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The effects of chroma on the line vs. chroma on the surround following non-differential training.

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THE EFFECTS OF CHROMA ON THE LINE VS. CHROMA ON THE SURROUND FOLLOWING NON-DIFFERENTIAL TRAINING

by
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B.A. (Hons.), University of Windsor, 1973

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
1974

ABSTRACT

Two groups of pigeons were non-differentially trained in the presence of a green vertical line on a white surround (Experimental Group) and a white vertical line on a green surround (Control Group). Each group was divided into two sub-groups and tested for generalization, to stimuli varied along the angularity dimension on two consecutive test days. Half of the Experimental Group was tested to a green line on a white surround and half to a black line on a white surround. Half of the Control Group was tested to a white line on a green surround and half to a white line on a black surround. No control by the angularity dimension was observed. Generalization gradients for all test groups were near equally flat. The groups tested under the green line and surround conditions produced significantly more overall responses than the groups tested under the black conditions. The results suggest that pigeons respond on the basis of a perceptual hierarchy following non-differential training on which colour ranks higher than the dimension of angularity.

PREFACE

I am grateful to Dr. Theodore T. Hirota, Chairman of my Thesis Committee for his infinite patience in guiding me through the most difficult parts of this experiment. His assistance and constructive criticisms in the preparation of this paper were greatly appreciated.

In addition I would like to thank Dr. Theodore Horvath and Dr. Arthur Smith for their guidance and understanding of the problems I encountered in writing this paper. My sincerest thanks also go to Rev. Claude Vincent for acting as my outside reader.

And last but not least I am greatly indebted to my wife Margaret for her unfailing confidence in me and for carrying the burden of typing and editing.

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CHAPTER I

INTRODUCTION

Since the time when classical conditioning experiments rode the crest of experimental inquiry, the process of stimulus generalization has been explored by introducing ever more complex stimulus situations to which an organism must somehow respond. From these responses, experimental psychologists have drawn conclusions regarding the limits to which an organism is capable of responding to similar stimuli. The concluding answers have ranged from as simple a statement as, an organism's initial response to a stimulus, after an appropriate training period, will transfer to similar stimuli if presented under similar conditions (Pavlov 1927), to the more complex answers drawn from operant conditioning experiments as first explored by B. F. Skinner (1938).

Not only have the experimental procedures undergone a historical transformation from the simple to the more complex procedures, but so has the choice of subjects. For instance, among the situational variables the initial natural observations of an organism's behaviour in its respective environment have been supplemented by introducing contrived situations for studying primarily the internal processes which do not lend themselves easily to natural observations. Here the classical experiment by Olds and Milner (1956) of induced selfstimulation, by implanting an electrode into a rat's brain, comes readily to mind.

Numerous species have been studied by the experimental psychologist, from simple one-cell organisms (Plenaria) to the highly complex human organism. All have contributed to the understanding of the learning process, from which inferences can be drawn about the capabilities of organisms to process information. The inference alluded to, of course, is the amount of learning taking place after an initial exposure to a stimulus situation. The emerging response patterns, fortified by reinforcement for correct responding, are indicative of the organism's learning capabilities, and by manipulating the test situation, experimenters can determine how much of this learning is generalized to similar stimuli.

One principle technique used in this area involves operant conditioning. In one of the early experiments with pigeons, Guttman and Kalish (1956) studied stimulus generalization to different colours. Using operant conditioning techniques, they first trained their food-deprived subjects to peck at a translucent light key for food reinforcement. They next trained these pigeons to respond to either green, yellow, or orange on the key and expected the birds to respond equally to any variation of wavelength within the same band as the training colour. However, their hypothesis was not supported by the results. The generalization gradients showed maximum responding at the training stimulus with diminished amounts at more distant wavelengths from the training colour. Guttman and Kalish (1956) concluded that pigeons are indeed capable of accurately identifying different wavelengths as if equipped with a frequency analyzer.

One possible way to measure general attentiveness of the organism is to compare stimulus generalization gradients. An organism is said to be attending to an aspect in its environment if variations of that aspect brings about a change in the behaviour of the organism (Reynolds, 1961). Consequently, after the organism has been trained to respond to a stimulus the resulting steep slope and peak of the generalization curve, during testing, implies that the organism has attended to the training stimulus or that the training stimulus gained control over the behaviour of the organism. A flat generalization gradient, on the other hand, may imply little or no control by the test dimension.

It has been shown that the slope of the generalization gradient, following single stimulus training, is influenced by prior training. For example, Mackintosh (1965) trained forty-eight rats to respond to a horizontal rectangle for one hundred rewarded trials and then extinguished responses to the training rectangle or one differing in brightness or orientation. Of the forty-eight subjects so trained, thirty-two received prior training on either a successive brightness or an orientation discrimination. Sixteen subjects received no prior training and showed intermediate gradients of generalization when tested under brightness or orientation conditions. Subjects tested on the dimension on which they had prior training showed a significantly steeper gradient, while the subjects tested on the dimension opposite to the pre-training dimension showed significantly flatter gradients. Mackintosh (1965) suggested that the mechanisms of attention must indeed be internal ones as suggested by Sutherland, (1959). Further, Mackintosh (1965) concluded that these results provided additional support to the earlier Sutherland and Mackintosh (1964) theory that the more an organism is trained to attend to one stimulus the less it will attend to another.

This position was disputed by Thomas (1969), Eck, Noel and Thomas

(1969), and Thomas (1970). These investigators theorized that training to one stimulus dimension enhances the organism's capacity to attend to other dimensions. For example, Thomas (1970) took particular exception to the theory expressed by Sutherland and Mackintosh (1964) which he called an "inverse hypothesis". In an experimental program designed to investigate the inverse hypothesis, Thomas (1970) and his associates obtained results which largely contradicted the theory that increases in stimulus control by one dimension are associated with decreases in stimulus control by another dimension. He concluded that the Mackintosh (1965) study, for instance, can be questioned on procedural grounds. Thomas (1970) argued that the method of measuring the slope of the generalization gradient (i.e. the degree to which the non-reversal problem was easier than the reversal problem) was idiosyncratic, and required a questionable assumption.

