SOME PHYSICAL DETERMINANTS OF ATTENTIONAL BEHAVIOR: A MEMORY APPROACH

By

DAUN HACKETT ADAMS

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1962

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1964

Submitted to the Faculty of the Graduate School
of the Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
DOCTOR OF PHILOSOPHY
May, 1967

SOME PHYSICAL DETERMINANTS

OF ATTENTIONAL BEHAVIOR:

A MEMORY APPROACH

Thesis Approved:

Larry T. Brown
Thesis Adviser

Julia L. McHale

Kenneth D. Sandvold

David L. Weeks

Donald J. Gould

N N Durham
Dean of the Graduate College

Dedicated to the Memory of

JOHN MAYNARD HACKETT

ACKNOWLEDGEMENTS

The writer wishes to express her appreciation to Dr. L. T. Brown, who served as major adviser, and to the members of the thesis committee: Dr. D. J. Tyrrell, Dr. K. D. Sanvold, and Dr. Julia McHale. A special thanks is extended to my interdepartmental member, Dr. David Weeks, whose advice and guidance was invaluable during the statistical analysis of the experimental data presented herein.

Acknowledgement is also given to the teaching staff at the University of Alabama, Huntsville, Alabama, especially Mr. Edwin Bartee, for their assistance and moral support while these experiments were being performed. I would also like to express my gratitude to my husband, Dr. David Adams, who gave unstintingly of his time and advice and to Dr. Henry Cross who encouraged me to continue in graduate school after I received my Bachelor of Science degree.

TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
	Purpose of the Study	3
	Design of the Study	3
II.	REVIEW OF THE LITERATURE	6
III.	METHOD	36
	Experiment I	49
	Subjects	49
	Procedure	49
	Experiment II	55
	Subjects	55
	Procedure	55
	Experiment III	57
	Subjects	57
	Procedure	57
IV.	RESULTS AND DISCUSSION	59
	Results	59
	Discussion	67
V.	SUMMARY AND CONCLUSIONS	75
BIBLIOGRAPHY		78
APPENDIX A		83

TABLE OF CONTENTS (CONT)

page

APPENDIX B 87

Factorial Data for Experiment I - By Group 88

Factorial Experimental Data - Response, Number of Errors 90

Factorial Data for Experiment II - By Group.......................... 91

Factorial Experimental Data - Response, Number of Errors 92

Raw Data for Preferred Scoring - Experiment II.................................... 93

Raw Data for Preferred Scoring - Experiment III 94

LIST OF TABLES

Table		Page
I.	Reflected-Light Readings from Three Points on the Experimental Screen	47
II.	Experiment I - Analysis of Variance, Factorial Design by Groups	60
III.	Experiment II - Analysis of Variance, Factorial Design by Groups	62

LIST OF FIGURES

Figure		
1-4	Patterns Showing the Two Levels of each of the Four Variables	37-40
5.	Three Different Levels of Border Widths Used for the Dissimilarity of Average Width of Border Variable	42
6.	Projector	46
7.	Camera Shutter	46
8.	Flow Diagram of Experimental Session	50
9.	Diagram of the Second-Order Interaction	63
10.	Comparison of the Results of Experiment I and Experiment II	65

CHAPTER I

INTRODUCTION

How man perceives his world has been an unanswered question of philosophers, physiologists, and many other scientists and scholars for centuries. The philospher Leibnitz defined perception as the internal state representing external things, and apperception as the "knowing" of this state. Others, such as Berkeley, as early as 1709 attempted to show how the principles of associationism could explain man's way of perceiving the environment. Kant emphasized the unity of the act of visual perception with perception mediated by other sense modalities. The psychophysicists Weber and Fechner attempted to experimentally differentiate between sensations and perceptions. In Leipzig, Wundt described "apperception" in terms that are still found today under the title "attention". The neurologists localized the visual center in the occipital lobes, whereas the physiologist Helmholtz, among other things, made important contributions to theories of color vision.

More recently, behaviorists have discussed perception in terms of stimulus-response bonds, while Gestalt psychology emphasized the phenomenal field. The Gestalt School has made important contributions to our knowledge of vision with its "Laws of Perception"; but, as in the past, the emphasis has been mainly on what happens within the organism, in other words, conscious experience. The widespread influence and general acceptance of Gestalt laws, particularly their emphasis on "good form" and "perceptual whole", led subsequent investigators away from attempting to specify the physical determinants of perceptual patterns.

Until recent years, no one had attempted to quantify physical shape. What aspects of physical patterns demand attention, are perceived, or remembered? Recent researchers from widespread areas of investigation have contributed much to understanding the manner in which organisms selectively respond to their visual environment. Several examples of these areas are: discrimination learning (Mackintosh, 1965), neural mechanisms of alerting (Deutsch & Deutsch, 1963; Morgan, 1965), exploratory behavior (Berlyne, 1960), and information theory (Broadbent, 1957; Miller, 1956). Paralleling these advances there has been increasing interest in isolating and specifying the physical properties which define complex visual patterns (Attneave & Arnoult, 1956; Brown, 1964; Michels & Zusne, 1965; Zusne, 1965). Several investigators (Berlyne, 1960; Brown, 1964) have studied the physical properties of complex patterns which govern attention using a performance approach (rather than a memory or learning approach, Berlyne, 1960) in which: "We first make sure that a number of stimuli are associated with distinct but incompatible responses and then present all the stimuli together to ascertain which response occurs and thus which stimulus dominates behavior (p. 56)." A memory approach was used in the present experiment in order to determine whether the physical parameters of visual patterns found to be important to attention using a performance measure are also important when a memory measure is employed.

Purpose of the Study

Selective attention has been found to be important to both performance and learning; but there has been little research directed to determining the importance of selective attention to memory. The term "attention" has several connotations. To avoid confusion, attention will be used in the present studies to mean "processes that determine which elements of the stimulus field will exert a dominating influence over behavior" (Berlyne, 1960, p. 45).

The purpose of this study was to investigate the importance of four properties of complex visual patterns to attention using a memory approach. Four quantifiable physical properties of visual patterns were selected from a relatively exhaustive list of component, pattern, and arrangement variables compiled by Brown (1964). The variables were: (1) angular variance (AV); (2) dissimilarity of average width of border (DAWB); (3) number of components (NC); and (4) number of turns (NT). Each of the variables was studied at two levels.

Design of the Study

The experimental design of the present study had its basis in a general approach suggested in Berlyne's 1960 text:

> The experimental procedure for attention in remembering involves exposing the subject to a number of stimuli simultaneously and then after their removal asking him to recall as many of them as he can (p. 72).

The experimental design was planned to conform to the following steps:

Step 1: Four variables were selected from Brown's (1964) list based on previous research findings;

Step 2: A method for constructing stimulus patterns based on the work of Attneave and Arnoult (1965) and Brown and O'Donnell (1966) was utilized. A total of sixteen stimulus patterns were prepared, each to represent one cell in a 2 x 2 x 2 x 2 factorial design;

Step 3: The patterns were then transferred to slides to be presented to subject (S) tachistoscopically. Tachistoscopic presentation in the present investigation referred to the presentation of visual stimulus patterns for a specified time interval. The definition of "tachistoscopic" states that the time interval is in the order of one-fifth second, or less (Webster, 1961, p. 874). (In reviewing the literature, however, it was discovered that this definition has not been adhered to).

Step 4: All test series were randomized with the criterion that the two levels of the four variables be presented an equal number of times throughout the experimental sessions;

Step 5: The patterns were presented to 48 Ss;

Step 6: Number of errors on recall of the two levels of each of the variables was used as a measure of attention in memory;

Step 7: The data were arranged in a 2 x 2 x 2 x 2 factorial design and were analyzed in a 2^n Factorial Analysis of Variance design;

Step 8: The numbers of errors for test slides 1-4 was compared with the number of errors for test slides 13-16 by means of a t-test to assess practice and/or fatigue effects.

It was predicted on the basis of previous research (Brown & O'Donnell, 1966) dealing with attention in performance that there would be fewer errors for: (a) high NT and NC than for low NT and NC. No predictions were made concerning AV and DAWB, as no previous attentional research examining these two variables has been uncovered.

Two pilot studies were performed to detect any problem in instructions and administration procedures. Also, five different exposure times were tested under two levels of background illumination. Subjects were tested individually and in groups to determine the most economical method of testing.

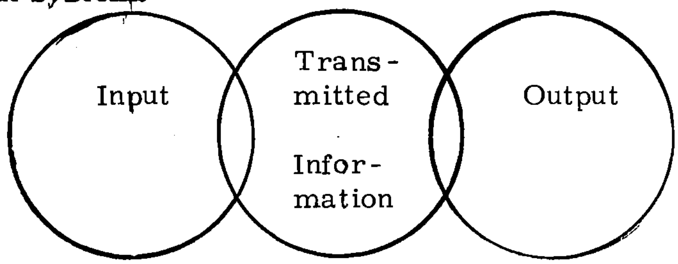
CHAPTER II

REVIEW OF THE LITERATURE

The present review consists of: (a) a brief discussion of current theories that relate to selective attention or immediate memory, (b) a review of papers which attempt to quantify physical form parameters, (c) a discussion of research on immediate memory, and (d) a discussion of specific design problems such as practice effects, instructions, exposure times, etc.

Current Theories

Information theory lends itself quite well to a discussion of attention. These investigators first attempted to quantify the information input from the external environment while taking into consideration the influence of the internal environment (past experience). Secondly, they attempted through refined research techniques to isolate how or what aspects of the environment are selected to occupy the organism's limited information-transmitting channels. Miller (1956) in a general review article discusses the human organism's capacity for processing information. He views the concept "amount of information" as being the same as "variance". Anything that increases variance also increases the amount of information. The organism is seen as a simple input-output system:



The left circle represents the possible variance in the information to be input into the organism. The right circle represents the variance in the output or the possible responses to the stimuli once it has been mediated by the central analyzing mechanisms. The center circle is the amount of transmitted information.

A theory of attention and immediate memory information theory terms has been presented by Broadbent (1957). A mechanical model (a Y tube) was presented to serve as an expository device to show that input can be through more than one sensory channel, but at some point this input merges and must go through a filtering or selective process. He indicated that with new reactions or acts, which any one of several responses will satisfy, there will be interference between stimuli. The author also states that the length of the immediate memory span is roughly constant regardless of the amount or type of information input. In a 1958 article, Broadbent proposed a filtering mechanism to account for the ability of the organism to keep messages on two different channels distinct. It was proposed that the organism filtered the input on the basis of characteristics to which it had been set, allowing only this input to proceed to the central analyzing mechanisms. Prior to 1962, Broadbent felt that the increase in reaction time when the number of alternative responses increased would be a good measure of the channel capacity of the central nervous system for incoming information. On examining the results of detection experiments, it was found that the least cautious Ss, i.e., Ss not afraid of risking a false report, had a higher probability of correct detections with only a slight increase in false reports. The traditional approach to psychophysical thresholds utilizes the "guessing correction" method of determining the probability of a response. This method assumes that when a certain proportion of errors is subtracted from the correct response, the number of correct responses is not influenced by the number of incorrect responses; in other words, the S's making an error on a particular detection would not influence his behavior on subsequent detections. Broadbent (1962) has recently modified his position in that reaction time to the input is assumed to be a function of the willingness of S to make errors. He proposes hypothetical processes in the brain that vary about an average value, i.e., he assumes a normal distribution in terms of probability of a response--one for each possible stimulus. The probability of errors increases with more stimuli to be considered, as a function of how well practiced the response is, and the willingness of S to make errors. The "hypothetical processes" are similar in formulation to the "arousal pattern" discussed by Berlyne (1960, p. 48).

The contributions of information theory to the understanding of visual perception are discussed by Attneave (1954). He states that as the retina has the possibility of being in any one of $10^{1,200,200}$ different states, it is apparent that there is much redundancy in the physical world which impinges on the visual receptors. It appears that the function of the perceptual process is to remove the unnecessary redundancy and to encode the information in the most economical manner. Psychophysical experiments attempting to measure this process run into the problem of differentiating between reasoning processes and perceptual processes. Limited control over incoming stimuli has been experimentally achieved by establishing a "set" in Ss. The author discusses several principles in an attempt to specify operations which the perceptual mechanism may perform, he also indicates appropriate psychophysical approaches to each. They are: redundancy; continuous regularity; discontinuous regularity, proximity, and interactions among sensory events. In terms of information content, he states that the highest amount of information in a visual pattern is found at angles or peaks of curvature and changes in homogeneous texture and/or color.

Two major theoretical approaches and research pertinent to animal discrimination learning are discussed by Mackintosh (1965). Continuity theory states that an organism learns an equal amount about all cues impinging upon the receptors. Non-continuity theory (e.g. Lashley, 1929, & Krechevsky, 1938) states that an organism attends to only one cue at a time, learning nothing about other "irrelevant" cues. Mackintosh proposes a modified non-continuity theory of attention, utilizing a two-state model which postulates a central mechanism of attention. This model proposes that: (1) in order for S to solve a discrimination problem, he must learn to attend to the relevant stimulus dimension; and (2) the more likely an organism is to attend to one cue, the less likely it is to attend to another cue. Thus an organism can be trained to attend to the relevant stimulus configuration to which he elicits the "correct" response. In a new situation in which the same stimulus dimension is used, but a different response required, learning is facilitated. This indicates that attention and choice of responses are not governed by equivalent laws, which allows this model to handle more of the experimental data than either the continuity or non-continuity theories. Three areas of research (acquired distinctiveness of cues, transfer along a continuum, and reversal learning) are discussed and interpreted in the framework of this model.

