12 | 3.06 |
| B X subj. w. groups | 240790.00 | 56 | 4299.82 | |

* $p < .05$

** $p < .01$

four groups provided no significant interaction effects of Groups x Stimuli (A x B). Therefore, no differences in the slopes of the overall gradients or the left side of the gradients occurred on the first day. No treatment effect of Groups (A) occurred for the overall gradients on Day 1. However, Group effects did occur on the left side of the gradient in three cases. Group 2 produced a significant Group (A) effect for the left side from Group 1, ($F=6.05$, $df=1/14$, $p<.05$). This analysis is presented in Table 7. A significant Group (A) effect indicates that Group 2 responded at a higher rate to the stimuli on the left side as compared with Group 1. This effect also occurred with Group 3, ($F=6.19$, $df=1/14$, $p<.05$) and with Group 4, ($F=7.23$, $df=1/14$, $p<.05$). These analyses are presented in Tables 8 and 9 respectively. It is clear from Figure 2 that Group 2 did produce a higher response rate for the left side on Day 1 of testing. Significant main effects of Stimuli (B) occurred for all analyses performed on the data from the first day of testing as well as the second day. This effect indicates that no group produced a flat gradient, and that the number of responses differed between stimuli.

Day 2 of generalization testing did produce significant interaction effects in the generalization gradients of the four treatment groups. To test the hypothesis whether Group 1, trained with two features and chroma on the line, would produce the steepest gradient, three analyses of variance with repeated measures were conducted on the overall gradients and three analyses were conducted on the left side of the generalization gradients. The first overall analysis on the absolute generalization gradients was performed on the data for Group 1 and Group 2. The outline of this analysis is presented in Table 10. There was a significant interaction of Group x Stimuli (A x B) for these two groups ($F=4.52$, $df=4/112$, $p<.01$). This difference was also significant for the left side of the gradient ($F=6.36$, $df=2/56$, $p<.01$). These analyses presented a comparison with the Baron and Vacek (1967) study and the results tend to support their finding.

A second overall analysis of variance examined the effect of equating number of features for two groups, although not equated for location of colour, either on the line or the surround. This analysis was carried out on the absolute generalization gradients for Group 1 and Group 3 and the outcome of the analysis is presented in Table 12. There was a significant interaction effect of Group x Stimuli (A x B) with Group 1 producing the steepest gradient, ($F=2.89$, $df=4/112$, $p<.05$). An analysis performed on the left side of these gradients also produced a significant interaction effect ($F=4.55$, $df=4/28$, $p<.01$). Table 13 shows the outcome of that analysis. It appears from this result that since both groups were equated for number of features, the difference that occurred may be due to whether colour is situated on the line or on the surround. An inspection of Figure 2 reveals that it is colour on the line that produces the steeper gradient.

The third overall analysis examined the effect of differing the number of features for the two groups but equating the two groups for chroma on the line as S+ during training. This analysis was conducted on the test data for Group 1 and Group 4 for all five test stimuli and the result is presented in Table 14. There was a significant interaction effect (A x B) with Group 1 again producing the steepest gradient ($F=3.26$, $df=4/112$; $p<.05$). An analysis on the left side of the gradient also showed a significant interaction effect ($F=4.99$, $df=2/56$, $p<.05$) as presented in Table 15. These results suggest that when both groups are equated for having chroma on the line, the group trained with two salient features produces a steeper gradient than the group trained with one salient feature.