Rather than embracing the theory of selective attention in his experiments with pigeons, Thomas (1970) proposed that discrimination training produces a state of "general attentiveness". In addition to attending to the relevant cues during the acquisition of the original training, the organism becomes increasingly sensitive to stimulus differences.

The aim in the experimental study of attention is the identification of stimuli that control responding in a given situation, (Reynolds, 1961). An organism may attend to several aspects of a discriminative stimulus with greater frequency and is thus said to be under control of that stimulus aspect. Newman and Baron (1965) proposed the possibility that organisms attend to the colour dimension to a greater degree than to the angularity dimension. This theory of a perceptual attending hierarchy was first elaborated on in a study by Jones (1954). Specifically, Newman and Baron (1965) tested three groups of pigeons along the dimension of angularity following differential training to (a) presence vs. absence of a white vertical line on a green surround, (b) presence vs. absence of a white vertical line on a green vs. red surround, and (c) a white vertical line present during reinforced and non-reinforced periods, on a green vs. red surround. A relatively steep gradient was obtained only for the group differentially trained to the presence vs. absence of a white vertical line on a green surround. Relatively flat gradients were obtained for the remaining two groups. The implication in this case is that the subjects could learn to attend to the presence vs. absence of the line only in the absence of the more dominant dimension, i.e., colour. Newman and Baron (1965) concluded that the differentially trained subjects attended more to the colour dimension than the angular orientation because colour ranks higher on the perceptual hierarchy.

Baron and Vacek (1967) hypothesized that, if colour is a more salient cue and thus more readily attended to than line orientation, then attention to angularity should be facilitated if the line itself was coloured. Baron and Vacek (1967) trained one group to discriminate between a green vertical line on a white surround as S+ and a white surround as S-. The control group was identical to Newman and Baron's (1965) group 1, which was trained to discriminate between presence vs. absence of a white vertical line on a green surround. Baron and Vacek (1967) obtained results consistent with the perceptual attending hierarchy proposed by Newman and Baron, (i.e., the group trained with the green line produced a steeper gradient).

Baron and Bresnahan (1969a) questioned the results of the Baron and Vacek (1967) study. Baron and Bresnahan (1969a) suggested that the colour on the surround may have decreased attention to the white line and produced the flatter gradient for the control group. Two groups of pigeons were differentially trained to a white line on a green or black surround as S+ and a green or black surround with no lines present as S-. While the group trained with black surrounds produced a steeper gradient, the differences were not significant. Thus, no evidence was presented to substantiate the suggestion that surround colour decreased attention to the line.

Baron and Vacek's (1967) hypothesis was examined by Hirota, Milam, and Ferenc (1973). Two groups of pigeons were trained to discriminate between presence vs. absence of a vertical line on a white surround. For one group (Experimental) the vertical line was green (S+). For the control group the vertical line was black (S+). The S- for both groups consisted of a white surround. Generalization tests along the angularity dimension showed equally steep gradients for both groups. Hirota, et al. (1973) concluded that colour on the line did not increase attention to the line. Hirota et al. (1973) suggested that a procedural difference during testing may have produced the different generalization gradients since Baron and Vacek (1967) simultaneously varied line orientation and wavelength during the test whereas the Hirota et al. (1973) experiment held wavelength constant and varied only line orientation during the testing phase.

A second study was conducted by Ferenc and Hirota (1973) to determine the effects on the slope of the generalization gradients, when one or two salient cues are made available during training (colour and line angularity). Four groups of pigeons were differentially trained: Group 1 to a green vertical line on a white surround (S+) and a white surround (S-), Group 2 to a white vertical line on a green surround (S+) and a green surround (S-), Group 3 to a white vertical line on a green surround (S+) and a white surround (S-), and Group 4 to a green vertical line on a white surround (S+) and a green surround (S-). By placing colour on the line (S+) when S- was a white surround or by placing colour on the surround (S+) when S- was also a white surround, both presence vs. absence of a line and presence vs. absence of colour were simultaneously available for Groups 1 and 3. For Groups 2 and 4 only the presence vs. absence of a line was the prominent feature. Differences in gradient slope along the angularity dimension appeared on the second of the two test days. Significant differences were found between Groups 1 and 4 and for Groups 3 and 2 indicating that pigeons trained to two cue features of the stimulus enhances their attention to line orientation. But a significant difference in gradient slope between Groups 1 and 3 when green was on the line for Group 1 as S+ and green on the surround for Group 3 as S+ suggested that colour on the line increased attention to the line when both Groups had two cue features present. It was concluded that consistent with the Baron and Vacek (1967) study, attention to line orientation was greater when the line was coloured than when the surround was coloured but then only when two stimulus features were simultaneously present.

So far, the relationship between colour and attention to line orientation, under differential training conditions, has been examined. It was shown by Baron and Bresnahan (1969a) that green on the surround did not decrease attention to line orientation. The Hirota, Milam, and

Ferenc (1973) result showed that addition of colour to line did not increase attention to line angularity. However, Ferenc and Hirota (1973) did show that colour on the line produces a steeper gradient than colour on the surround, thus confirming the Baron and Vacek (1967) hypothesis. Further, the Ferenc and Hirota (1973) study showed that a critical factor contributing to the steeper gradient under the green line condition as compared to the green surround condition, was the availability of two cues under the former condition and only one under the latter condition during discrimination training. It was concluded by Newman and Baron (1965) that differential training to presence vs. absence of line is required to establish stimulus control by line orientation when colour is not available as an alternate basis for discrimination. This conclusion was primarily based on the theory that colour is a more salient cue than line orientation.