Recently there has been increasing interest among orthodox S-R theorists in two-factor models, but there is still a reluctance to deal with central mechanisms. Theorists attempting to deal with central mechanisms to mention a few, suggest orienting responses (Spence, 1960), mediating responses (Kendler & Kendler, 1962), observing responses (Wychoff, 1952), switching in the relevant analyzer (Sutherland, 1959), and learned attention responses (Lovejoy, 1965; Zeaman & House, 1963). Mackintosh presents evidence that orienting response theories and mediating response theories will not account for the experimental data. Attention theories are further delineated by him and hope for increasing rigor in these theories is held for mathematical theories (Lovejoy, 1965; Zeaman & House, 1963).

Another distinct theoretical approach is the area of neurological theories. Deutsch and Deutsch (1963) find Broadbent's (1958) filter theory inadequate to explain how the organism analyzes comples messages. They propose a nonspecific, diffuse system in the brain, known as the recticular activation system (RAS), which has afferent and efferent connections with the higher perceptual mechanisms. This system subserves selective attention. Briefly, a complex visual message fires the neurons in the optic nerve, and travels in toto upwards to the RAS. If the message is above the afferent connections, no message is transmitted. The only message transmitted would be that part which is at the same level, in the diffuse system, as the afferent perceptual connection which leads to higher central mechanisms. Morgan (1965) presents neurophysiological evidence supporting Deutsch and Deutsch. He divides the general system they discuss into two parts: (1) the RAS which has both inhibitory and excitatory functions, and is considered to be the general mechanism of arousal; and (2) the diffuse thalamic projection system which is an accessory mechanism that controls more transient increases in arousal and attention.

Current Research

Paralleling the attempt to find neurological correlates for attentional processes, there has been an increasing number of attempts to quantify physical form parameters (Attneave, 1957; Attneave & Arnoult, 1956; Brown, 1964; Brown & O'Donnell, 1966; Hochberg & McAlister, 1953; Michels & Zusne, 1965; Zusne, 1965). This has opened the way to investigation of the physical properties which define complex visual patterns. The first major attempt at quantification was performed by Hochberg and McAlister (1953). This research represented an effort to draw parallels between non-quantified gestalt laws of organization and the objective stimulus pattern. Drawings of four Kopfermann "cubes" were presented to 80 Ss for 100 sec. each. A random signal tone was sounded and S indicated whether the perception of the cube at the point was bidimensional or tridimensional. The results supported the hypothesis that cubes possessing the best phenomenal symmetry as two-dimensional patterns would be perceived least frequently as cubes, and were interpreted as an approximate quantitative index of figural "goodness". In other words, the patterns with the best symmetry were perceived more correctly as two-dimensional. The stimulus characteristics found to be important were line segments, angles, and points of intersection.

Attneave (1957) attempted to find a single physical measure which would predict apparent "complexity". He considered six variables: (1) matrix grain, (2) curvedness, (3) symmetry, (4) number of turns,

(5) P^2/A (the square of the perimeter, divided by area), and (6) angular variability. Seventy-two randomly constructed shapes were judged on a seven-category rating scale from "Extremely Simple" to "Extremely Complex" by 168 Ss. Approximately 90% of the variance in the judgements was explained by: number of independent turns, 78.7%; (b) symmetry, 3.8% (however, symmetrical figures were judged more complex than asymmetrical figures, when the number of independent turns was held constant); and (c) angular variance, 7.1%. The result that angular and curved shapes were judged approximately equal is surprising in terms of information theory. This theoretical approach would predict curved shapes as being perceived as more complex as curved shapes require more physical dimensions for their specification, and, consequently, contain more information. P^2/A reached marginal significance when the variance shared with angular variance was considered. Matrix grain had no apparent effect on judgements. The author concluded that the possibility of devising a single measure of complexity is remote.

Considering the frequency with which random shapes are used in perceptual research, Zusne and Michels (1964) point out the necessity for specifying the visual stimuli in terms of invariants. As the visual world has main directions (vertical, horizontal, etc.) which are not inherent in random shapes, a basic reference axis for computing orientation should be developed. These investigators hypothesized that, given a suitable task, Ss eyes would follow the physically and/or psychologically dominant direction more frequently than other dimensions. Thirteen S's eye movements were recorded in response to 42 stimulus polygons. The results did not bear out the hypothesis and a reference axis could not be computed from the data.

The short history of research attempting to quantify form dimensions was reviewed by Michels and Zusne (1965). The authors classify physical parameters in three categories, and discuss their utility in view of the experimental data. The categories are:

1. Transitive parameters - a change in one parameter affects the information content and/or the shape so radically that it places that shape into another population of shapes, e.g., number of sides and linearity of contour.
2. Transpositional parameters - a change in one parameter does not change the information content nor the structure of the shape, e.g., area and rotation.
3. Intransitive parameters - a change affects structure, but not information, e.g., dispersion, symmetry, and elongation.

In general, it has been demonstrated that the amount of information can be changed without changing the judged complexity (Attneave, 1957), but as information increases, there is increased difficulty in the S's performing the task (French, 1954). Number of sides has proven to be a valuable predictor of discriminability (Brown, et al, 1962, Michels, et al, 1962). Michels and Zusne further report that limited research has been conducted considering the contour of lines or curvature. The research that has been done indicates no clear utility in quantifying physical properties for this variable. One pragmatic reason for the scarcity of research in this area is the difficulty of quantification of irregular line. The only angular measure that has exhibited usefulness has been angular variance (Attneave, 1957).

Most researchers deal with area by merely equating the area of the stimulus to keep this variable constant. No research has been found where the areas of shapes were equated for perceived size. Investigations of the importance of rotation to behavior are difficult to access due to the complexity of the designs and the failure to establish satisfactory reference axes.

The literature reveals that while dispersion of patterns and/or shapes (Arnoult, 1960; Zusne and Michels, 1962a, 1962b) and symmetry (Arnoult, 1960; Attneave, 1957) have proven to be useful predictors in a variety of perceptual tasks; the same does not apply to elongation (Zusne & Michels, 1962a, 1962b). In summary, those physical parameters found to be useful are amount of information, number of sides, symmetry, angular variance, and dispersion. More research is needed with the area, the rotation, and the curves of visual form patterns.

Attneave and Arnoult (1956) reviewed the history of shape and pattern perception and suggested several methods for developing a psychophysical approach (some of which were incorporated in the present research problem). Methods for constructing and analyzing patterns were suggested for closed contours, angular shapes, open contours, and patterns. These investigators suggest the use of analytical methods to determine the physical parameters of patterns and doing a great deal of research to determine which of these parameters have psychological importance.

Brown (1964) proposes a comprehensive list of component, pattern, and arrangement variables to be utilized in the quantative description of visual patterns. A number of these variables have exhibited experimental usefulness: line segments, angles and intersections (Hochberg & McAlister, 1953); number of turns, symmetry, and angular variance (Arnoult, 1960); number of turns and length-of-line variability (Beaver & Brown, 1963); number of components and angular variance (Brown & O'Donnell, 1966); number of turns (Brown, Hitchcock & Michels, 1962; Michels, Pittman, Hitchcock & Brown, 1962); and symmetry of component (Attneave, 1955, 1957; Arnoult, 1960; Zusne & Michels, 1962a, 1962b).

Immediate Memory and Set

There is much evidence in the literature that the type of instructions or "perceptual set" will influence Ss recall. A large number of investigators analyzing the influence of set have advanced a hypothesis of perceptual selectivity or sensitization to account for increase in correct responses (Boring, 1924; Chapman, 1932; Hoisington & Spencer, 1958;

Postman & Bruner, 1949). On the other hand, Averbach and Coriell (1961), Brown (1954, 1958, 1960), Karlin and Brennan (1957), Lawrence and Coles (1954), Lawrence and Laberge (1956), Long, Reid and Henneman (1960), present evidence for the hypothesis that set acts on retention and response mechanisms rather than on the perceptual process itself.

Lawrence and Coles (1954) divided 60 Ss into three groups. The test stimuli consisted of 50 familiar pictures that were divided into two groups. Discrete alternatives (DA; stimuli judged perceptually discrete or different by the experimenters Es and two judges) and similar alternatives (SA; stimuli judged perceptually similar by the Es and four judges). The judges listed alternatives to the correct response and Ss were instructed either before or after stimulus presentation as to what these alternatives were. Subjects were to score which of the alternatives correctly identified the stimulus. With DA group there should be little decrement in accuracy of recognition regardless of whether the alternatives were presented before or after the test stimuli. With the SA group there should be a drop in accuracy with the alternatives presented after the test stimuli if "set" modifies the perception itself. The third group functioned as a control group to demonstrate that the two alternatives did facilitate test performance. Five exposure times were used. Results indicated increased accuracy with increased exposure time. Both the DA group and the SA group were clearly superior to the control group, but no significant differences were found between these two groups. This suggests that set does not operate on the perception itself, but rather, has the facilitative effect on the memory trace, or on alternative responses.

By eliminating conditions where set could influence the selection of stimuli in perception and where set could be rehearsed during the memory process Brown (1954) presents evidence for two types of influence in immediate memory. The first items in memory will be subject to interference from concurrent retention, i.e., attempts to retain the part yet to be recalled and later items will be interfered with by this interpolated material or the first items recalled. These effects were tested for by presenting Ss with two series of items, Arrows (A) and Numbers (N). Recall sets were given either prior to presentation of test stimuli, known (k) or just after the presentation of test series, ambiguous (a). Subjects were presented on each trial with a pair of digits and a four-choice arrow. The Ss were required to draw a line of approximately the same length as the arrow while reading aloud the digits. The following eight conditions were tested: A(a), A(k), N(a), N(k), AN(a), AN(k), NA(a), NA(k). A second experiment was performed eliminating the (k) condition and substituting Letters (L) for N. The effect of concurrent retention was tested, e.g., the effect of N on the recall of A by comparing A(a) and AN(a). Interpolated recall was tested, e.g., the effect of N on the recall of A, by comparing A(a) and NA(a). The results indicate that recall is considerably higher under (k) conditions than under (a) conditions. This was explained as the effect of set to learn the series to be recalled, by traces set up in memory. The data confirmed a two-stage process of forgetting, operating in the immediate memory span which cannot be accounted for in terms of temporal delay (Brown, unpublished in Brown, 1954, found no drop in recall with simply a time delay). This suggests that recall in immediate memory is an active process.

A definition of memory span as proposed in Brown's 1958 article based on a trace decay hypothesis:

> When a sequence of items is presented, the interval between the perception of each item and the attempt to recall that item will depend on the length of the sequence. If the sequence exceeds a certain length, decay of the memory traces of some of the items will proceed too far for accurate recall of the sequence to be possible. This length is the memory span. Thus, the trace-decay hypothesis can explain both the origin of the span and why forgetting occurs when the span is exceeded (p. 13).

A memory trace is defined as the neural substrate of retention. Three experiments were performed utilizing tachistoscopic presentation of paired consonants in the test design. The pertinent results were reported as:

1. When the stimuli required for recall were below memory span limits, additional (interpolated) stimuli interfered with recall. This phenomenon was labeled "competition-in-recall" by Brown.
2. The effect of the additional stimuli was only slightly dependent on similarity with test stimuli; also, they had little effect when they preceded test stimuli, indicating that for-

getting can not be attributed to "overloading the channel capacity" of the organism.

3. The effect of interpolated stimuli before recall was still significant even if several seconds intervened between the presentation of required stimuli and additional stimuli, indicating that forgetting is due to an active process, not merely a temporal delay.

The studies reviewed here which indicate more efficient perceptual functioning with pre-established sets have a methodological weakness in their designs. The higher recall when instructions are given prior to stimulus presentation, rather than after, may be due to better conditions for retention of instructions. Brown (1958) has presented evidence that memory during the storage process(es) is very easily disturbed by presenting Ss with two sets of stimuli in immediate succession, the first of which the Ss were to recall. Forgetting was greater for Ss having the interpolated material than for a control group which had the same temporal delay, but without the second set of stimuli. Brown (1960) performed an experiment to eliminate these differential effects by giving Ss two instructions per trial, critical instructions (what S was to report) and neutral instructions (where S was to score stimuli on scoring sheet). One set of instructions was given prior to presentation of the stimulus and one set of instructions was given simultaneously with the stimuli. Forty-eight Ss were presented with two sets of stimuli (digits and consonants) on each trial for .09 sec. which they were to score in terms of class, position, and/or color. Results showed that when critical instructions were prior to presentation of the test stimuli, Ss performed significantly better when the instructions were limited to only color and/or position. The study did not conclusively answer the question proposed, as recall was better on class of stimuli when instructions were given prior to the presentation of the test stimuli. The author concludes that a selective process was able to operate during perception on the basis of class, but it was not able to operate on the basis of position and color. He suggests that further research is needed to determine whether this selective process acted on the perception or during the memory process.