To further examine the effects of placing chroma on the line or the surround and varying the number of features, an analysis of variance was performed between Groups 3 and 4. Group 3 contained chroma on the surround and two features. Group 4 contained chroma on the line and one salient feature. During generalization testing, the two groups produced almost identical gradients for the second day of testing as shown in Figure 3. The interaction effect for this analysis was not significant either for the overall gradient or the left side ($F<1$). From this result it seems that when birds are trained with chroma on the surround and two features, the treatment is identical to being trained with colour on the line and only one feature. However, from this information it is difficult to predict whether, for Group 3, the presence of two features may have increased the slope of the gradient to resemble Group 4, or whether chroma on the surround produced this effect. Therefore, a subsequent analysis between Group 2 and Group 4 sought to distinguish between these two alternatives. In this analysis the two groups were equated for consisting of one feature, and differed for location of the colour; Group 2 containing chroma on the surround and Group 4 containing chroma on the line. The interaction term for the analysis between Groups 2 and 4 showed a significant difference ($F=2.51$, $df=4/112$, $p < .05$) (see Table 16). However, the interaction effect was not significant for these two groups for the left side of the gradient ($F=2.39$, $df=2/56$, $p > .05$) as Table 17 indicates.

The final analysis to be discussed examined the effect of equating chroma on the surround but varying the number of features during training. The analysis was carried out on Group 2 (one feature) and Group 3 (two features). The results for that analysis for the overall gradient and for the left side are presented in Tables 18 and 19 respectively. A significant interaction effect occurred for the overall gradient ($F=2.53$, $df=4/112$, $p < .05$) but not for the left side ($F=3.06$, $df=2/56$, $p > .05$). From Figure 3 it is evident that it was Group 3 that produced the steeper generalization gradient. Therefore, when equated for chroma on the surround, one feature produced a steeper gradient than two features. This is contrary to the predicted effect.

# CHAPTER IV

## Discussion

In most cases, the results of the present study tend to support the hypotheses. One exception that occurred was with respect to the hypothesis that groups trained with a green vertical line would produce steeper gradients than groups trained with colour on the surround: no difference in slope of the generalization gradients occurred between Group 3 and Group 4.

The present study did not produce clear-cut differences in the effect of placing colour on the line or on the background, varying the number of features. Group I and Group 4 were both trained with a green vertical line as S+, but differed in the number of ways in which to learn the discrimination. Since Group I and Group 4 were equated for colour on the line, any differences in slope of the generalization gradients could be attributed to the training conditions. Group 2 and Group 3 were equated for colour on the surround and any difference in those generalization gradients could also be attributed to the number of features present during training. Looking at Group 3 and Group 4 it was predicted that Group 4 would produce a steeper gradient because it contained chroma on the line. The actual results revealed that the two groups were almost identical in the shape of their gradients. This finding indicates that circumstances do exist when the location of chroma, either on the line or the background, does not produce differences in the slope of generalization gradients. The conditions in which this occurs seems to be the case is when training occurs varying the number of features present during discrimination training. Other possible conditions may also occur but must be delineated with further study.

Newman and Baron (1965) trained one of four groups of pigeons to discriminate the presence-absence of a white vertical line on a green surround as S+, and a red surround with the line absent as S- (Group 2). Examining the discrimination data for this group, it is clear that the birds learned the discrimination on the first day of training, with about 92.5 per cent of the total responses made to S+. During generalization testing, however, a flat gradient occurred along the angularity dimension. Baron (1965) concluded that when given a complex stimulus, consisting of colour and a vertical line, the colour element was attended to more readily than the line. The present experiment consisted of a group that might be compared with Group 2 of the Newman and Baron study. Group 3 of the present study was trained to discriminate a white vertical line on a green surround as S+ and a white surround as S-. The birds in this group could have learned the discrimination on the basis of the presence-absence of the vertical line, or by discriminating on the basis of colour, as did the Ss in Group 2 of the Newman and Baron study. The generalization gradients for this group indicates that colour could be seen as a relevent dimension during discrimination as well as a dominant feature (Baron, 1965). If Ss in this group attended to the colour dimension during training, then generalization testing should produce flat gradients along angularity. But, this was not the case. Therefore, these results cast doubt upon the perceptual attending hierarchy theory which assumes that colour is high in the attending hierarchy of the pigeon. Since the colour of S- (white) was the same as the vertical line of S+, as opposed to the different colour (red) in the Newman and Baron study, a confounding result may have occurred. The tests used in this experiment were not sensitive to this possibility.