Freeman and Thomas (1967) disagreed with the Newman and Baron (1965) conclusion that differential training was required to establish stimulus control by the weaker dimension (angularity) when colour is present. They hypothesized that the presence of green on the surround during testing, in the Newman and Baron (1965) study, may have masked sitmulus control by angularity. Consequently, subjects may utilize the colour aspect, of the stimulus, more than line orientation since colour ranks higher on the perceptual hierarchy. Freeman and Thomas (1967) trained their pigeons non-differentially to the same training stimulus as in the Newman and Baron (1965) study. They tested their subjects to angularity orientations on a green surround as well as a black surround. The results showed that stimulus control by line orientation was masked by the presence of a green surround during testing as indicated by a flatter gradient when compared to subjects tested with a black surround. From these results Freeman and Thomas (1967) concluded that, while the subjects may have attended to line orientations during non-differential training, it was masked by the presence of green on the surround during testing. The evidence for the masking effect was demonstrated by the steeper gradients for the subjects tested under black surround conditions.

Newman and Benefield (1968) conducted an experiment in which they tested the Freeman and Thomas (1967) conclusion. Two groups of pigeons were differentially trained and one group non-differentially. Group 1 (differential) was trained to a white vertical line on a green surround as S+ and a green surround as S-. Group 2 (differential) was trained to a green surround as S+ and a white vertical line on a green surround as S-. Group 3 (non-differential) received training only to a white vertical line on a green surround. During testing to line orientations the surround colour was either green or black. It was expected that when the black surround was present both differentially and non-differentially trained subjects would produce equally steep gradients. However, when the surround was green the differentially trained subjects would show steeper gradients than the non-differentially trained subjects. It was reasoned that subjects trained differentially would have received specific training to attend to the line orientations whereas subjects non-differentially trained would attend more to the colour aspect of the stimulus rather than to the line orientations. The results were consistent with their expectations. For the non-differentially trained subjects, colour presumably interfered with attention to line orientation because of its dominant position in the perceptual hierarchy. In contrast, differentially trained subjects attended equally to line orientation regardless of the surround. Therefore, colour appears to mask control by line orientation with non-differential training but not with differential training.

Baron and Bresnahan (1969a) trained two groups of pigeons non-differentially to a white line on either a green or black surround. The purpose of this study was to test the Newman and Benefield (1968) results that colour may mask attention to line orientation. Flatter gradients were obtained for the non-differentially trained group to a black surround than for the green surround group, but were not significant. Their results are not in agreement with the Newman and Benefield (1968) study which showed that colour interfered with attention to line orientation for non-differentially trained subjects.

In a follow-up study Baron and Bresnahan (1969b) trained two groups of pigeons non-differentially to a white vertical line on either a green or black surround. During the testing phase of the experiment the two groups were subdivided with half of each training group tested for generalization to line orientation on a green surround, and the remaining half on a black surround. It was found that groups trained with the green surround produced steeper gradients irrespective of the surround colour during testing. Baron and Bresnahan (1969b) concluded that contrary to the Freeman and Thomas (1967) and Newman and Benefield (1968) results, colour did not mask responding to the angular orientation during testing. Further, these results supported the earlier conclusion (Baron and Bresnahan, 1969a) that, with non-differentially trained subjects, attention is non-selective and that colour on the surround increases attention to line orientation.

Thomas, Svinicki, and Svinicki (1970) replicated the Baron and Bresnahan (1969b) study. They hypothesized that a more powerful within subjects test procedure may be required to investigate the effects of background conditions on the attention to line orientation. Two groups of pigeons were non-differentially trained to a white vertical line on either a green or black surround. During testing to line orientation each subject was exposed to five angular projections of a white line on both green and black surrounds. The results of this study contradicted the Baron and Bresnahan (1969a, 1969b) finding and, instead, confirmed the masking effects reported by the Freeman and Thomas (1967) and Newman and Benefield (1968) studies. The results showed that background conditions during training had no significant effect on line orientations. During testing, however, generalization gradients to line orientation were steeper under the black background conditions than under the green background conditions, lending support to the dominance of colour over angular projections. However, since Baron and Bresnahan (1969b) used a houselight in the experimental chamber and Thomas et al. (1970) did not, its presence may have been a critical factor in producing the masking effect.

This possibility was examined by Thomas, Ernst, and Andry (1971). Two groups of pigeons were non-differentially trained to a white vertical line on a yellow surround. One group had a houselight present in the experimental chamber, during training and testing, while the second group was trained and tested under houselight off conditions. A generalization test to five angular projections was administered to each subject in which only one stimulus presentation in every ten contained the yellow background. For the remainder of the test condition the background was black. The results indicated that under the houselight on conditions subjects yielded essentially identical generalization gradients under both background conditions. For the houselight off group, however, a masking effect was observed. It was concluded that, although yellow was used as a background condition instead of green as in the Thomas et al. (1970) study, the use of a houselight was a more critical factor in demonstrating a masking effect, than a specific wavelength. The results supported the Thomas et al. (1970) conclusion that under houselight off conditions, white angular projections stand out more dramatically, therefore subjects seem to be distracted from attending to coloured background conditions. The presence of a houselight may have been responsible for Baron and Bresnahan's (1969b) failure to observe a masking effect.

While some evidence suggests that differential training is required to establish line stimulus control in the presence of colour on either line or surround (Newman and Baron, 1965), other evidence suggest the opposite. The studies by Freeman and Thomas (1967) and Baron and Bresnahan (1969) suggest that differential training was not required to establish stimulus control to angular orientation when colour was also present. Their point of view is that attention to sitmuli is non-selective and only specific training procedures are required to enhance line attention when the more salient colour stimulus is also present. Obviously, there is disagreement about which training condition is the more consistent one in producing reliable generalization gradients. However, agreement seems to be consensual that a masking effect occurs under non-differential training conditions, because of the dominance of colour on the perceptual hierarchy. It has also been suggested that a masking effect can be eliminated by the presence of a houselight in the experimental chamber during training and testing (Thomas, Svinicki, and Svinicki, 1970; Thomas, Ernst, and Andry, 1971).

In the light of the above evidence it seemed appropriate to examine the effects of colour on the line vs. colour on the surround on attention to line angularity, following non-differential training with the houselight off.