In an attempt to resolve the theoretical differences between those researchers who feel that set influences the perceptual process and those researchers who feel that set acts on the memory traces of the perception Long, Reid and Hennaman (1960) presented a three-stage process of responses: (1) stimulus-discrimination, (2) identification or recognition, and (3) instrumental responsing. The basic rational underlying their procedure was that set functions as a response-"limiter". The purpose and procedure of Experiment I was as follows: (1) Can set vary in degree? This was investigated by varying the number of alternative responses, the level of ambiguity of the stimuli, and the temporal arrangements for presenting alternatives. Three levels of degraded letters were used, scaled according to frequency of identification in previous research. Seventy-two Ss were tested, three serving under each treatment combination (four levels of response restriction, two temporal arrangements, three levels of ambiguity). The data indicate that:

1. Increases in ambiguity or increases in the number of possible responses produce decreases in identifications.
2. Increase in response restriction produces increases in identification.
3. Viewing alternatives before and after test stimuli had no more effect than viewing alternatives after test presentation, which supports the hypothesis that set does not facilitate discrimination of stimulus-elements (Lawrence & Coles, 1954; Lawrence & LaBerge, 1956).

The results indicate that the facilitative effect of set is not due to response availibility alone. The authors contended that there were too many alternative responses in Experiment I, so proceeded with Experiment II, in which they restricted the number of alternatives presented before and after the test item. They found results to support their hypothesis that set before and after the test stimulus can augment discrimination. Further analysis indicated that this held true only when two alternatives were employed (rather than 4 or 8). Experiment III was performed with minor modifications to see if the results of Experiment II could be repeated. The results of this experiment again were interpreted in view of the three-stage process proposed by the authors.

These authors interpret their results in terms of set influencing the perceptual process. They commit the error of postulating a process, then not accepting the negative results in Experiment I. They performed two more studies which superficially supported their theory. There were no controls on differential learning effects or the effect of Ss having the instructions administered twice as opposed to Ss having instructions administered once, and, in this author's opinion, does little to answer the question concerning the influence of set on the perceptual process itself. Much more adequately designed research has been done (Averbach & Coriell, 1961; Brown, 1954, 1960; Lawrence & Coles, 1954; Lawrence & LaBerge, 1956; Sperling, 1960; and many others) suggesting that set does not alter the perceptual process. For example, Brown, 1954 (reviewed on page 18) controlled the level of familiarity of the Ss with the instructions by administering the instructions to all Ss once varying only the temporal arrangement of the stimuli to be recalled. An alternative suggestion may be proposed from the general results of these other investigations. Their results indicate that there may be a two-stage process functioning where set influences motor response by decreasing the number of response alternatives, but only after the perception has taken place. The message to respond and the response selection stimuli are transmitted to motor centers (i.e., storage mechanisms) after the perception.

In an information theory context Averbach and Coriell (1960) designed an experiment to measure the functional properties of short-term storage in visual perception. They considered: decay, erasure, and "readout" by utilizing technique developed by Sperling (1960) to answer the question of storage capacity. Rather than showing S a visual display and asking him to report as many items as he can remember, this technique involves showing S a test stimulus, then a visual marker (bar) is presented and S is asked to report what item was in that position. A negatively accelerated function was obtained with increasing time intervals between the display and the bar marker, indicating decay in the short-term memory system. The effects of erasure (substantiating Brown's 1958 contention that memory is easily disturbed) were tested by using a circle to indicate the item to be reported. When the circle follows the item to be reported the erasure effect is greatest at 100 msec. In preliminary work done by the authors they found that the bar marker when close to the test letter disturbed recall. The decrease in recall with the circle was interpreted in view of the relative distance of the circle from all parts of the test stimuli. They also state that there may not have been sufficient time for readout. At first in memory the circle merely superimposes the test stimulus. At 100 msec. the test stimulus has not yet had time to be read into permanent storage and erasure takes place. Evidence for this was shown as performance improved with increased temporal delay between the test array and the circle marker in the order of 200 msec. The S has had sufficient time to read the test array into permanent memory and the circles no longer function to erase the letter. To measure the effect of readout, the test array was shown with the letter to be reported marked with the bar marker. A short time later, the erasing circle was presented. Results indicated that the circle functioned to erase the marked letter with time intervals less than 200 msec. The rapid increase in performance at 200 msec. is interpreted as the perception having had time to be read into permanent storage. One letter followed by the circle at 100 msec. is not disturbed and was reported correctly 100 percent of the time. Four letters which are normally reported perfectly, when followed by the circle performance decreases significantly.

The authors conclude:

1. The visual storage system can be tapped selectively.
2. Readout is disturbed when too much data are input.
3. Decreased performance with circle marker after 100-msec delay is due to a change over from super-position to an erasure condition.
4. The visual system contains a storage system with rapid readin and relatively slow readout (exposure times were in the order of 50 msec., whereas maximum readout was in the order of 200-270 msec.).

5. This system includes an erasure mechanism, specific in function.

6. Storage time is approximately 1/25 sec.

A series of four experiments were performed by Epstein and Rock (1960) to separate the influence of recency and/or frequency from expectancy, utilizing Schafer-Murphy ambiguous profiles, Boring's ambiguous wife and mother-in-law, and Wertheimer's ambiguous stroboscopic movement patterns. Sixty Ss in Experiment I were "set" during instructions to expect any one of four slides to be different. They were shown the following series: A, A, A, A/B (where A/B is an ambiguous pattern containing both A and B). An expectancy view would predict the perception of B whereas, both frequency and recency would predict the perception of A. The results of Experiment I found clear support for recency and frequency versus expectancy. Experiment II was performed to determine if expectancy played a role in Experiment I. Forty Ss in Experiment II were tested without the "set" instructions. The determinant in this experiment was frequency-recency. The Ss were divided into four groups and shown one of the following series: A, B, B, B, A/B; B, A, A, A, A/B; M, W, W, W, W/M; W, M, M, M, W/M. The results of this experiment show again the superiority of frequency-recency over expectation. Experiment III was designed to identify the crucial variable of either frequency or or recency. This was done by holding frequency constant and setting recency and expectancy in opposition. In this experiment a test series appeared as follows: M, W, M, W, M, W, W/M. The results strongly supported recency. Experiment IV was designed to test the influence of frequency apart from recency. The independent variable was the frequency with which the non-recent figure was presented. For example, Group 1 was presented with A, A, A, B, A/B and Group 4 was presented with M, M, M, M, M, M, W, W/M. Although the results yielded a slight drop in recency response, the influence of this variable was so strong that even in Groups 5 and 6 where the ratio of frequency to recency presentations was 12:1, the average percent of recency responses was 60.5%. A corollary experiment was performed testing the role of expectancy alone. This was done by interposing a 5 min. time interval between the last stimulus presentation and the test situation to mitigate the effects of recency. The Ss were then told they would be shown the last figure they had seen. There was no evidence favoring an expectancy hypothesis, even though it was opposed by no other factor. The authors conclude that recency (and memory traces of the perceptual event) is the critical variable for shape-perception, whereas in research problems that introduce need-sets and expectations, expectancy may play a role. In the present investigator's opinion, these results present difficulties for information theories' explanation of perception. Information theory states that perception is a process of selecting information from a stimulus array and then this percept is confirmed or modified in view of a hypothesis based on past experience. The brief exposure times ($<$0.5 sec.) used in the above experiments should according to information theory strengthen the dominant hypothesis, expectancy, or predisposition. These results fail to support this interpretation. The authors feel that their findings indicate a need for a further examination of the role of specific memory traces. It is interesting to note that, although this article was not published until 1960, none of the recent literature in information theory was reviewed. Present information-theory research emphasizes the role of a selective process that functions during the short-term memory span.

Teichner, Reilly and Sadler (1961) combined two traditional experimental procedures in studies of attention span by requiring S to search a visual display and then identify more than one symbol in the display. Subjects were tested in groups of three with an exposure time of the test material set at 1 sec. and an intertrial interval of 10 sec. One group of 12 Ss identified alphabet letters-identification task (IT). It was felt by the authors that the identification group would first have to process information in terms of numbers of categories before they could identify the alphabet letters within the category. The second group reported the number of different alphabet letters-discrimination task (DT). It was felt that if the two groups differed significantly this would be the first experimental evidence supporting a long theorized difference between perceptual span processes and short-term memory, as the IT group, either implicitly or explicitly, would be processing the information first in terms of numbers of categories regardless of the correctness of identifications. The prediction that the DT group would be superior was supported in that the optimum span for reporting numbers was approximately 4.2 categories while for the IT group the optimum span was approximately 3.4 letters. The loss of information in the memory span was attributed to the requirement of identification. These results indicate that perceptual capacity is greater than short-term memory capacity. The implication is that the number of categories that S can discriminate is limited to a greater extent if he is required to name the categories. These authors (Teichner and Sadler, 1962) continued their research to test the effects of exposure time and density of figures in a visual display on discrimination. It was proposed that as exposure time increased, memory would be aided. However, beyond some adequate scanning time of the display, perception would not be aided. As predicted, at an 0.5-sec. exposure time, identifications increased as density or number of stimulus patterns increased, due to increased information contained within a fixation. At an exposure time of 2.5 sec. (assumed sufficient for scanning) further improvements in perception were small.

Design Problems

The following articles have been reviewed presenting experimental support and rationale for design procedures used in the present research.

Lawrence and LaBerge (1956) dealt with four levels of instructions on accuracy of reporting three stimulus dimensions. The Wisconsin

Card Sorting Task stimuli functioned as test items. These stimuli differ in color, form, and number of figures per card. The four levels of instructions were: (1) Equal instructions-S was to record all three dimensions; (2) Emphasis instructions-S was to attend to a dominant dimension, but was to record all three parameters; (3) One-only instructions-S was to report only the dominant dimension; and (4) Ordered instructions- after the presentation of the card, the E specified the order in which S was to score. Instructions (4) present a methodological problem in that instructions (1) through (3) were administered after stimulus presentation. As mentioned previously, Brown (1954) indicated that immediate memory is easily disturbed by interpolated material. All Ss were tested in groups of 5, seated six ft. from the screen where the test patterns were presented for .10 sec. Subjects had a 15-sec. intertrial interval for scoring. The results indicate that a constant amount of material is transmitted irrespective of type of instructions. The order in which S scored the three variables had a significant effect. This effect suggests that the act of writing down the first variable increased the temporal delay, thereby interfering with the recall of the following variables. This order effect is accounted for by the interaction of memory and response factors.

Campbell and Freeman (1955) investigated the effects of experimentally induced language on perceptual learning. Perceptual learning was defined by the authors as language facilitating paired associate learning of unstructured picture-pairs. Subjects were instructed to associate 15 unstructured picture-pairs under three conditions: (1) No language associated with the picture-pairs, (2) A meaningful label associated with the picture-pairs as determined by 16 Ss and/or the E in a preliminary study, (3) A relational phrase denoting a common characteristic between the picture-pairs. The results indicated that language alone does not facilitate learning as the "Meaningful Labels" group made more errors than the "No Language" group. Learning was most facilitated by relational instructions, suggesting once again the need for careful formulation of instructions in perceptual learning research.

It has been suggested that both order in which variables were recalled and language associated with the test patterns to be recalled are crucial variables in any design of perceptual research. Richard (1965) suggests that it is more beneficial to reduce response similarity than stimulus similarity. He also predicts for future research that greater improvement in recall of stimuli will result from response predifferentiation than from stimulus predifferentiation. By using circles and rectangles of high to low discriminability associated with differing responses, Richards experimentally supported the prediction that reduced response similarity is more beneficial to learning than reduced stimulus similarity. In view of these results and Campbell and Freeman's (above), it was decided in the present problem to change the scoring procedure for Ss (0 = Low and 1 = High for all four variables) utilized in the pilot study to scoring categories that were more meaningfully related to the parameters and which reduced the response similarity (numbers and words).

In view of the recent emphasis on Information Theory and more specifically, the concept of channel capacity and immediate memory span, the question may be raised as to whether the information content of the slides utilized in the present research was such as to overload the channel capacity of the S. This would have served to confound the results, since errors in recall were to be attributed to interference in immediate memory, not to limited perceptual capacity (or in other words, not to a failure to perceive due to overloading the Ss perceptual mechanisms). Attneave (1954), Miller (1956), Teichner and Sadler (1962) (reviewed previously) emphasize the role of redundancy or perceptual coding in the visual world - the higher the redundancy, the less information contained in that pattern. The stimulus patterns in this research were highly redundant and would appear to be within the channel capacity of human Ss.

A well designed study by Kaswan and Young (1963) considers the variables of exposure time, intensity, and spatial relationships in determining visual perception. They presented Ss with evenly spaced dots and paired dots, at eight exposure times ranging from .004

sec. to .512 sec., and at eight intensities ranging from .09 mL to 11.84 mL. They found that an exposure time of .064 sec. resulted in better than 70% accuracy for both types of designs at all but the two lowest intensities. (They postulate a two-phase temporal process in the perception of complex visual display which depends on the total energy involved, i.e., intensity X exposure time. Once a stimulus is detected, the second phase involves discrimination and depends on spatial differentiation). In relation to the present problem, these results would suggest that the exposure time and intensity used in the present study were more than adequate for the perception of the four factors. Mooney (1960) found no clear-cut superiority for recognition of visual patterns at longer exposure times than for short exposure times. These results are not incompatible with those of Kaswan and Young's since Mooney's exposure times were longer (.07 sec. and 5.0 sec.) and the test stimuli were forms of three levels of ambiguity. Even with these procedural differences, the percentage of false recognitions for the forms at .07 sec. was in the order of 30% to 40% (or, conversely, approximately 70% correct identification). The trend indicated by the data was in the direction of increased accuracy with increased exposure time.