Baron and Vacek (1967) obtained differences in the slopes of generalization gradients on the first day of testing but not on the second. The present study found that significant differences in the slopes of the gradients occurred on the second day of testing but not on the first. Newman and Baron (1965) reported that their Group I (trained with a white vertical line on green as S+, and a plain green key as S-) showed greater control by angularity on the second day of testing. The present study produced the same effect, and is also in accord with Clarkson (1970). Honig, Boneau, Bernstein, and Pennypacker (1963) found that a steep generalization gradient occurs immediately after discrimination training and flattens later. However, procedural differences between the Honig et al. study and the present study may lead to this contrary effect.

Many outcomes of the present investigation have been explained in terms of colour on the line producing steeper gradients than a coloured surround, or two features during discrimination traing producing steeper gradients than one feature. As was mentioned earlier in this paper, birds may respond on the basis of differences in area of colour elements. For example, Group 4 could have learned the discrimination on the basis of a small amount of green (the vertical line of S+) and a large amount of green (the all green key of S-). Therefore, stimulus elements may be placed in a hierarchy arrangement due to the relative size of these elements on the retinal field (Baron, 1965). The results show that gradients were obtained along the angularity dimension, indicating that birds attended to line tilt during testing. However, the birds may have attended to both the line and to the colour during training but this can only be delineated with a further experiment.

The present experiment was designed to reconcile some earlier inconsistent findings in the literature. This study revealed that a groups of pigeons trained with two features and colour on the line produced steeper gradients than groups trained with colour on the surround or one feature, as well as two features and colour on the line and one feature. However, it may be premature to consider experiments in which the number of features or the salience of features is manipulated. A wide range of possible stimuli exist which may be attended to, such variables as loudness, frequency, brightness etc. The results of many studies utilizing these variables are not always consistent (Honig, 1970). Care must be taken in judging the reliability of many of these results. Baron (1965) realized many of these problems and suggested further research be done to determine positional arrangements of stimulus elements in an attending hierarchy, as well as to examine those independent variables which may modify this arrangement.

# APPENDIX A

## Order of Presentation of S+ and S-

## During Discrimination Training

Order of Presentation of S+ and S-

During Discrimination Training

| | | | |
|---|---|---|---|
| 1. | S+ | 33. | S- |
| 2. | S- | 34. | S+ |
| 3. | S- | 35. | S- |
| 4. | S+ | 36. | S+ |
| 5. | S- | 37. | S+ |
| 6. | S+ | 38. | S- |
| 7. | S+ | 39. | S+ |
| 8. | S- | 40. | S- |
| 9. | S+ | 41. | S- |
| 10. | S- | 42. | S+ |
| 11. | S- | 43. | S- |
| 12. | S+ | 44. | S+ |
| 13. | S- | 45. | S+ |
| 14. | S+ | 46. | S- |
| 15. | S+ | 47. | S+ |
| 16. | S- | 48. | S- |
| 17. | S+ | 49. | S- |
| 18. | S- | 50. | S+ |
| 19. | S- | 51. | S- |
| 20. | S+ | 52. | S+ |
| 21. | S- | 53. | S+ |
| 22. | S+ | 54. | S- |
| 23. | S+ | 55. | S+ |
| 24. | S- | 56. | S- |
| 25. | S+ | 57. | S- |
| 26. | S- | 58. | S+ |
| 27. | S- | 59. | S- |
| 28. | S+ | 60. | S+ |
| 29. | S- | 61. | S+ |
| 30. | S+ | 62. | S- |
| 31. | S+ | 63. | S- |
| 32. | S- | 64. | S+ |