Purpose of the Present Study:

The present study was designed to examine the effects of colour on the line vs. colour on the surround following non-differential training. One group of pigeons (Experimental) was trained to respond to a green line on a white surround. The control group was a replication of the Thomas, Svinicki and Svinivki (1970) group, non-differentially trained to a white line on a green surround. During testing each group was divided into two groups and tested with either a green line on a white surround, a black line on a white surround (Experimental), or a white line on a green or black surround (Control). During generalization testing only the angular orientations of the lines were varied while the background conditions were held constant.

The following hypotheses were proposed:

(1) Colour on the line would produce steeper gradient slopes than colour on the surround.

(2) That green on the line would show steeper gradients than black on the line.

Support for hypothesis one is available through the Baron and Vacek (1967) and Ferenc and Hirota (1973) studies under differential training procedures.

Support for hypothesis two is also available through the Baron and Vacek (1967) study indicating that colour ranks higher on the perceptual attention hierarchy. The present hypothesis tested if under non-differential training colour remained higher on the perceptual hierarchy.

The independent variable in this study was the presence or absence of colour under no houselight conditions. The dependent variable was the number of responses made during generalization testing.

CHAPTER II

METHOD

Subjects

The subjects were 20 experimentally naive, adult male, White Carneaux Pigeons, obtained from the Palmetto Pigeon Plant, Sumter, S.C. All subjects were housed in individual cages and maintained at 75% ($\pm$ 10 gms.) of their free-feeding body weight during the experiment. Subjects had ad-lib access to water in their respective home cages. At the beginning of the experiment subjects were randomly assigned to one of two experimental groups.

Apparatus

The apparatus used in this experiment consisted of 2 standard Lehigh Valley experimental cubicles (Model 1417C) each containing a test compartment (Model 1417) in which the 27-cm-high by 24-cm-wide rat panel was replaced by a test panel containing a single 2.5-cm-diameter key 22.5 cm above the floor. Three sides of the test compartment, excluding the test panel containing the response key and the door, were covered with a flat black vinyl lining to eliminate any reflections from the response key light and the feeder light. A 5-cm-square feeder opening was located 13 cm below the key. A Grason-Stadler In-Line Digital Display unit projected the stimuli on the transparent response key in each cubicle. The lines projected on the response keys were tilted at one of five angular orientations varied in 22.5 deg. steps from a position 45 deg. counterclockwise to 45 deg. clockwise from the vertical. Stimuli consisted of a green line on a white surround or a white line on a green surround. All lines were 0.7-cm- by 2.5-cm-long. The green line and green surround could be replaced by a black line or a black surround by switching off the light for the Kodak Wratten Filter No. 13 (537 n m.) in the In-Line display unit. A lighted food hopper, containing a grain mixture, provided the reinforcement. Access to reinforcement was of 3 sec. duration. During reinforcement the stimulus key was blacked out. White noise was continuously present through a speaker in each experimental chamber. A speaker in the room housing the chambers, masked extraneous sounds. There was no houselight present in any of the experimental chambers throughout the experiment. All experimental sessions were programmed by means of relays, timers, and steppers, located in an adjacent room. All responses and reinforcements were automatically recorded on four digital counters and on cumulative recorders.

Procedure

<u>Preliminary Training</u>: Three days of preliminary training was provided for all subjects. On Day 1, subjects were randomly assigned to one of two treatment groups and magazine and key-peck trained by successive approximation. Thirty continuously reinforced key-peck responses were allowed on Days 1 to 3. During this training phase a green vertical line on a white surround was continuously present on the key for the experimental group (Group-E), and a white vertical line on a green surround for the control group (Group-C), except during reinforcement. Each pecking response at the key provided 3 sec. access to the food hopper.

Variable-Interval Training: On Days 4 and 5 all subjects were gradually shifted from a schedule in which each response was reinforced on a variable interval (VI) schedule in which one reinforcement occurred on the average during each 30-sec. presentation of the stimulus by the end of Day 4, and during each 1-min. presentation by the end of Day 5. For the next ten days (Days 6-15) the VI 1-min. non-differential training session was in effect for all subjects. Again, for Group-E the stimulus was a green vertical line on a white surround and for Group-C a white vertical line on a green surround. Each subject received 30 min. of non-differential training per day under the VI 1-min. schedule. After 10 days the VI training was terminated for all subjects.

Warm-up and Generalization Test: Days 16 and 17, following the VI training, were used to administer a generalization test along the angularity dimension to all subjects. Preceding the generalization test, on each day, a warm-up session was administered to the subjects. The warm up sessions consisted of 5 min. (reinforced) presentations of the training stimulus for the respective groups.

On the first day of generalization testing (Day 16) each training group was divided into two subgroups of 5 subjects each. Five subjects from each group were tested with either green lines (Group E-Green) or green surrounds (Group C-Green). The remaining 5 subjects in each group were tested with either a black line (Group E-Black) or black surround (Group C-Black). The generalization test along the angularity dimension consisted of lines tilted 22.5 and 45 deg. from the vertical both clockwise and counterclockwise, including the vertical (S+).

Each subject received ten presentations (30 sec. each) of the five angular dimensions in a counterbalanced sequence but never with the vertical first. No reinforcement was provided during the testing phase of the experiment. Each stimulus presentation was separated by a 0.45 sec. blackout.

Statistical Analysis

A two-factor analysis of variance, with repeated measures on one factor was performed on total responses per session during non-differential training; the factors being treatment group (A) and days (B). Two three-factor analyses of variance with repeated measures on one factor was performed on the total nūmber of responses to each stimulus on each of the two test days; the factors being surround (A) groups (B) and stimuli (C).

All analyses of variance were performed by the University of Windsor's computer programme.

CHAPTER III

RESULTS

Non-Differential Training

All subjects learned to key-peck for reinforcement. A graphic representation of the mean response rates to the training stimulus for Groups E and C over the ten days of non-differential training are shown in Fig. 1. Total responses for each bird to the training stimulus, for the ten days of VI 1-min. training are shown in Appendix A. The mean response rates during the 5-min. warm-up periods on test days 1 and 2 are included in Fig. 1 for comparison purposes only but were not included in calculating the analysis of variance on the training data.