In any study attempting to utilize an immediate-memory design, it is essential to control for the effects of learning, practice, and warm-up to be reasonably assured that S's errors are not due to one or more of these factors rather than the factor under investigation. In investigating the effects of practice on central and peripheral visual acuity, Bruce and Low (1951), using Landolt broken circles, found that accuracy of central visual acuity did significantly improve with practice. Peripheral vision was measured from the following points: out 30^{o}, up 30^{o}, down and out 60^{o}, up and out 30^{o}, and out 90^{o}. Central vision was the center of these measurements. One hundred and thirteen Ss passed the test for visual acuity by judging which of four different gaps corresponded to the test circle which was presented briefly. These Ss were then given eight weeks practice, 40 min. per day, on identification of aircraft utilizing a correction procedure. Thirty medical students with corresponding visual acuity served as control Ss. It was clearly demonstrated that central visual acuity did improve with practice. Peripheral vision yielded a trend toward improvement, but the results are not comparable to those for central acuity as the authors did not give the Ss similar specific practice for peripheral vision. They interpret their results in view of developing perceptual motor skills. Sprague (1959) investigated the effects of three types of training procedures on tachistoscopic recognition thresholds: (1) Pronounce group - S read and pronounced each nonsense syllable, (2) Read group - S read each nonsense syllable to himself, and (3) Verbal group - S orally pronounced each syllable after hearing E pronounce it. The major variable operating appeared to be the frequency of prior occurance of the nonsense syllable. Both the Pronounce group and the Read group had significantly lower thresholds with increased practice, but not the Verbal group. The difference may be due to the fact that the Verbal group did not have the opportunity to see the nonsense syllable they were to pronounce, whereas the Ss of the other groups had more practice, i.e., they saw the word and pronounced it either to themselves or orally. The author concludes that frequency of prior exposures is one of the critical variables for effectively lowering tachistoscopic thresholds, thereas the verbal method is not effective.

It has been argued on the basis of Gibson's 1950 predifferentiation hypothesis that predifferentiation training would facilitate shape discrimination. Arnoult (1953) states that studies which have supported the predifferentiation hypothesis have not adequately controlled for warm-up effects and learning-how-to-learn effects. He carefully controlled for these factors in a design using nonsense shapes, requiring Ss to identify whether the test stimuli were the same or different from the standard stimulus. Two hundred and fifty airmen were used as Ss, of which 200 were given 2 min. of study before the discrimination task. He found no support for a facilitative effect of predifferentiation training and emphasized again the need for controlling for warm-up and learning-how-to-learn effects.

CHAPTER III

METHOD

Stimulus Patterns

The test stimuli were selected from Brown's (1964) stockpile of randomly determined shapes. Sixteen stimulus patterns were prepared, each representing one cell in a 2 x 2 x 2 x 2 factorial design. The four factors were angular variance, dissimilarity of average width of border, number of turns and number of components. Each of these factors was considered at two levels, i.e., angular variance - alike or different; dissimilarity of average width of border - similar or dissimilar; number of turns - 3 or 12; and number of components - 3 or 18. (See Figures 1-4 which show actual slides drawn to scale illustrating all four factors at both levels of each factor.)

Angular variance (AV) is a measure of the variability in size of the angles (or changes in curvature) which characterizes the contour of a figure (Brown and O'Donnell, 1966). The AV is obtained by measuring the size of each angle in a figure and computing the variance of the distribution of these measurements. All measurements were made with the interior of the figure as the point of reference so that convex turns were measured as less than 180 degrees and concave turns as greater