# APPENDIX B

## Responses During Discrimination Training

Responses During Discrimination Training

| Group | S# | Stimulus | Days 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 11022 | S+ | 1676 | 1941 | 2406 | 2541 | 2451 | 2427 | 2181 | 2663 | 2572 | 2697 |
| | | S- | 24 | 6 | 0 | 2 | 0 | 5 | 2 | 4 | 15 | 5 |
| I | 1228 | S+ | 801 | 766 | 1018 | 1227 | 1126 | 844 | 986 | 1056 | 1011 | 1019 |
| | | S- | 16 | 22 | 13 | 8 | 5 | 4 | 0 | 0 | 0 | 1 |
| I | 1099 | S+ | 769 | 891 | 724 | 862 | 976 | 1035 | 1209 | 1379 | 1495 | 1586 |
| | | S- | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 |
| I | 9065 | S+ | 914 | 1201 | 1183 | 1294 | 1188 | 1628 | 1633 | 1850 | 1623 | 1989 |
| | | S- | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| I | 965 | S+ | 1232 | 1160 | 1274 | 1264 | 1605 | 1902 | 2116 | 2433 | 2607 | 2455 |
| | | S- | 10 | 29 | 48 | 90 | 221 | 139 | 79 | 53 | 61 | 67 |
| I | 10060 | S+ | 542 | 768 | 1277 | 1377 | 916 | 1002 | 867 | 967 | 1081 | 973 |
| | | S- | 22 | 5 | 16 | 1 | 14 | 13 | 20 | 21 | 19 | 62 |
| I | 1259 | S+ | 974 | 942 | 769 | 1206 | 837 | 898 | 1283 | 1271 | 1171 | 1283 |
| | | S- | 8 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| I | 1239 | S+ | 1597 | 1238 | 1216 | 1219 | 1202 | 1372 | 1604 | 1638 | 1609 | 1489 |
| | | S- | 30 | 2 | 0 | 7 | 29 | 13 | 40 | 16 | 9 | 2 |

Responses During Discrimination Training

| Group | S# | Stimulus | Days 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5664 | S+ | 1113 | 1453 | 1618 | 1545 | 1493 | 1341 | 1430 | 1671 | 1919 | 2090 |
| | | S- | 3 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 0 | 1 |
| 2 | 3373 | S+ | 1306 | 1499 | 1368 | 1384 | 1147 | 1536 | 1419 | 1264 | 1325 | 1396 |
| | | S- | 12 | 8 | 6 | 15 | 1 | 5 | 1 | 18 | 12 | 7 |
| 2 | 3065 | S+ | 1042 | 1084 | 1494 | 1711 | 2246 | 1786 | 2407 | 2370 | 1707 | 1976 |
| | | S- | 5 | 1 | 0 | 0 | 0 | 6 | 5 | 12 | 2 | 3 |
| 2 | 11452 | S+ | 1281 | 1158 | 2069 | 2412 | 3085 | 2918 | 2014 | 1945 | 1920 | 1794 |
| | | S- | 19 | 33 | 64 | 9 | 25 | 89 | 24 | 21 | 15 | 3 |
| 2 | 663 | S+ | 869 | 1191 | 1208 | 1468 | 1455 | 1656 | 1641 | 1506 | 1846 | 1786 |
| | | S- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 2 | 686 | S+ | 636 | 746 | 1009 | 1046 | 1296 | *1486 | 1517 | 1469 | 1457 | 1520 |
| | | S- | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 661 | S+ | 1913 | 2081 | 2124 | 2117 | 1844 | 1850 | 2215 | 2222 | 2388 | 2155 |
| | | S- | 8 | 3 | 0 | 1 | 0 | 0 | 3 | 3 | 5 | 6 |
| 2 | 1229 | S+ | 898 | 894 | 1111 | 1268 | 1519 | 1415 | 1368 | 1354 | 1451 | 1433 |
| | | S- | 0 | 0 | 1 | 6 | 6 | 2 | 0 | 0 | 0 | 0 |