A two-factor analysis of variance with repeated measures on the last factor was carried out on total responses per session during training. The results of that analysis of variance are presented in Table 1. Inspection of Table 1 shows a significant main effect for Days (B) ($F = 14.88$, $df = 9/162$, $p < .01$) and indicates an increase in total responses across the 10 training days. There is a suggestion in Fig. 1 that Group C differed from Group E in overall responses to the training stimulus, however this difference failed to approach significance ($F = 3.49$, $df = 1/18$, $p > .05$). Further, the absence of a significant interaction effect of Groups x Days (A x B) ($F = 0.89$, $df = 9/162$, $p > .05$) indicates that both groups learned to respond to the training stimulus equally well.

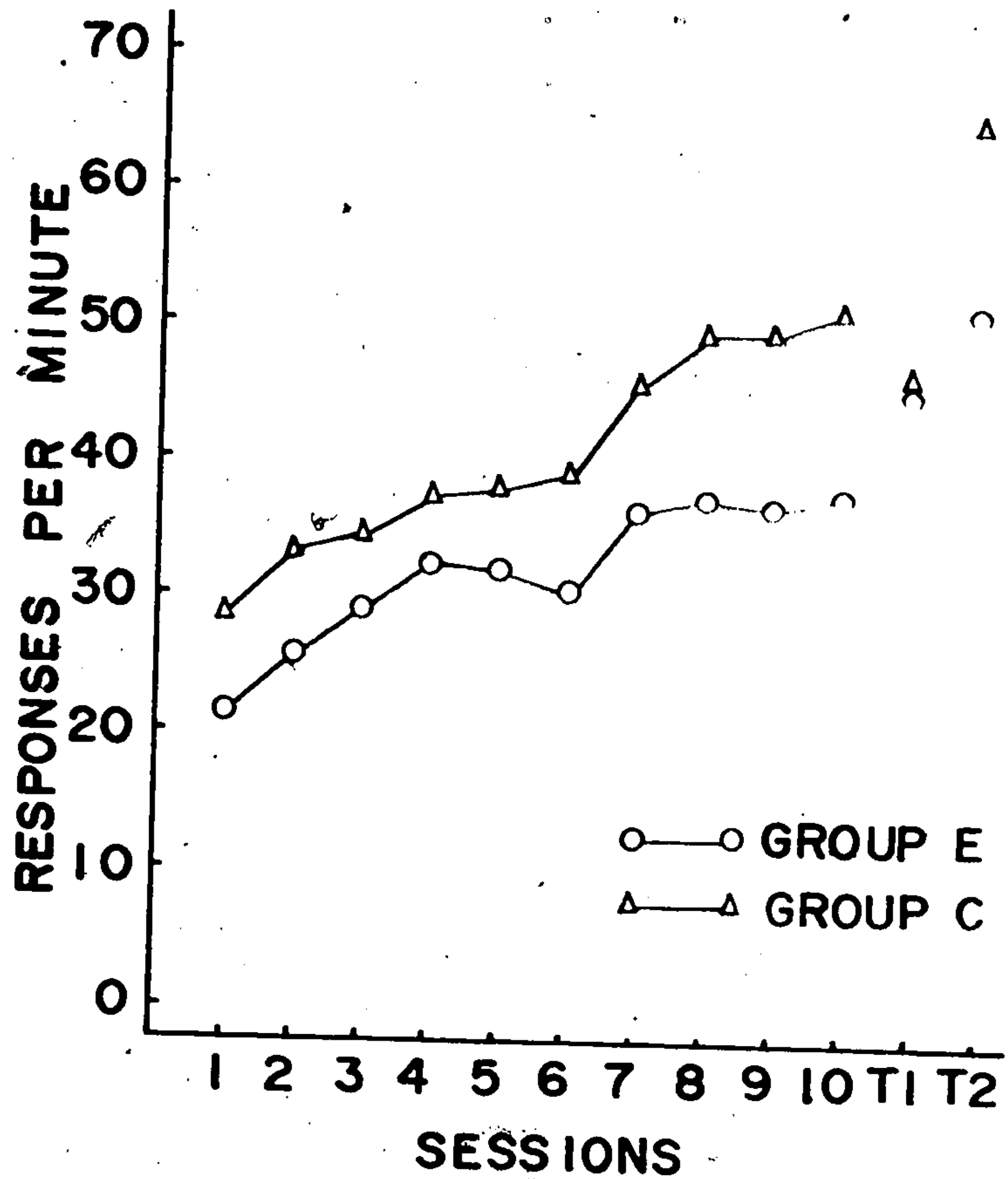

Fig. 1 Mean number of responses per minute during non-differential training and during the five minute warm-up period on test day one and two

TABLE I

Analysis of Variance of Mean Number of Responses per Minute During Non-Differential Training

Source	SS	df	MS	F
<u>Between subjects</u>				
A (Groups)	2973872.72	1	2973872.72	3.49
Subj. w. groups	15299734.56	18	849985.25	
<u>Within subjects</u>				
B (Days)	6378389.78	9	708709.97	14.88**
AB	381538.58	9	42393.17	0.89
B x subj. w. groups	7714015.24	162	47617.37	

** $p < .01$

Generalization Test

The absolute generalization gradients for Test Days 1 and 2 are graphically represented in Fig. 2. The order in which the five test stimuli were presented on each test day is presented in Appendix B. Mean total number of responses to the five test stimuli were calculated for the four test groups. Appendix C contains the total number of responses during the 5-min. warm-up periods, the total number of responses to the five test stimuli as well as the calculated means for the four test groups on Test Day 1, and Appendix D contains the same data for Test Day 2.