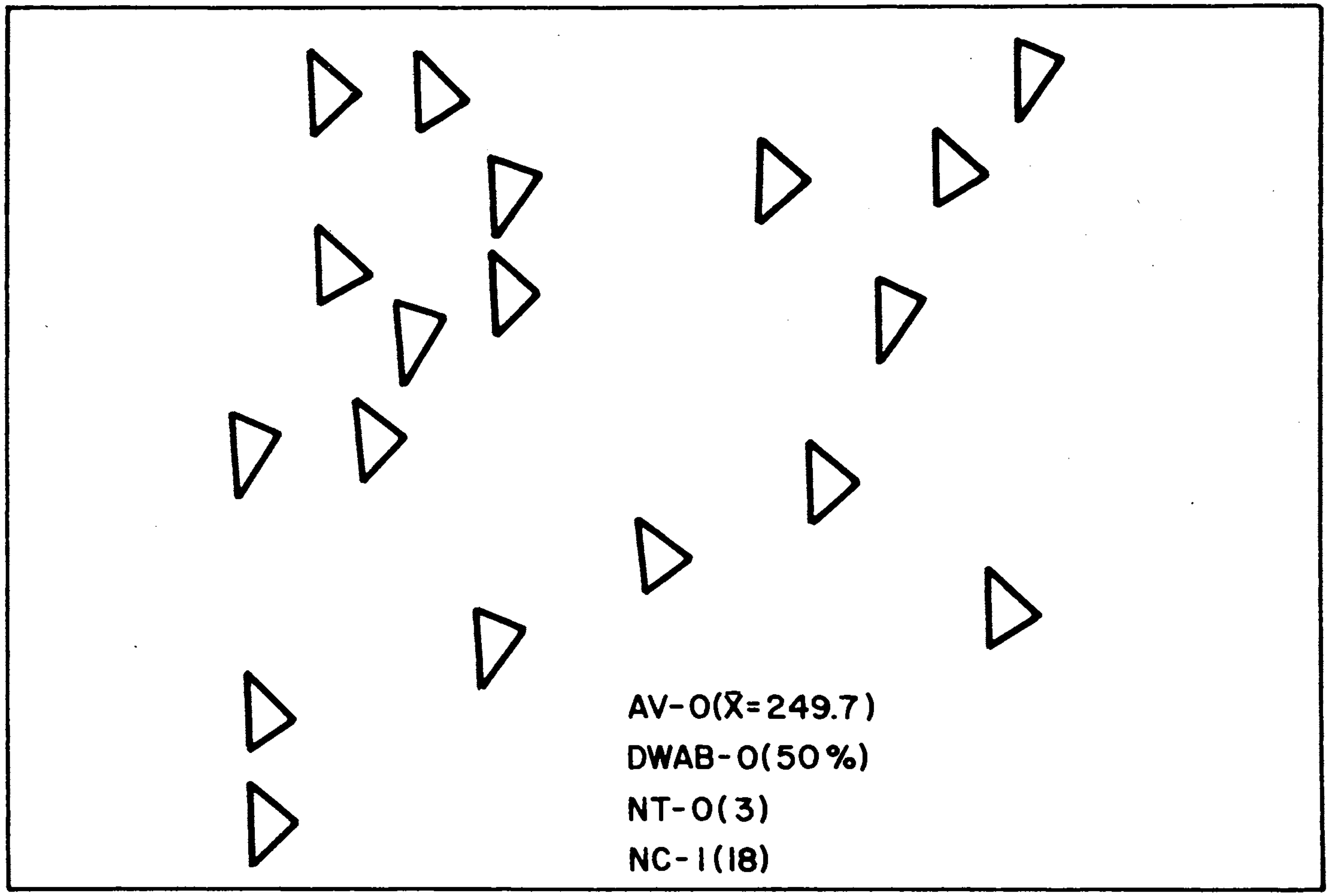


Figure 1. Patterns Showing the Levels of the Four Variables

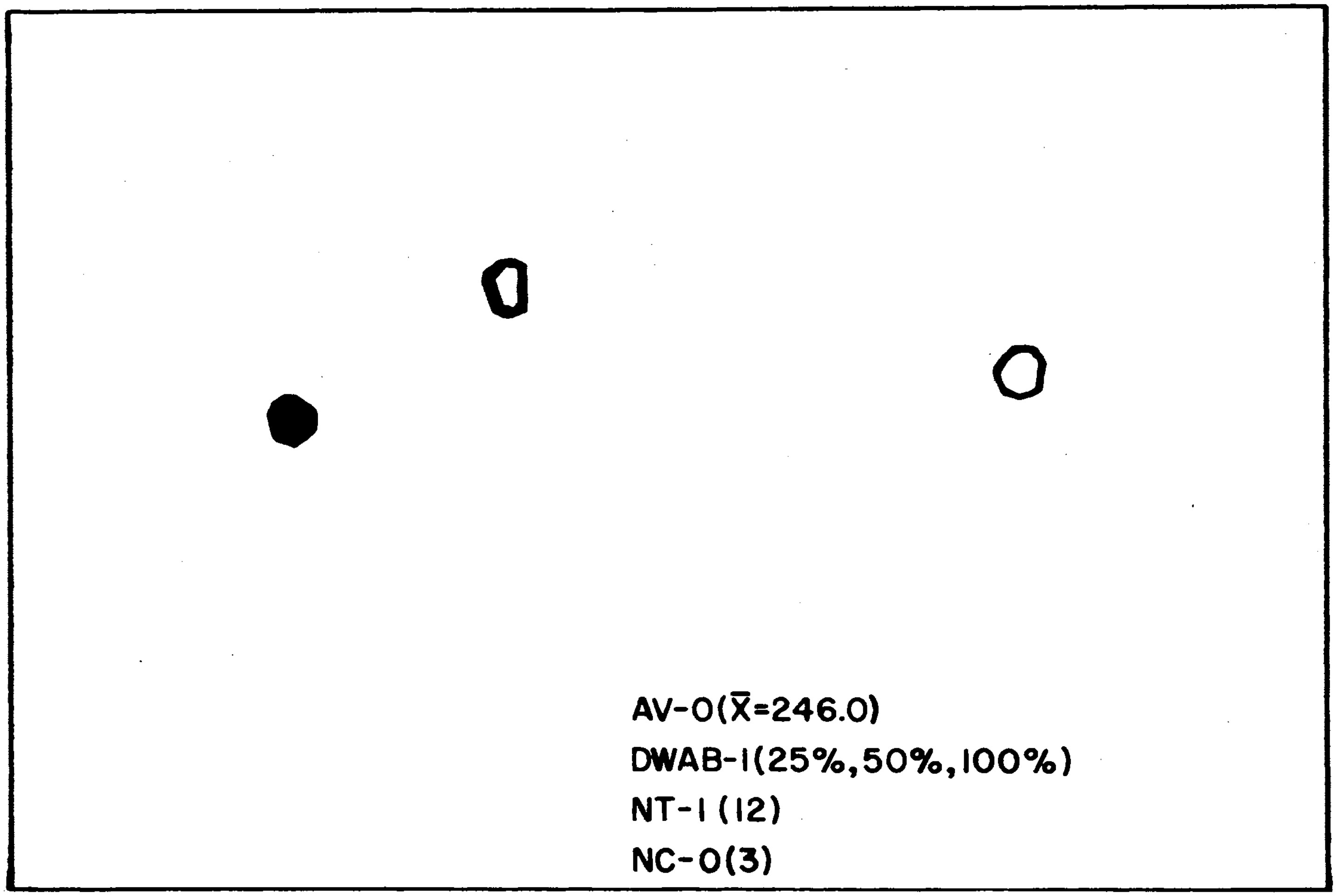


Figure 2. Patterns Showing the Levels of the Four Variables

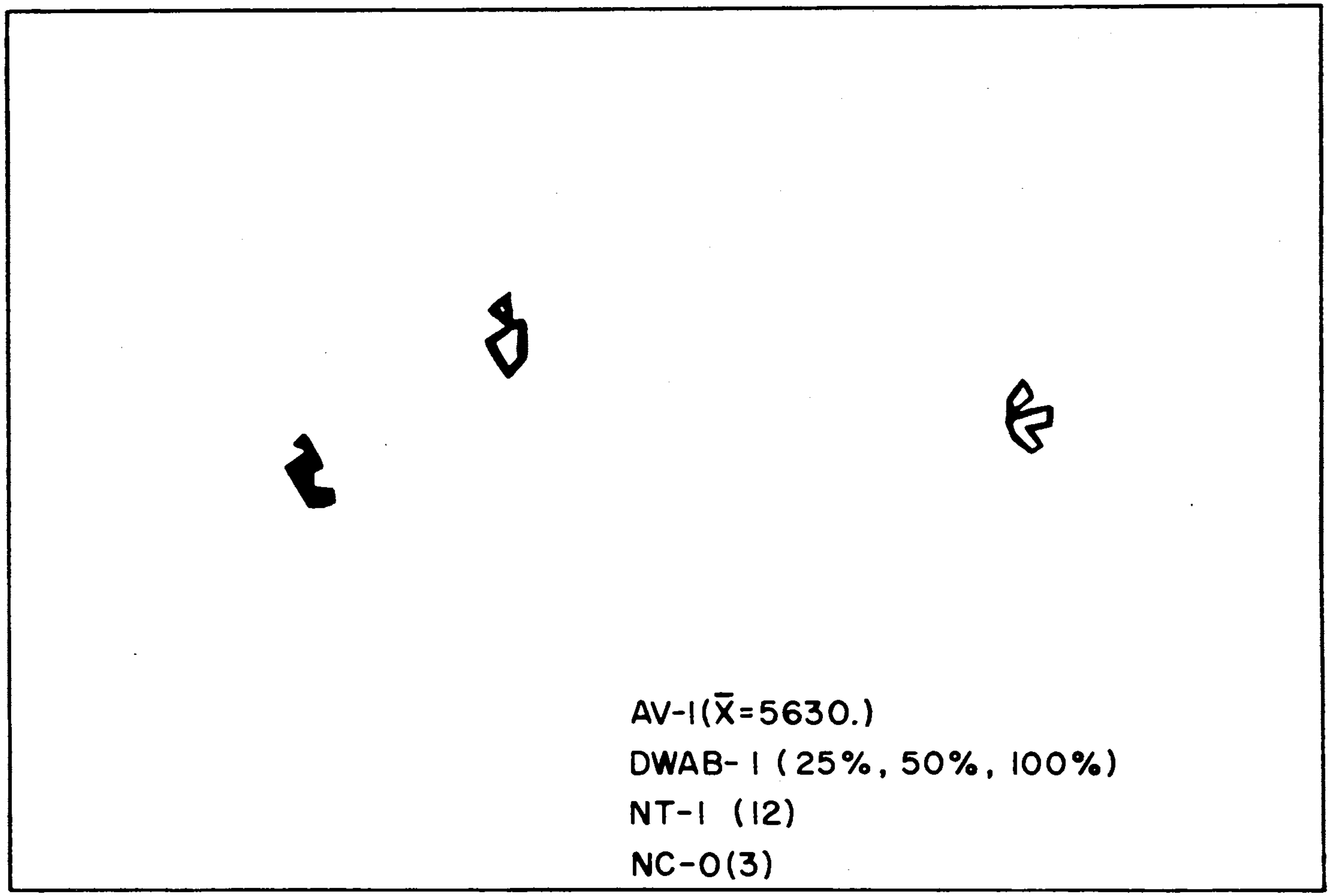


Figure 3. Patterns Showing the Levels of the Four Variables

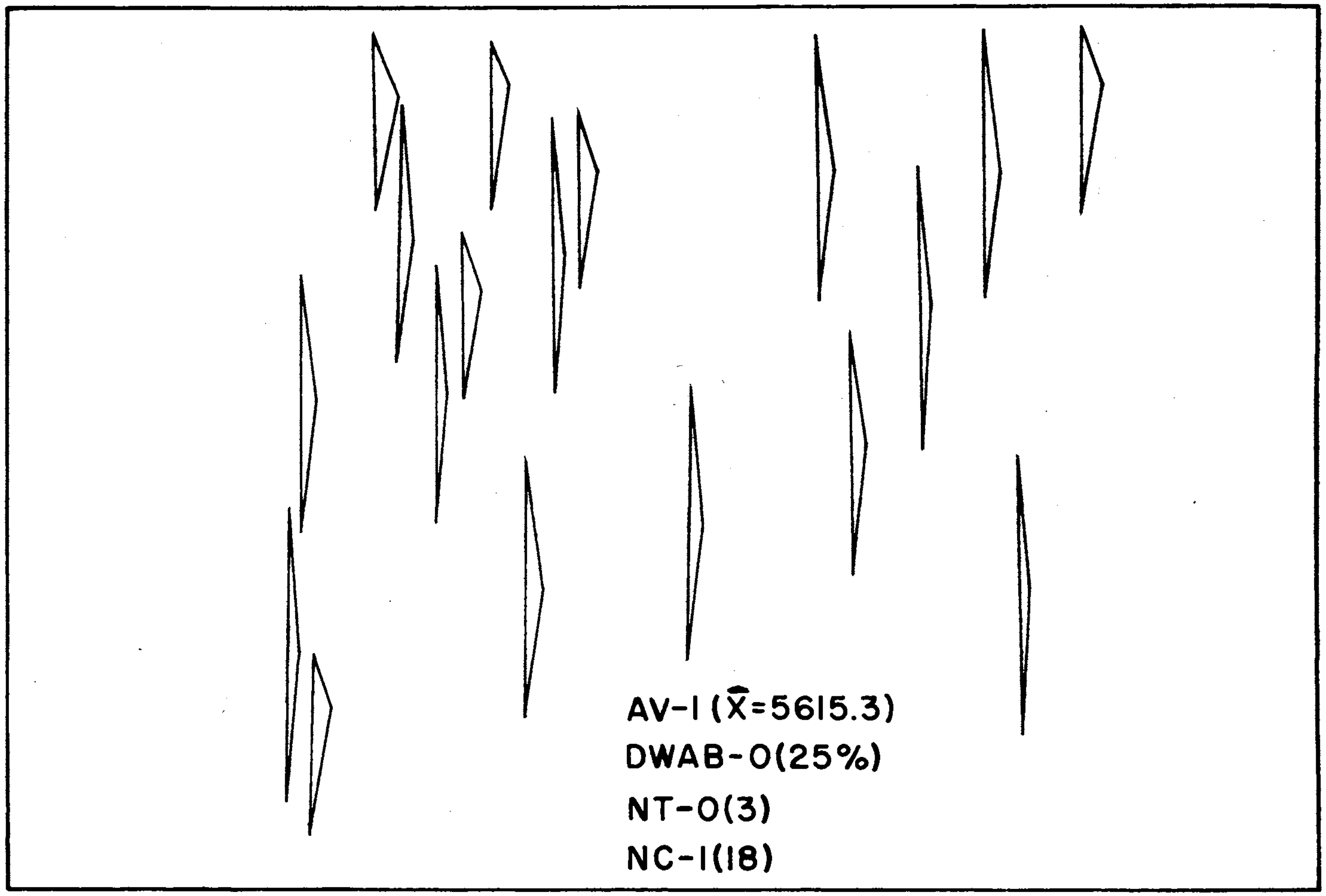


Figure 4. Patterns Showing the Levels of the Four Variables

than 180 degrees. Three triangles and three 12-angled figures with relatively low AV (mean AV = 246 and 249.7, respectively) were selected to represent the low level of AV. Three triangles and three 12-angled shapes with relatively high AV (mean AV = 5615.3 and 5630, respectively) were selected to represent the high level of AV. The figures were chosen so that each triangle with low AV was matched as closely as possible in AV with one of the 12-angled shapes with low AV. The same procedure was followed in selecting shapes with high AV.

Dissimilarity of average width of border (DAWB) refers to the borders of the shapes within a slide. If the borders of the shapes were all the same width, this variable, for this slide, would be scored as similar. If the borders between shapes in a slide were different widths the variable would be scored dissimilar. Three different border widths were used. The three different borders are shown in Figure 5. Eight slides composed the dissimilar level of the factor and 24 slides were constructed with shapes of similar border width. Eight of these bore shapes with 100% border width. The 100% border width was defined as the smallest border that will completely fill a figure. Eight of the patterns bore shapes with 50% border width, If, for example, the 100% border should be 1/2 in., then 50% border width would be 1/4 in. Eight of the patterns contained shapes with 25% border width. Within the dissimilar patterns one-third of the figures had 100% border widths, one-third had 50% border widths, and one-third had 25% border widths. The assignment of dissimilar borders was consistent across slides bearing the same number of components.

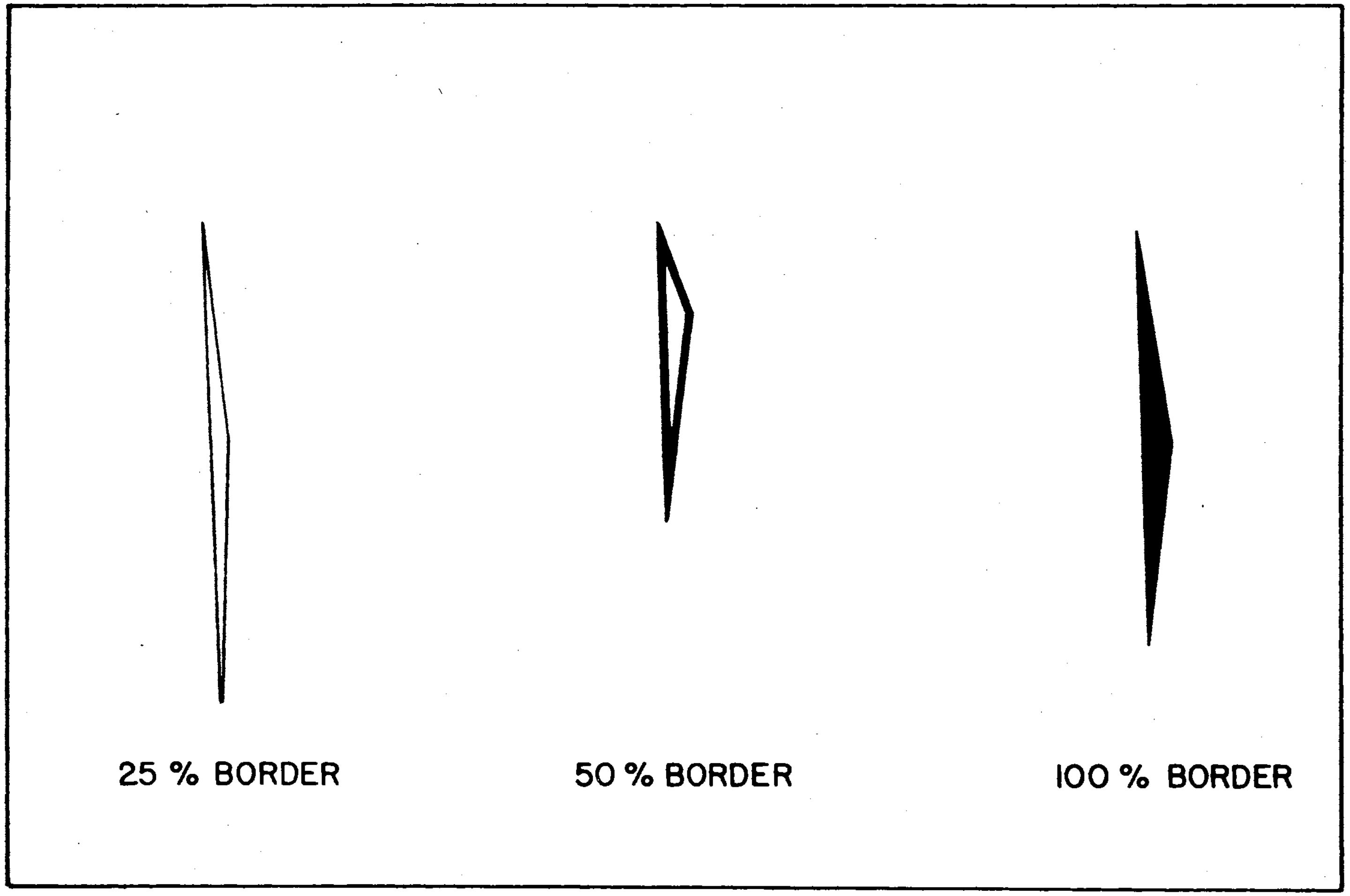


Figure 5. Three Different Levels of Border Widths Used for the Dissimilarity of Average Width of Border Variable

Number of turns (NT) refers to the number of angles (or changes in curvature) which characterizes the contour of a figure. A turn was defined as any change in direction. To provide shapes representing two levels of NT a pool of 50 3-sided (triangles) and 50 12-angled polygons were constructed according to Method I of Attneave and Arnoult (1956).

Number of components (NC) refers to the number of figures which make up a pattern. The two levels of NC utilized in the present experiment were 3 and 18. To prepare a prototype for the 18-component pattern, a 25 cm. x 25 cm. grid was drawn and 18 cells were chosen by means of a table of random numbers. Following Brown and O'Donnell (1966) measurements were taken of four properties of this prototype pattern: (1) average distance separating the 18 cells (11.16 cm.), (2) standard deviation of the distances between the cells (6.07 cm.), (3) average "height" of the cells (10.39 cm.) and (4) average "dextrality" of the cells (10.72 cm.). A second 25 cm. x 25 cm. grid was then drawn and three cells were chosen to provide a 3-component prototype pattern with properties similar to the 18-component patterns. The values of the 3-component prototype on the four-pattern dimensions were 13.93 cm., 5.84 cm., 10.33 and 10.67 cm., respectively.

The 3-component pattern containing triangles of low AV was prepared first. Three triangles of low AV were randomly assigned to the three cells of the 3-component prototype pattern. The 3-component pattern containing 12-angled shapes of low AV was prepared by assigning each of the components to the same cell as assigned to the triangle matched with it in AV. The same procedure was followed for 3-component patterns containing triangles and 12-angled shapes of high AV.