Responses During Discrimination Training

| Group | S# | Stimulus | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 11001 | S+ | 895 | 1130 | 1329 | 1229 | 1260 | 1236 | 1219 | 1258 | 1268 | 1235 |
| | | S- | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 4002 | S+ | 1539 | 1940 | 2276 | 2136 | 1827 | 1793 | 2045 | 1902 | 1508 | 1849 |
| | | S- | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 5643 | S+ | 549 | 600 | 649 | 965 | 1097 | 1148 | 1215 | 1302 | 1471 | 1445 |
| | | S- | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 11915 | S+ | 1093 | 1443 | 1870 | 1899 | 1789 | 2071 | 2257 | 2366 | 2544 | 2619 |
| | | S- | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 3 | 1257 | S+ | 1269 | 1692 | 1210 | 1436 | 1736 | 2070 | 1604 | 1458 | 1939 | 2004 |
| | | S- | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 1298 | S+ | 1235 | 1700 | 1815 | 2128 | 2362 | 2560 | 2595 | 3170 | 2959 | 2899 |
| | | S- | 10 | 11 | 12 | 7 | 25 | 34 | 61 | 51 | 14 | 14 |
| 3 | 1233 | S+ | 796 | 810 | 622 | 636 | 649 | 958 | 1348 | 1493 | 1924 | 1928 |
| | | S- | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 0 |
| 3 | 658 | S+ | 1312 | 1402 | 1451 | 1378 | 1733 | 1449 | 1632 | 1427 | 1573 | 1471 |
| | | S- | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Responses During Discrimination Training

| Group | S# | Stimulus | Days 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 9686 | S+ | 841 | 1249 | 1627 | 1718 | 1538 | 1755 | 1799 | 1754 | 1785 | 2242 |
| | | S- | 13 | 0 | 2 | 4 | 11 | 1 | 0 | 1 | 1 | 2 |
| 4 | 11033 | S+ | 1455 | 1348 | 1523 | 1768 | 1628 | 1542 | 1695 | 1662 | 1687 | 1938 |
| | | S- | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 |
| 4 | 10516 | S+ | 740 | 778 | 786 | 785 | 908 | 906 | 1014 | 1686 | 1244 | 1291 |
| | | S- | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| 4 | 10080 | S+ | 449 | 477 | 590 | 777 | 759 | 765 | 939 | 1141 | 1594 | 2487 |
| | | S- | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 1 |
| 4 | 1228 | S+ | 1464 | 1324 | 1718 | 2426 | 2456 | 3167 | 3305 | 2863 | 2783 | 2662 |
| | | S- | 0 | 0 | 0 | 0 | 5 | 2 | 0 | 1 | 1 | 0 |
| 4 | 8824 | S+ | 681 | 603 | 777 | 1143 | 1190 | 1515 | 1740 | 1770 | 1600 | 1617 |
| | | S- | 5 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 4 | 1274 | S+ | 1289 | 1408 | 1303 | 1242 | 1397 | 1437 | 1414 | 1640 | 1616 | 1653 |
| | | S- | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 4 | 8822 | S+ | 1073 | 1259 | 1214 | 1622 | 2035 | 1870 | 1896 | 1899 | 2078 | 1902 |
| | | S- | 1 | 1 | 0 | 0 | 2 | 2 | 1 | 1 | 0 | 2 |