A three-factor analysis of variance with repeated measures on the last factor, performed on the total number of responses for Test Day 1, provided three significant F ratios. The results of this analysis are presented in Table 2. A significant main effect of colour (A) occurred ($F = 6.61$, $df = 1/16$, $p < .05$) indicating a higher level of responding when the test stimuli contained green on either line or surround. No significant Groups (B) effect occurred on Test Day 1. However, a significant Stimuli (C) effect occurred ($F = 5.67$, $df = 4/64$, $p < .01$). This effect indicates different numbers of responses between stimuli. A significant interaction effect of colour x Groups x Stimuli (A x B x C) also occurred ($F = 4.14$, $df = 4/64$, $p < .01$). This effect becomes clear by inspecting Fig. 2 which shows that on Test Day 1 there was a noticeable decrease in responding to the training stimulus for Group C - G but an increase for Group B - G, yet total overall responding to the five test stimuli was higher for Group C - G than for Group E - G. This difference, however, did not occur for Groups E - B and C - B which accounts for the triple interaction effect.

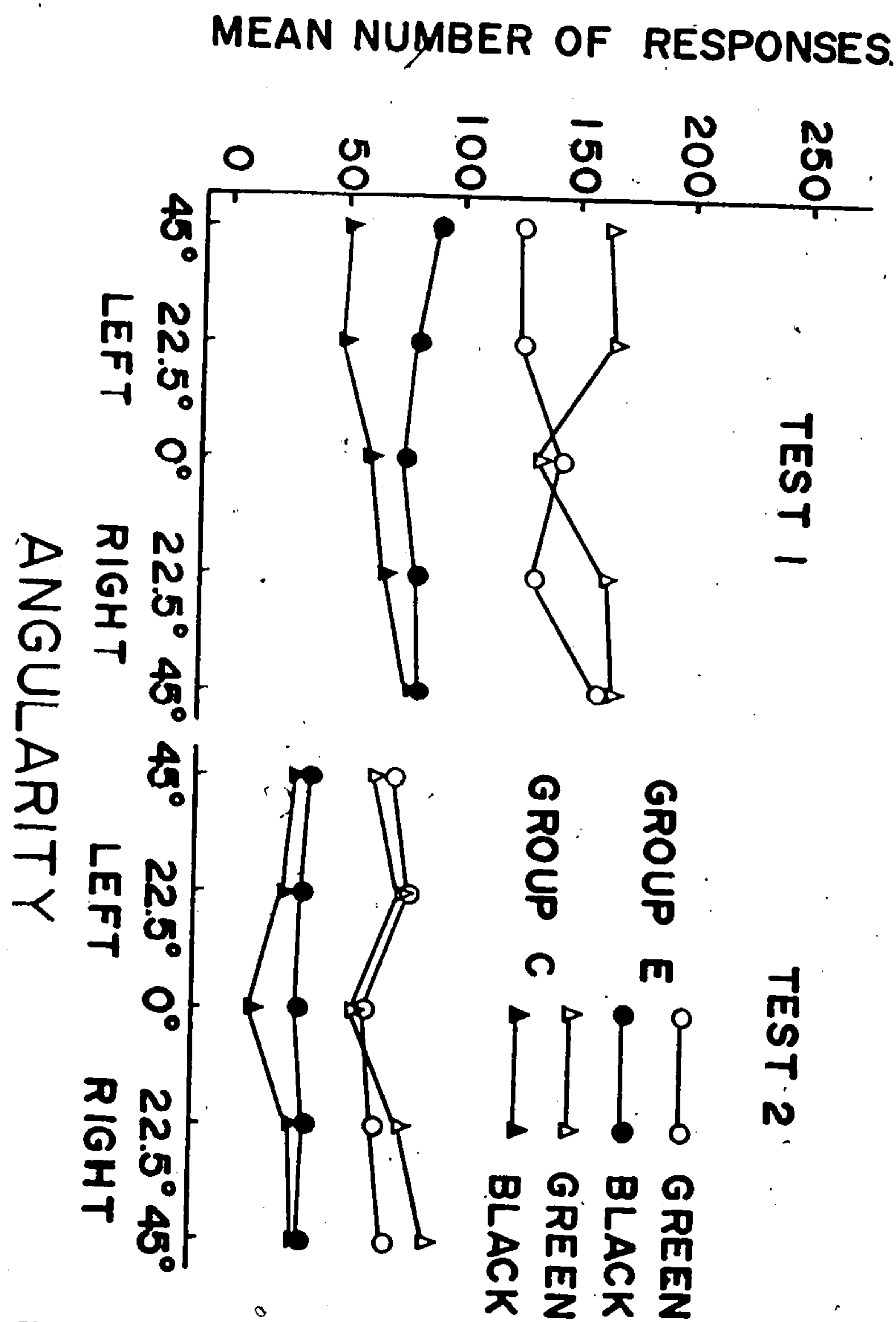

Fig. 2 Absolute generalization gradients for Groups E (green and black line conditions) and Groups C (green and black surround conditions) for test days one and two

TABLE 2

Analysis of Variance of Total Number of Responses to Each Stimulus During Generalization Test 1

Source	SS	df	MS	F
Between subjects				
A (Colour)	129456.04	1	129456.04	6.61 *
B (Groups)	125.44	1	125.44	0.01
AB	10983.04	1	10983.04	0.56
Subj. w. groups	313542.32	16	19596.39	
Within subjects				
C (Stimuli)	6018.94	4	1504.73	5.67 **
AC	78.66	4	19.66	0.07
BC	1720.66	4	430.16	1.62
ABC	4396.86	4	1099.21	4.14 **
B X subj. w. groups	16985.28	64	265.39	

* $p < .05$

** $p < .01$

A three-factor analysis of variance with repeated measures on the last factor was also carried out on the total number of responses for Test Day 2. The results of the analysis are shown in Table 3. A significant main effect for Colour (A) occurred again on Test Day 2 ($F = 4.68$, $df = 1/16$, $p < .05$) also indicating that the higher level of responding to the green test stimuli over the black test stimuli accounted for the significant result. Also, a significant Stimuli (C) effect ($F = 3.05$, $df = 4/64$, $p < .05$) can be observed, indicating again that number of responses differed between the five test stimuli. There was no significant interaction effect between Colour x Groups x Stimuli (A x B x C) observed in this analysis ($F = 0.56$, $df = 4/64$, $p > .05$). The absence of a three-way interaction effect on Test Day 2 may be accounted for by the near equal response tendencies of the green and black stimuli groups.