The 18-component pattern with triangles of low AV were randomly assigned to the 18 cells in the 18-component prototype pattern, with the restriction that each shape occupy six cells. The 18-component pattern containing 12-angled shapes of low AV was prepared by assigning each of these shapes to the same six cells assigned to the triangle matched with it in AV. The same procedure was followed for 18-component patterns containing triangles and 12-angled shapes of high AV.

With regard to the DAWB variable, eight slides were designed with high dissimilarity. One-third of their shapes had 100% borders, one-third 50% borders, and one-third 25% borders. For example, a 3-component pattern would have one shape with a 100% border, one shape with a 50% border, and one shape with a 25% border. The same procedure was followed with the 18-component patterns, i.e., six shapes had each of the three different border widths. Twenty-four slides were constructed for the low level of DAWB, eight of which contained components with 100% border width, eight which contained components with 50% border, and eight which contained components with 25% border width. All subjects were presented with the eight dissimilar slides, whereas one-third of the subjects were presented with the 100% borders, one-third with the 50% borders, and one-third with the 25% borders.

The low level of DAWB was counter-balanced across subjects so that any effects of this factor could be attributed to similarity or dissimilarity of the borders rather than to border widths per se.

All shapes were placed in a verticle orientation (see Brown, 1963). Since the shapes were 200 mm.^{2} in area and the cells to which they were assigned were 100 mm.^{2}, each shape was placed by centering it by eye on its respective cell.

The 16 patterns were prepared for photography by cutting the shapes from dark-colored adhesive tape with a sharp blade and, using the contours of the drawn shapes as guides, applying them to a white background. The patterns were then photographed and prepared as 2 in. x 2 in. slides. The figures appeared black against a transparent background.

A 28 1/2 in. x 22 1/2 in. section of white cardboard was prepared with a sample of each of the stimulus shapes drawn on with a black grease pencil. The four factors at two levels were drawn on the cardboard to be used as examples during the administration of the instructions.

Apparatus

The apparatus employed in the present study included a Kodak Carousel (Model 800) projector (see Fig. 6). Stimulus duration was calibrated to .10 sec. by a Graphex camera shutter (shown in Fig. 7). The slides were projected on a 30 in. x 40 in. beaded screen. The

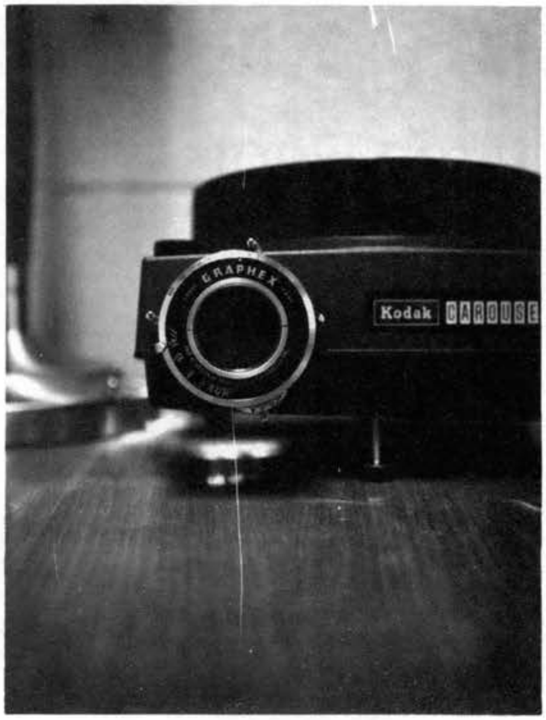


Figure 6. Projector

Figure 7. Camera Shutter

brightness of the reflected light from the screen was measured with a General Electric exposure meter, Type PR-1. The suggested procedure for measurement was used, i.e., "Measure screen brightness by holding the meter light-cell against the center of the illuminated screen and then drawing the meter (set for LOW range) backwards until the maximum reading is obtained (p. 40, Operating Manual, General Electric)". General Electric suggests that to obtain the best possible projected image the screen should reflect at least 9 footlamberts without a slide in the projector. Five readings each were taken at three points on the screen, three times during the course of the experiment. The average of these five readings, expressed in footlamberts are shown in Table 1.

Table 1

Reflected-Light Readings (ft. L) from
Three Points on the Experimental Screen

Reading

Position	Left-Side	Middle	Right-side
1	42	50-	42
2	42	50	42
3	42	50-	42

The fluorescent ceiling light was left on throughout the experimental sessions as pilot testing yielded no difference between high illumination (fluorescent ceiling light) and low illumination conditions (shaded lamp with a 60-watt bulb). As dark adaption is a variable in visual perceptual research, this procedure eliminates the possibility of confounding effects and decreased the possibility of after images occurring after the slide presentation. The projector was left on at all times during testing sessions so that the transient intensity of the bulb would not be a factor.

The projector was placed on a desk 10 ft. in front of the screen and 4 ft. in back of the Ss. The slides were placed in the projector so that all patterns appeared in the same orientation.

The experimental room had three light-proof doors with no windows (for dimensions and location of apparatus see Appendix A). The room was situated in a basement adjoining a classroom which was unoccupied during experimental sessions, so that there were virtually no extraneous noises. The wall behind the screen was covered with white sheets to reduce distracting stimuli. Three standard school desk chairs were placed 6 ft. in front of the screen.

EXPERIMENT I

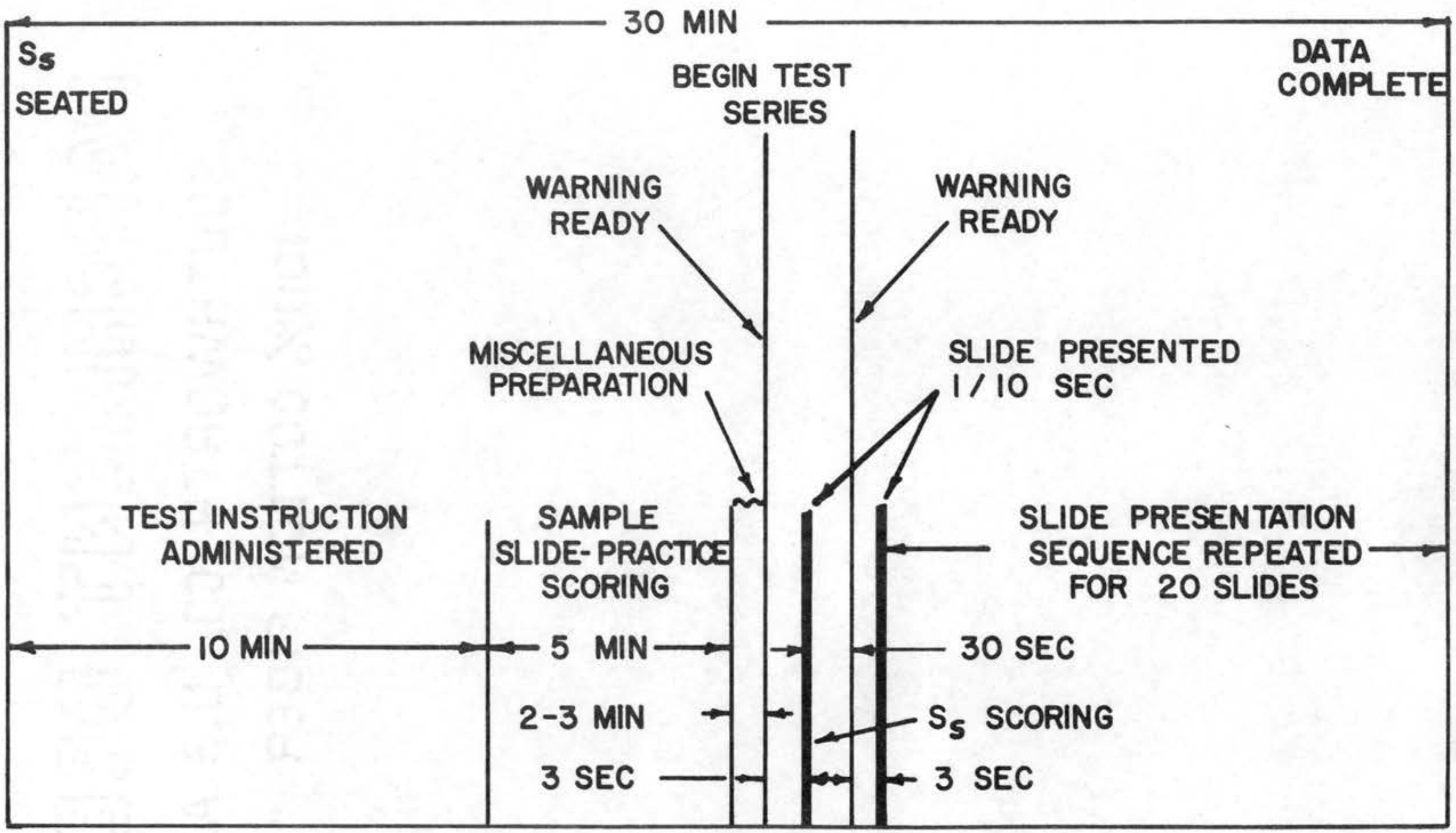
Subjects

The subjects were experimentally naive, undergraduate volunteers enrolled in introductory psychology courses at the University of Alabama, Huntsville Campus, Huntsville, Alabama. Forty-eight males Ss were used.

Procedure

Each S was randomly assigned to a group of three for a 30-min. experimental period. The group of Ss met in the adjoining classroom and waited until the E escorted them into the experiment room. Subjects were seated and given scoring sheets on which the variables had been randomly ordered (see flow diagram, Fig. 8).

Lawrence and LaBerge (1956) suggested that the order in which the stimuli are reported will influence recall. The scoring sheets were randomly developed to avoid this order effect. (A sample scoring sheet may be found in Appendix A). The column labels relating to the factors were designed to have high "meaningfulness" as Campbell and Freeman (1955) found that verbal labels facilitated recognition only if related very specifically to the factors. The "meaningfulness" of the labels was decided upon by asking pilot Ss which of several alterna-



SEQUENTIAL ORDER OF TESTING PROCEDURE

Figure 8. Flow Diagram of Experimental Session

tive labels seemed to be most closely related to the variables.

An experimental session began with Ss looking at the example card which was placed on the screen while E read the instructions, followed by four practice slides scored on the back of the scoring sheets with E correcting the responses. The magazine was then returned to the first slide and the Ss were instructed to turn their scoring sheets over. Four practice trials were given with the same four slides to familiarize the Ss with tachistoscopic presentation and, more specifically, to familiarize them with the time intervals. The E said "Ready" to assure that all Ss were attending to the screen. Each slide was presented for .10 sec. The time interval between the projection of each slide was pre-set to 30 sec. The 30-sec. interval provided ample time for scoring during the pilot study. The 16 slides of the test series were presented without interruption. These four practice slides were members of the experimental slides chosen so that each property was equally represented. For example, two of the practice slides bore triangles, and two bore 12-angled shapes. Each slide in the experimental series was used as a practice slide an equal number of times. The presentation of slides was such that each of the three different sets of patterns with similar border widths was presented an equal number of times. The 16 experimental patterns were presented in 16 random orders, each group of three Ss receiving a different order.

Instructions

The preliminary remarks to Ss after they were seated in the lab were designed to keep Ss from looking for a "catch" or from being concerned that E was measuring personality variables:

> This is strictly an experimental or brass instrument psychological experiment. I am not concerned with personality variables. I'm only concerned with how man perceives his visual world or simply, what do people remember from what they see.

The following instructions were then administered:

> This is an experiment in psychology concerned with visual perception. I will project slides on a screen. The components or figures in each slide are very abstract. Make no attempt to identify them. I am concerned with four variables. Look at your answer sheets and you will find them listed across the top of the page. They are: (1) Angles, (2) Number of Components, (figures), (3) Number of Turns, and (4) Borders.

The descriptions (see below) of the variables were randomized to avoid any order effect. An example of the two levels of each variable was pointed out on the example cards and the appropriate place to score was indicated as each variable was discussed.

> By number of turns, I mean how many turns you would have to make if you were walking around the edge of the figure. If the figure in a slide should have 3 turns, you would check here (point). If the figure in a slide should have 12 turns, then you would check here.

> By Borders I mean how different the borders in each slide are. If the borders in a slide should be similar then you would check here (point). If the borders of the figures should be different or dissimilar in a slide, then you would check here (point).
>
> By angles I mean how different the angles in each slide are. If the angles in a slide should be alike, you would check here (point). If the angles of the figures should be different, then you would check here (point).
>
> I must be sure that you understand these instructions, so let's go over them again.

The four paragraphs describing the four variables were repeated.

Pointing to the answer sheets and example cards were discontinued.

> Now I am going to show a practice slide. Turn over your answer sheets and score the variables in the following order: (1) Borders (pause), (2) Number of Turns (pause), (3) Number of Components (pause), and (4) Angles (pause).

The scoring was checked by E and the correct variable was pointed out on the practice slide to give immediate knowledge of results. The same procedure was followed for the next three practice slides. Scoring of variables was randomized for each of the four practice slides for the Ss within each experimental group and also among the groups. The slide magazine was quietly returned to the first practice slide.

> Turn your answer sheet over. When I say "Ready" you are to look at the screen. The slide will be presented very briefly and then you will have 30 sec. in which to score each

of the four variables for that slide. At the end of 30 sec. I will say "Ready" and you should again look at the screen. Follow these procedures throughout the presentation of all 20 slides.