# APPENDIX C

## Order of Presentation of Stimuli

## During Generalization Test

# Order of Presentation of Stimuli

# During Generalization Test

1. 22.5° left
2. 0°
3. 22.5° right
4. 45.0° left
5. 45.0° right
6. 0°
7. 45.0° left
8. 22.5° left
9. 22.5° right
10. 45.0° right
11. 22.5° right
12. 22.5° left
13. 45.0° left
14. 0°
15. 45.0° right
16. 45.0° left
17. 22.5° right
18. 0°
19. 22.5° left
20. 45.0° right
21. 22.5° left
22. 0°
23. 22.5° right
24. 45.0° left
25. 45.0° right
26. 0°
27. 45.0° left
28. 22.5° left
29. 22.5° right
30. 45.0° right
31. 22.5° right
32. 22.5° left
33. 45.0° left
34. 0°
35. 45.0° right
36. 45.0° left
37. 22.5° right
38. 0°
39. 22.5° left
40. 45.0° right
41. 22.5° right
42. 22.5° left
43. 45.0° left
44. 0°
45. 45.0° right
46. 45.0° left
47. 22.5° right
48. 0°
49. 22.5° left
50. 45.0° right

APPENDIX D

Responses to Stimuli During Generalization Testing

for Test Day One

Responses to Stimuli During Generalization Testing

for Test Day One

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| I | 11022 | 130 | 348 | 481 | 353 | 140 |
| I | 1228 | 56 | 116 | 182 | 169 | 104 |
| I | 1099 | 150 | 132 | 308 | 200 | 92 |
| I | 9065 | 10 | 37 | 284 | 213 | 23 |
| I | 965 | 87 | 227 | 425 | 384 | 131 |
| I | 10060 | 68 | 186 | 369 | 293 | 131 |
| I | 1259 | 4 | 175 | 259 | 91 | 19 |
| I | 1239 | 24 | 289 | 401 | 304 | 88 |
| TOTALS | | 529 | 1510 | 2709 | 2007 | 728 |
| MEANS | | 66.12 | 188.75 | 338.63 | 250.87 | 91.00 |

Responses to Stimuli During Generalization Testing

for Test Day One

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 2 | 5664 | 234 | 327 | 631 | 567 | 138 |
| 2 | 3373 | 138 | 267 | 370 | 366 | 282 |
| 2 | 3065 | 48 | 388 | 356 | 230 | 34 |
| 2 | 11452 | 106 | 386 | 443 | 380 | 209 |
| 2 | 663 | 98 | 309 | 396 | 84 | 1 |
| 2 | 686 | 117 | 217 | 303 | 254 | 57 |
| 2 | 661 | 234 | 396 | 458 | 347 | 260 |
| 2 | 1229 | 144 | 194 | 261 | 237 | 106 |
| TOTALS | | 1119 | 2484 | 3218 | 2465 | 1087 |
| MEANS | | 139.88 | 310.50 | 402.25 | 308.13 | 135.88 |

Responses to Stimuli During Generalization Testing

for Test Day One

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 3 | 11001 | 55 | 181 | 218 | 170 | 94 |
| 3 | 4002 | 272 | 368 | 406 | 444 | 207 |
| 3 | 5643 | 176 | 160 | 270 | 125 | 65 |
| 3 | 11915 | 122 | 207 | 337 | 249 | 85 |
| 3 | 1257 | 43 | 100 | 458 | 372 | 155 |
| 3 | 1298 | 44 | 152 | 171 | 110 | 78 |
| 3 | 1233 | 38 | 213 | 351 | 249 | 231 |
| 3 | 658 | 17 | 61 | 269 | 131 | 34 |
| TOTALS | | 767 | 1442 | 2480 | 1850 | 949 |
| MEANS | | 95.88 | 180.25 | 310.00 | 231.25 | 118.63 |

Responses to Stimuli During Generalization Testing

for Test Day One

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 4 | 9686 | 66 | 358 | 509 | 419 | 121 |
| 4 | 11033 | 41 | 295 | 425 | 317 | 148 |
| 4 | 10516 | 43 | 121 | 123 | 107 | 23 |
| 4 | 10080 | 145 | 206 | 276 | 211 | 126 |
| 4 | 1228 | 64 | 129 | 191 | 187 | 86 |
| 4 | 8824 | 105 | 255 | 252 | 293 | 72 |
| 4 | 1274 | 65 | 185 | 277 | 274 | 148 |
| 4 | 8822 | 141 | 175 | 143 | 129 | 97 |
| TOTALS | | 670 | 1724 | 2196 | 1937 | 821 |
| MEANS | | 83.75 | 215.50 | 274.50 | 242.12 | 102.62 |