TABLE 3

Analysis of Variance of Total Number of Responses to Each Stimulus During Generalization Test 2

Source	SS	df	MS	F
Between subjects				
A (Colour)	41046.76	1	41046.76	4.68 *
B (Groups)	302.76	1	302.76	0.03
AB	888.04	1	888.04	0.10
Subj. w. groups	140312.80	16	8769.55	
Within subjects				
C (Stimuli)	3171.26	4	792.81	3.05 *
AC	788.14	4	197.03	0.76
BC	1341.74	4	335.43	1.29
ABC	588.06	4	147.01	0.56
B X subj. w. groups	16640.40	64	260.00	

* $p < .05$

CHAPTER IV

DISCUSSION

No support for the initial hypothesis in the present experiment could be found. The expectation that control by angular orientation would be enhanced by placing colour on the line (i.e. that colour on the line would show steeper generalization gradients than colour on the surround) was not supported by the present results. Instead the results suggest that the subjects tested under green conditions responded on the basis of colour. Neither of the test groups responded on the basis of angular dimensions which is evident by the nearly flat gradients for both the experimental and control groups as shown in Fig. 2. Further inspection of Fig. 2 also shows that neither group, on any of the two test days, responded more to the zero deg. line position which had been the training stimulus. It must therefore be assumed that line angularity did not gain stimulus control. Further, on the basis of the present results it is doubted that control by line angularity can be established through the non-differential training procedure.

The suggested theory closest to the above results appears to be that of Jones (1954) indicating the possibility that the organisms respond on the basis of a perceptual hierarchy. This theory is supported by Baron (1965) and Newman and Baron (1965) who concluded that colour ranks higher than angular projections on the perceptual hierarchy. Therefore to establish effective control by line angularity differential training (presence vs. absence of line) is required. Further evidence to this effect is presented in a study by Jenkins and Harrison (1960) who obtained relatively flat gradients for non-differentially trained subjects to a tonal stimulus. Their conclusion was that visual stimuli presented in an analogous manner, that is following non-differential training, might also result in a flat generalization gradient. But it should be made clear that stimuli which show no influence on responding after prolonged non-differential training may still gain discriminative control by means of differential training.

Interestingly, stimulus control by the angularity dimension following differential training is influenced by the colour dimension. The evidence to this effect has been presented in the Baron and Vacek (1967) study which confirmed the theory of an attending hierarchy in which colour ranks relatively high and also showed that the placement of colour on the line rather than on the surround further enhanced attention to the line stimuli. However, a replication of the Baron and Vacek (1967) study by Hirota, Milam, and Ferenc (1973) in which two groups of pigeons were differentially trained to green and black lines on white surrounds did not support these findings. Both groups in the Hirota et al. (1973) study showed equally steep gradients following generalization testing. The procedural difference between the two studies which was offered as a possible explanation for the difference in results appears to be a mere technicality in the experimental procedures. Of greater significance here is the fact that an achromatic surround acted as a neutral stimulus during differential training whereas during non-differential training surround competes with line angularity for attention. Repeated reinforcement then of line and surround combinations, during training, will gain control over the subject's responding as a single stimulus unit which results in flat gradients, or nearly so, when variations of these stimuli are introduced during testing in extinction.

There is still the question why other investigators have found stimulus control by angularity following non-differential training. For instance, the results of the Freeman and Thomas (1967) study did show steeper gradients for the black surround group than for the green surround group contrary to the attending hierarchy theory advocated by Newman and Baron (1965). However, closer examination of the Freeman and Thomas (1967) study shows their results to be somewhat biased in that their test conditions were not held constant. Aside from testing to a greater angularity range their subjects were tested to green and black surrounds after training to green surrounds only, resulting in a slightly steeper gradient to the black surround. A footnote in the Baron and Bresnahan (1969b) study indicates that Freeman and Thomas (1967) question the reliability of their own observation.

The Baron and Bresnahan (1969b) results show reliably steep gradients to the angular projections on green and black surrounds following non-differential training. It was concluded that surround colour did not influence the gradient slopes during testing to angularity. These results are not consistent with the findings in the present experiment in which the control groups were identical to the Baron and Bresnahan (1969b) chromatic surround groups. The results may very well have been due to their using a houselight throughout the experiment whereas the present study did not.

The use of a houselight appeared to be an important factor to Thomas, Svinicki, and Svinicki (1970). They concluded that the presence of a houselight in the experimental chamber provided a visual array of stimuli which distracted the subjects from attending to the less salient stimuli of angularity. Therefore the presence of a houselight in the Baron and Bresnahan (1969b) study may have been responsible for their failure to observe a masking effect. This conclusion was later confirmed by Thomas, Ernst, and Andry (1971). Based on the results in the present experiment, however, the absence of a houselight in the experimental chamber appeared to be of no significant consequence to stimulus attention.

The within-subject's design which Thomas et al. (1970) utilized to test their hypothesis appears to be of greater importance here since the present experiment, which was a replication in experimental procedure of the Thomas et al. (1970) study except for the within-subject's test design, did not confirm their findings. It appears that the alternation of green and black stimuli during testing may have influenced the rate of responding since all their subjects had an opportunity to respond to the training stimulus during part of the test period.

In conclusion, the rejection of the various experimental procedures as insufficient would be premature since all have contributed toward an understanding of the problems involved. It is suggested that a unified procedure is needed with a strong emphasis on the organism's learning capabilities. Based on the present results, attention to line angularity seems best established through differential training. But attention to colour can be established without differential training conditions. The present results support the view that colour ranks higher on the perceptual hierarchy. What needs further investigation are more effective training conditions exerting greater control over responding to specific line stimuli.