Now I am ready to begin. Please make no comments during the experiment. Make sure that you are scoring the right variable in the right column and that you are scoring the correct slide number. Ignore the click that the projector makes as it changes slides. The important thing is that when I say "Ready" you look at the screen and wait for the slide to be presented.

EXPERIMENT II

It was reported by Lawrence and LaBerge (1956, reviewed previously on page 30) that the order of scoring variables had a significant effect on recall. It was noted during Experiment I that many Ss developed a preference in their order or scoring the four variables regardless of the order presented on the scoring sheet. For example, many Ss scored NC first, regardless of the order in which it appeared on the scoring sheet. It was decided on the basis of these observations to conduct a further study in which the Ss would be forced to score the variables in the order in which they appeared on the answer sheets. It was predicted that there would be more errors found in Experiment II than in Experiment I because of the forced order scoring.

Subjects

Eighteen experimentally naive male Ss volunteered from introductory psychology and sociology classes at the University of Alabama, Huntsville Campus, Huntsville, Alabama.

Procedure

The procedure followed in this experiment was identical to the procedure utilized in Experiment I except for minor changes in the last paragraphs of the instructions.

> Now, I am ready to begin. Please make no comments during the experiment. Make sure you are scoring the right variable in the right column and that you are scoring the correct slide number. Also, make sure you score the variables in the order in which they appear on your scoring sheets, i.e., (point) start on the left and work across to the right. Do not skip any of the variables. Work from left to right.
>
> Ignore the click that the projector makes as it changes slides. The important thing is that when I say "Ready" you look at the screen and wait for the slide to be presented.

The E sat directly behind the Ss to ascertain that Ss followed instructions in regard to the order of scoring. All Ss followed instructions concerning the order of scoring.

After each test session E asked the following questions:

1. Did you score the variables in the order found listed on the top of your answer sheets?

2. On the back of your answer sheets write down the order in which you would have liked to score the variables.

All Ss answered question No. 1 in the affirmative. As an experiment concerned with Ss preference for scoring the variables was being formulated, question No. 2 was asked to ascertain whether the expected trend would also be found with these Ss. It was expected that the most frequently preferred scoring would be the order in which Ss had been forced to score during the test series, but that, if S indicated a different order of scoring, it would correspond to the preferred order expected in the subsequent experiment.

EXPERIMENT III

In what order would Ss score the variables if they were free to score them in any order they chose? Experiment III was designed to answer this question. It was predicted on the basis of observations made during Experiments I and II that NC would be scored first by Ss, with NT being chosen to be scored second. No predictions were made for AV and DAWB.

Subjects

The Ss were 12 experimentally naive professors and students at the University of Alabama, Huntsville Campus, Huntsville, Alabama.

Procedure

The procedure followed in this experiment was nearly identical to those followed in Experiments I and II. The only changes were again in the instructions.

> This is an experiment in psychology concerned with visual perception. I will project slides on a screen. The components or figures in each slide are very abstract. Make no attempt to identify them I am concerned with four variables. Turn over your answer sheets and list them--abbreviate if you want: (1) Angles, (2) Number of Components (figures), (3) Number of Turns, and (4) Borders. I would suggest NC or NF for Number of Components; B for Borders, NT for Number of Turns, and A for Angles.

> Now, look at this example card.

The description of the four variables was the same as for Experiment I (p. 52-53).

> Now, I am going to show a practice slide. Turn over your answer sheets and write down the variables and score them: (1) Borders - similar or dissimilar (pause), (2) Number of Turns - 3 or 18 (pause), (3) Number of Components - 3 or 18 (pause), and (4) Angles - alike or different (pause).

The E instructed Ss to score the four practice slides in four different random orders with the qualification that each of the variables appear once in the first position and once in the last position.

> Turn your answer sheet over. When I say "Ready" you are to look at the screen. The slide will be presented very briefly and then you will have 30 sec. in which to score each of the 4 variables for that slide. At the end of 30 sec. I will say "Ready" and you should again look at the screen. Follow these procedures throughout the presentation of all 20 slides.
>
> Now, I am ready to begin. Please make no comments during the experiment. Make sure that you are writing down each variable and that you are scoring the correct slide number. Ignore the click that the projector makes as it changes slides. The important thing is that when I say "Ready" you look at the screen and wait for the slide to be presented.

CHAPTER IV

RESULTS AND DISCUSSION

The data of Experiments I and II were analyzed by means of an analysis of variance with the data arranged in a 2 x 2 x 2 x 2 factorial design. The data of Experiment III were analyzed by use of Friedman's non-parametric two-way analysis of variance (Siegel, 1956). As the Ss were tested in groups of three, the data of Experiments I and II were analyzed in terms of groups.

Results

Experiment I

The results obtained for Experiment I were as follows (see Table II in which A = AV; B = DAWB; C = NT; and D = NC):

1. None of the stimulus factors achieved significance at the .05 level of confidence.
2. No significant differences were found among groups indicating that the differences among groups were not significantly greater than the inter-subject differences within the groups.

TABLE II

ANALYSIS OF VARIANCE, (EXPERIMENT I)

Source	df	SS	MS	F	P
Subjects	47	35.99	.77		
Groups	15	12.10	.81	1.08	
Within Groups	32	23.89	.75		
Treatments	15	14.90			
A	15	1.17	1.17	1.54	
B	1	.13	.13	.13	
AB	1	.01	.01	.01	
C	1	2.30	2.30	3.03	
AC	1	.63	.63	.83	
BC	1	.13	.13	.17	
ABC	1	3.26	3.26	4.29	<.05
D	1	2.52	2.52	3.32	
AD	1	.02	.02	.03	
BD	1	.52	.52	.68	
ABD	1	1.02	1.02	1.34	
CD	1	.08	.08	.11	
ACD	1	.58	.58	.76	
BCD	1	.33	.33	.43	
ABCD	1	.92	.92	1.21	
ERROR	705	198.69	.28		
Error (a)	225	171.70	.76	15.20	<.001
Error (b)	480	26.99	.05		
TOTAL	767	248.24			

3. The only significant source of variance lay in a second-order interaction (AV x DAWB x NT; see Fig. 9).

4. Error a (Groups x Treatments) was highly significant, indicating that the grouping of Ss accounted for a large portion of the variance in this experiment. Error b is the Ss within Groups x Treatments interaction. As Error a was significant it was used for the within-subjects tests.

To assess practice effects the number of errors for the first four test slides was compared with the number of errors for the last four test slides by means of a t-test. The obtained t-value (t = 3.053, df = 94, p = < .01) indicated a change in accuracy between the first and fourth quartile. The greater number of errors was made in the fourth quartile. This suggests that the practice trials were sufficient to preclude practice and/or learning effects. The higher incidence of errors found in the fourth quartile indicates that fatigue effects were possibly operating.

Experiment II

The results obtained for Experiment II were as follows (see Table III):

1. None of the stimulus factors or interactions achieved significance at the .05 level of confidence.

2. Again, as in # 3 above, the Groups x Treatments variance (Error a) accounted for a large portion of the variance.

TABLE III

ANALYSIS OF VARIANCE, (EXPERIMENT II)

Source	df	SS	MS	F	P
Subjects	17	51.64			
Groups	5	4.50	.90		
Within Groups	12	47.14	3.93		
Treatments	15	4.89			
A	1	1.68	1.68	1.36	
B	1	.35	.35	.28	
AB	1	.35	.35	.28	
C	1	.06	.06	.05	
AC	1	.12	.12	.10	
BC	1	.35	.35	.28	
ABC	1	.01	.01	.01	
D	1	0	0	0	
AD	1	.01	.01	.01	
BD	1	.35	.35	.28	
ABD	1	1.13	1.13	.92	
CD	1	.06	.06	.05	
ACD	1	.35	.35	.28	
BCD	1	.06	.06	.05	
ABCD	1	.01	.01	.01	
ERROR	255	107.02	.42		
Error (a)	75	91.90	1.23	15.37	<.001
Error (b)	180	15.12	.08		
TOTAL	287	163.50			

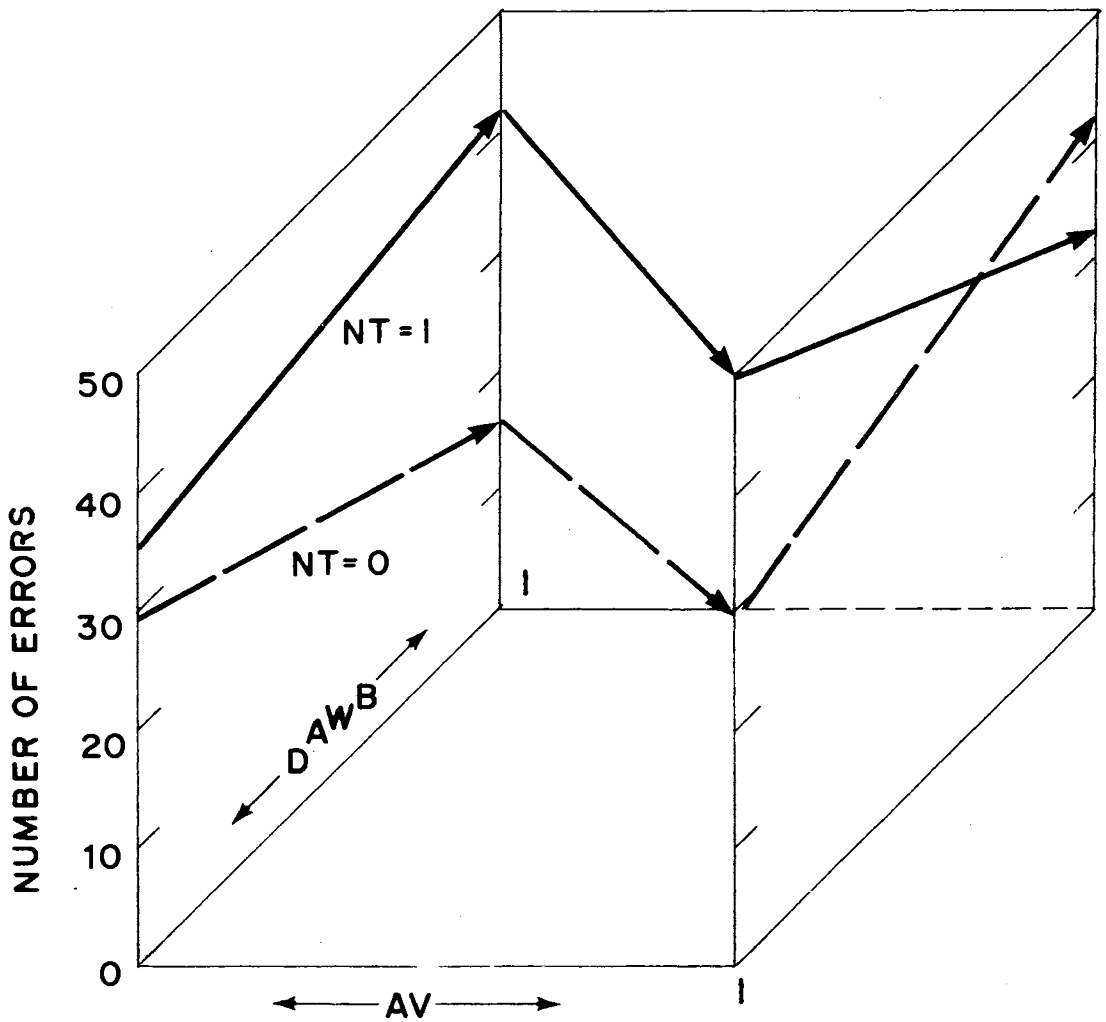


Figure 9. Diagram of the Second-Order Interaction

Since it was significant, it was again used for the within-subjects tests.

Comparison of Experiment I and Experiment II

Experiment II differed from Experiment I in that S was forced to score the variables in the order in which they appeared on the answer sheet. In Experiment I S was free to score the variables in any order he chose. The data obtained in Experiments I and II are graphically depicted in Figure 10.

Brown's (reviewed on page 18) concurrent and interpolated forgetting effect in the immediate memory span would account for the greater number of errors for Experiment II. Subjects, when forced to score variables in a particular order can not utilize their past experience for organizing perceptions (easiest first or hardest first) in memory; therefore, there would be more concurrent interference (i.e., attempts to retain that which is to be remembered) moreover, the first variable scored would interfere with the other variables to be recalled (interpolated forgetting).