APPENDIX E

Responses to Stimuli During Generalization Testing

for Test Day Two

Responses to Stimuli During Generalization Testing

for Test Day Two

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| I | 11022 | 7 | 68 | 287 | 110 | 1 |
| I | 1228 | 6 | 21 | 140 | 54 | 11 |
| I | 1099 | 5 | 13 | 240 | 54 | 66 |
| I | 9065 | 0 | 13 | 294 | 127 | 21 |
| I | 965 | 8 | 49 | 238 | 106 | 10 |
| I | 10060 | 2 | 53 | 311 | 196 | 8 |
| I | 1259 | 4 | 213 | 387 | 99 | 8 |
| I | 1239 | 0 | 62 | 434 | 98 | 23 |
| TOTALS | | 32 | 492 | 2331 | 844 | 148 |
| MEANS | | 4.00 | 61.50 | 291.38 | 105.50 | 18.50 |

Responses to Stimuli During Generalization Testing

for Test Day Two

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 2 | 5664 | 30 | 339 | 418 | 232 | 15 |
| 2 | 3373 | 46 | 247 | 439 | 298 | 91 |
| 2 | 3065 | 44 | 257 | 159 | 109 | 6 |
| 2 | 11452 | 20 | 124 | 153 | 63 | 46 |
| 2 | 663 | 4 | 173 | 278 | 8 | 0 |
| 2 | 686 | 41 | 208 | 330 | 127 | 32 |
| 2 | 661 | 66 | 212 | 325 | 108 | 51 |
| 2 | 1229 | 18 | 127 | 155 | 108 | 20 |
| TOTALS | | 269 | 1687 | 2257 | 1053 | 261 |
| MEANS | | 33.63 | 210.88 | 282.13 | 131.63 | 32.63 |

Responses to Stimuli During Generalization Testing

for Test Day Two

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 3 | 11001 | 1 | 51 | 150 | 105 | 0 |
| 3 | 4002 | 22 | 184 | 383 | 59 | 6 |
| 3 | 5643 | 7 | 101 | 322 | 232 | 36 |
| 3 | 11915 | 95 | 94 | 171 | 68 | 44 |
| 3 | 1257 | 7 | 33 | 82 | 34 | 1 |
| 3 | 1298 | 11 | 64 | 160 | 44 | 1 |
| 3 | 1233 | 68 | 113 | 186 | 74 | 31 |
| 3 | 658 | 53 | 148 | 173 | 178 | 13 |
| TOTALS | | 264 | 788 | 1627 | 794 | 132 |
| MEANS | | 33.00 | 98.50 | 203.38 | 99.25 | 16.50 |

Responses to Stimuli During Generalization Testing

for Test Day Two

| Group | S# | 45°L | 22.5°L | 0° | 22.5°R | 45°R |
|---|---|---|---|---|---|---|
| 4 | 9686 | 5 | 18 | 376 | 177 | 33 |
| 4 | 11033 | 3 | 70 | 110 | 108 | 8 |
| 4 | 10516 | 6 | 56 | 158 | 112 | 33 |
| 4 | 10080 | 1 | 11 | 117 | 41 | 0 |
| 4 | 1228 | 2 | 67 | 100 | 68 | 2 |
| 4 | 8824 | 6 | 311 | 418 | 87 | 30 |
| 4 | 1274 | 4 | 77 | 70 | 21 | 2 |
| 4 | 8822 | 75 | 137 | 142 | 132 | 29 |
| TOTALS | | 102 | 747 | 1491 | 746 | 137 |
| MEANS | | 12.50 | 93.38 | 186.38 | 93.25 | 17.13 |

# REFERENCES

Baron, M. R. The stimulus, stimulus control, and stimulus generalization. In D. I. Mostofsky (Ed.) Stimulus generalization. Stanford: Stanford University Press, 1965, 62-71.