APPENDIX A

[illegible]ing Non Differential Training

RESPONSES DURING NON-DIFFERENTIAL TRAINING

GROUP	SUBJECT #	DAYS 1	2	3	4	5	6	7	8	9	10
Experimental	2(120)	720	877	886	719	631	804	1038	888	1117	1057
Experimental	11(2052)	500	568	863	934	777	684	929	980	936	800
Experimental	8(237)	1012	899	1355	1527	1393	1018	1092	985	1110	1394
Experimental	6(2038)	511	500	548	800	871	796	913	1052	1054	1050
Experimental	7(2374)	405	695	676	841	934	856	1201	992	883	793
Experimental	20(202)	538	833	787	1197	1247	1183	1373	1416	1354	1406
Experimental	5(212)	900	860	864	864	899	1014	1316	1510	1401	1492
Experimental	17(196)	686	940	1012	898	979	928	1128	1542	1285	1358
Experimental	12(197)	520	675	773	1019	851	775	720	503	620	701
Experimental	13(214)	314	535	536	569	603	654	734	792	782	672

RESPONSES DURING NON-DIFFERENTIAL TRAINING

GROUP	SUBJECT #	DAYS 1	2	3	4	5	6	7	8	9	10
Control	4(826)	635	739	830	789	692	947	1286	1162	1075	993
Control	3(136)	629	1085	1067	1375	1311	1399	2130	2448	2780	2742
Control	9(233)	1206	1272	1279	1233	1144	1037	934	1137	1020	1003
Control	15(2388)	717	1082	1145	1159	1459	1364	1738	2118	1914	2032
Control	1(128)	1055	1039	956	874	825	1019	1197	1174	1238	1422
Control	16(2062)	1342	1470	1437	1625	1671	1394	1416	1655	1841	2066
Control	18(2391)	780	981	1293	1311	1280	1413	1688	1713	1642	1742
Control	19(2041)	637	603	741	846	941	975	1115	1297	1101	1161
Control	14(2373)	639	514	601	790	674	730	737	752	732	786
Control	10(206)	437	622	496	677	777	853	810	665	788	647

APPENDIX B

Order of Presentation of Test Stimuli

Order of Presentation of Test Stimuli

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° left
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 C

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Experimental Group (Green Line) Experimental Group (Black Line) Control Group (Green Surround) Control Group (Black Surround)

Test Day I

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Experimental Group (Green Line)

Test Day I

Group	S#	Warm-up to Training Stimulus	Test Stimuli				
			45°L	22.5°L	0°	22.5°R	45°R
Exp. Green	13	164	80	82	101	89	106
Exp. Green	5	348	133	172	189	168	181
Exp. Green	8	277	224	169	200	203	253
Exp. Green	11	231	119	108	139	137	146
Exp. Green	2	217	66	90	89	73	111
TOTALS		1237	622	621	718	670	797
MEANS		247.40	124.40	124.20	143.60	134.00	159.40

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Experimental Group (Black Line)

Test Day 1

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Exp. Black	12	141	62	57	55	61	56
Exp. Black	17	278	73	89	57	83	88
Exp. Black	20	220	145	142	137	143	139
Exp. Black	7	85	74	65	68	57	69
Exp. Black	6	295	101	58	71	103	100
TOTALS		1019	455	411	388	447	452
MEANS		203.80	91.00	82.20	77.60	89.40	90.40

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Control Group (Green Surround)

Test Day I

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Control Green	14	113	80	73	68	84	72
Control Green	19	304	195	188	157	200	165
Control Green	16	412	173	148	151	149	190
Control Green	1	237	111	160	102	117	114
Control Green	15	184	264	261	213	268	305
TOTALS		1250	823	830	691	818	846
MEANS		250.00	164.60	166.00	138.20	163.60	169.20

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Control Group (Black Surround)

Test Day I

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Control Black	10	85	0	0	1	0	1
Control Black	18	277	40	94	55	75	121
Control Black	9	269	40	50	52	52	64
Control Black	3	516	175	190	189	211	259
Control Black	4	198	3	8	1	2	2
TOTALS		1345	258	242	298	340	447
MEANS		269.00	51.60	48.40	59.60	68.00	89.40

APPENDIX D

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Experimental Group (Green Line) Experimental Group (Black Line) Control Group (Green Surround) Control Group (Black Surround)

Test Day 2

Total Responses During Five Minute Warm-up to the Training Stimulus ~~and~~ to Test Stimuli During Generalization Testing for Experimental Group (Green Line)

Test Day 2

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Exp. Green	13	134	42	68	57	57	61
Exp. Green	5	279	77	99	62	93	73
Exp. Green	8	267	188	159	105	119	156
Exp. Green	11	206	52	34	43	37	32
Exp. Green	2	267	15	45	35	25	42
TOTALS		1153	374	405	302	331	364
MEANS		230.60	74.80	81.00	60.40	66.20	72.80

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Experimental Group (Black Line)

Test Day 2

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Exp. Black	12	135	24	43	45	26	23
Exp. Black	17	313	44	17	28	20	12
Exp. Black	20	274	70	80	64	93	92
Exp. Black	7	170	1	22	10	10	21
Exp. Black	6	274	47	21	29	38	32
TOTALS		1166	186	183	176	187	180
MEANS		233.20	37.20	36.60	35.20	37.40	36.00

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Control Group (Green Surround)

Test Day 2

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Control Green	14	97	17	41	27	34	42
Control Green	19	308	51	77	59	87	120
Control Green	16	435	90	105	50	81	78
Control Green	1	254	48	45	46	36	77
Control Green	15	292	115	121	112	144	135
TOTALS		1386	321	389	294	392	452
MEANS		277.20	64.20	77.80	58.80	78.40	90.40

Total Responses During Five Minute Warm-up to the Training Stimulus and to Test Stimuli During Generalization Testing for Control Group (Black Surround)

Test Day 2

Group	S#	Warm-up to Training Stimulus	Test Stimuli 45°L	22.5°L	0°	22.5°R	45°R
Control Black	10	188	0	0	0	0	0
Control Black	18	336	0	4	2	0	5
Control Black	9	356	17	5	2	7	6
Control Black	3	708	140	121	57	151	158
Control Black	4	274	0	1	0	0	0
TOTALS		1862	157	131	61	158	169
MEANS		372.40	31.40	26.20	12.20	31.60	33.80

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