Baron, M. R. & Vacek, C. T. Generalization gradients along wavelength and angularity dimensions in pigeons following two differential training procedures. Psychonomic Science, 1967, 9, (7B), 423-424.

Blodgett, H. C., Mc Cutchan, K., & Mathews, R. Spatial learning in the T-maze: The influence of direction, turn, and food location. Journal of Experimental Psychology, 1949, 39, 800-809.

Clarkson, T. H. Stimulus control and the post-discrimination gradient: Effects of the amount of discrimination training. Unpublished Major Paper, University of Windsor, 1970.

Eninger, M. U. Habit summation in a selective learning problem. Journal of Comparative and Physiological Psychology, 1952, 45, 604-608.

Hirota, T. T., Milam, V. K., & Ferenc, D. W. Does chroma on the line increase attention to the line in pigeons? Animal Learning and Behaviour, in press.

Honig, W. K. Attention and the modulation of stimulus control. In D. I. Mostofsky (Ed.) Attention: Contemporary theory and analysis. New York, Appleton-Century-Crofts, 1970, 193-238.

Honig, W. K., Boneau, C. A., Burnstein, K. R., & Pennypacker, H. S. Positive and negative generalization gradients after equivalent training conditions. Journal of Comparative and Physiological Psychology, 1963, 56 (1), 111-116.

Hull, C. L. Principles of behaviour. New York: Appleton-Century-Crofts, 1943.

Jenkins, H. M. Measurement of stimulus control during discriminative operant conditioning. Psychological Bulletin, 1965, 64, 365-376.

Lashley, K. S. The mechanism of vision: XV. Preliminary studies of the rat's capacity for detail vision. Journal of Experimental Psychology, 1938, 18, 123-193.

Mostofsky, D. I. The semantics of attention. In D. I. Mostofsky (Ed.) Attention: Contemporary theory and analysis, New York, Appleton-Century-Crofts, 1970, 9-24.

Newman, F. L., & Baron, M. R. Stimulus generalization along the dimensions of angularity: A comparison of training procedures. Journal of Comparative and Physiological Psychology, 1965, 60, 59-63.

Skinner, B. F. The behaviour of organisms; an experimental analysis. New York: Appleton-Century-Crofts, 1938.

Sutherland, N. S., & Holgate, V. Two-cue discrimination learning in rats. Journal of Comparative and Physiological Psychology, 1966, 61, (2), 198-207.

Terrace, H. S. Stimulus control. In W. K. Honig (Ed.) Operant behaviour: Areas of research and application. New York, Appleton-Century-Crofts, 1966, p. 271-344.

Warren, J. M. Additivity of cues in discrimination learning by primates. Journal of Comparative and Physiological Psychology, 1953, 46, 484-486.

Warren, J. M. Perceptual domiance in discrimination learning by monkeys. Journal of Comparative and Physiological Psychology, 1954, 47, 290-292.

Winer, B. J. Statistical principles in experimental design. McGraw - Hill, New York, 1962.

## Vita Auctoris

| | |
|---|---|
| 1948 | Born in Windsor, Ontario, Canada to Sophie and William Ferenc |
| 1953-1962 | Educated at King George Public School in Windsor, Ontario |
| 1962-1967 | Attended Walkerville Collegiate Institute, Windsor, Ontario, and graduated with an Honours Secondary School Diploma |
| 1971 | Graduated with the degree of Bachelor of Arts (Honours) in Psychology from the University of Windsor, Windsor, Ontario |
| 1971-1973 | Registered as a full-time graduate student at the University of Windsor, Windsor, Ontario |