Siegel (1956) suggested that when two independent samples are used and an homoscedastic distribution of errors cannot be assumed, the Chi-square is the appropriate statistic. A Chi-square between mean errors for all variables at both levels was therefore performed. The results are graphically depicted in Figure 10. It was predicted that the

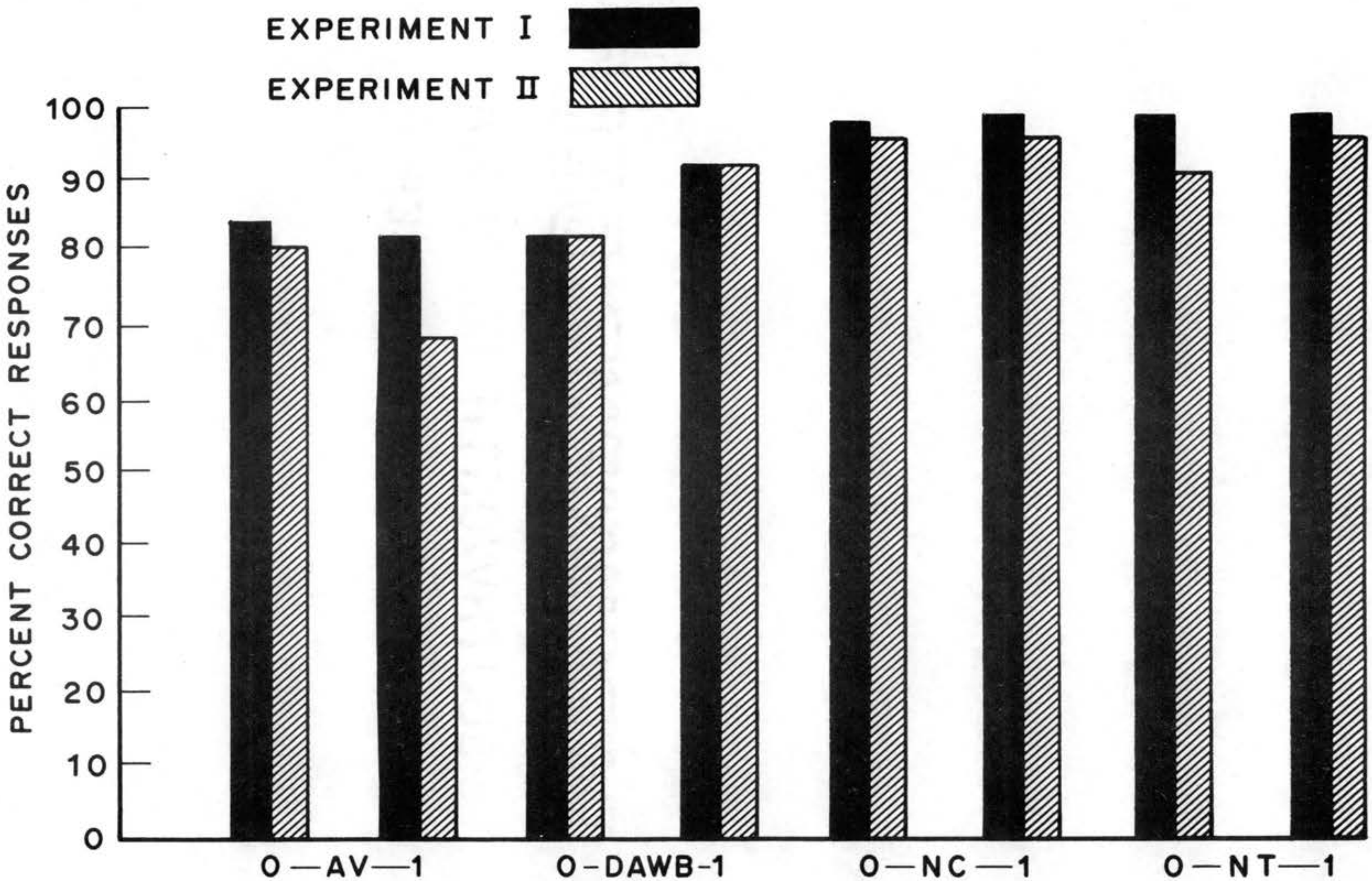


Figure 10. Comparison of the Results of Experiment I and Experiment II

forced-order scoring used in Experiment II would yield more errors across all properties than would the scoring procedure used in Experiment I. The obtained results were in the predicted direction. Angular variance at the high level and NT at the low level were significant ($p < .01$; see discussion).

Experiment III

The results obtained for Experiment III, when analyzed by Friedman's non-parametric two-way analysis of variance, indicated that the Ss' preferred order of scoring did not differ significantly from a chance order of scoring (see Appendix B).

DISCUSSION

Although the results of the present experiments do not clearly answer the questions presented, much was learned which should facilitate further research in visual perception using a memory approach.

The significant AV x DAWB x NT interaction may be explained in information-theory terms (see Fig. 9). For all combinations of AV and DAWB, with the exception of AV=1 and DAWB=1 as NT increased the number of errors decreased. A pattern exemplifying the latter finding may be seen in Figure 3 on page 39 with NC=0. Before going into a discussion of this interaction it will be necessary to define operationally "redundancy". In a recent article, Evans (1967) points out two diametrically opposed uses of the concept of redundancy. "Schematic" redundancy (used by Attneave, 1954, and Hochberg and McAllister, 1953) refers to repetition in a pattern of certain aspects common to all of the patterns, therefore, simpler patterns have more redundancy. "Discrimination" redundancy (used by Garner, 1962) suggests that by limiting the schematic redundancy or repetition within a pattern the correction set or number of alternatives is decreased. An example differentiating between the two types of redundancy taken from Evans (p. 104), with schematic redundancy in the left column and discrimination redundancy in the right column:

WA 5-3172	872-3185
WA 5-7393	296-2618
WA 5-8286	513-2366

It will be noted in the right column that only two numbers are needed to discriminate that the numbers in that column are different. Therefore, complex patterns increase discriminability and are more redundant. The fact that errors decreased with NT=1 at AV=1 and DAWB=1 may be due to increased discrimination redundancy. One of the difficulties in dealing with these patterns mentioned by the Ss (discussed on page 70) was that figures with NT=1 and AV=0 (see Fig. 2) looked more like circles and should be scored NT=0. It is quite apparent in comparing Figures 2 and 3 that NT is much easier to discriminate with AV=1. Also, several Ss had difficulty understanding the instructions for DAWB. The width of borders for this variable appeared to vary at the point of curvature where the lines come together. Subjects had difficulty understanding the DAWB meant a comparison among figures within a slide, not a comparison of the width of border within one figure. This difficulty was especially apparent with the elongated triangles (see Fig. 4). With DAWB=1 discrimination redundancy would be increased as there would be more elements differing within that pattern. With AV=1, NT=1 and DAWB=1 it is possible that the fewer errors for NT=1 was due to the greater information contained in the stimulus patterns and, hence, their increased discriminability from test slides containing AV=0 and DAWB=0. (Attneave, 1957, and Hochberg & McCallister, 1953, indicate that the greatest information is contained at points of intersection and curvature.)

Number of turns has proven to be a valuable predictor in perceptual and attentional research (Hochberg & McAllister, 1953; Attneave, 1957; Brown & Farha, 1966). In addition to the possible difficulty in discrimination mentioned above, the failure of this factor to reach significance in the predicted direction (i.e., fewer errors for the high level of NT) may be due to the Ss' difficulty in accepting the instructions defining this variable (see below for a discussion of sampling difficulties). The failure of both NC and NT to reach significance may also be explained on the basis by the 10 sec. exposure-time which may have been too long to differentiate between levels of these variables; very few errors were made on either stimulus factor, however, the selection at the .10 sec. exposure-time was based on the literature and pilot work. To evaluate the pertinence of these factors to perceptual research utilizing a memory design it may be necessary to design research using shorter exposure times. Further research is needed utilizing both longer and shorter exposure times.

Pilot work indicated that no significant effect due to grouping Ss should be expected. This, along with the large number of investigators in perceptual research who utilize groups instead of testing individuals, led the present investigator to test Ss in groups of three. In retrospect, the difference in sampling procedures might account for the differences between the results of the pilot work and those of the experiments reported here. In the pilot study students were solicited from the halls of the University and from the coffee shop. In the actual experiments a sheet of paper was passed among students of general psychology courses with testing times listed. The Ss were permitted to sign up at whatever time was most convenient for them. There was an obvious tendency for friends to sign up for the same time. There is a unique population of students at Huntsville Campus, mainly older engineering students involved in the aerospace industry and transfer students from the main campus of the University of Alabama. Students majoring in the engineering sciences had difficulty accepting instructions differentiating the levels of AV. Students majoring in liberal arts felt that the 12-sided figures (NT=1) were more like circles and should therefore be scored as NT=0. Many Ss had critical comments concerning the definition of the variables. It was impossible to devise instructions to satisfy both groups. Intelligence factors may also have been playing a significant role. These subject variables may very well account for the large grouping effects.

Further procedural difficulties can be found in comparison of Experiment I and Experiment II. Those variables most influenced by a change in instructions were AV and NT, i.e., more errors were made by Ss on these variables in Experiment II (see Fig. 10).

In Experiment I Ss were free to score the variables in any order they chose. In Experiment II the Ss were forced to score in the order disignated on the answer sheets. When Ss were free to score the variables past experience may have played a significant part, for they may have scored either the perceived "easiest" variable first or the perceived "hardest variable first (so they would not forget). The forced-order scoring in Experiment II had some effect on all of the variables with the exception of DAWB. The failure of DAWB to yield more errors in Experiment II could be expected as DAWB was not perceived as the "easiest" or "hardest" variable. The data collected for the third experiment lends some support to this explanation. Although the results of Experiment III did not achieve significance, the data were in the predicted direction. Number of components was considered the easiest variable to remember (with NT considered the second easiest), as evidenced by the fewer number of errors on these factors and as reported by the Ss. Angular variance was considered the most difficult variable on the basis of number of errors and Ss reporting. Almost half of the Ss (5 out of 12) preferred to score NC first and 25% preferred to score AV first. In Experiment II almost half of the Ss would have chosen to score NC first (8 out of 18) and 25% of the Ss would have scored AV first (see raw data for Experiments II and III in Appendix B). Therefore, it appears as if Ss recall from immediate memory is influenced by their "innate" or learned preference for coping with things to be remembered. If a S prefers to recall the "easiest" variable first and is prevented from doing so by forced-order scoring the interpolated recall of the other variables is going to lead to more errors on the "easiest" variable, as the Ss not only has to remember the visual pattern but he also has to remember in what order he is to score the variables.

Brown's (1954, reviewed on page 18) concurrent and interpolated forgetting effect in the immediate memory span would account for the greater number of errors for Experiment II. Subjects, when forced to score variables in a particular order can not utilize their past experience for organizing perceptions (easiest first or hardest first) in memory; therefore, there would be more concurrent interference (i.e., attempts to retain that which is to be remembered) moreover, the first variable scored would interfere with the other variables to be recalled (interpolated forgetting).

Many investigators have reported that the order-of-reporting effect is due to memory and response factors rather than to perception itself (Averbach & Coriell, 1961; Brown, 1954; 1958; 1960; Karlin & Brennan, 1957; Lawrence & Coles, 1954; Lawrence & LaBerge, 1956, Long et al, 1960). The theoretical argument involved can be condensed and stated as follows: . When a visual pattern is presented to a S, are errors in perception of that pattern due to: (a) a failure of the organism's physical preceptual mechanism to incorporate all of the pattern; or, (b) forgetting processes, assuming the entire visual "picture" has been transmitted to the visual storage system of the central nervous system? Hubel and Wiesel (1962) found cortical neurons in cats which responded to specific patterns of retinal stimulation but these elementary pattern-detectors have not yet been demonstrated in humans. If similar mechanisms can be found in man, concepts of perceptual selectivity, perceptual set, etc. may be fruitful, but until such time a discussion of perceptual storage or memory factors would appear to be more parsimonious as they do not require explanatory physiological mechanisms. Further research may indicate that perception is a function of both processes.

Further research using these four variables may indicate that AV and DAWB account for more errors than NC and NT. It will be necessary in an immediate-memory design to establish base lines of S's performance with these variables before fruitful comparisons can be made between levels of these variables. As mentioned previously, Ss reported that NC and NT were the easiest variables; therefore, it seems consistent to predict that Ss would make fewest errors on NC and NT, as they would attend first or recall (due to past experience) these properties first. Research evidence (Teichner, et al, 1961) indicates that Ss, either implicitly or explicitly, catagorize visual objects in terms of numbers. Also, those points on the contours at which turns occur are locations with the highest information content. Reporting of, or attending to these properties might then preclude the recall of AV and DAWB. Other research (Fitts & Biederman, 1965; Neisser, 1963) suggests that it is possible to train Ss to vary the order of examination of dimensions in memory. Further research using these variables should include some measure of the S's preferences, whether learned or "innate" for organizing visual percepts.

CHAPTER V

SUMMARY AND CONCLUSIONS

Three experiments were designed to investigate the effects of four physical parameters of visual patterns on human attention. The patterns were constructed, placed on slides, and presented tachistoscopically to subjects. The parameters were: angular variance, dissimilarity of average width of border, number of turns, and number of components. Recall of these variables was used as the measure of attention.

Forty-eight male undergraduate students were tested in Experiment I. The data were analyzed by means of 2 x 2 x 2 x 2 analysis of variance. The only significant result was a second-order interaction. A t-test comparing the performance on the first four test slides with that on the last four test slides ruled out practice effects, but indicated fatigue effects were possibly operating.

As it was observed in the first experiment that the subjects did not follow the order of scoring designated on the answer sheets, Experiment II was performed to measure the effect of forced-order scoring. Eighteen male undergraduates served as subjects. All errors for the four factors were in the same direction as Experiment I. Again, however none of the variables achieved statistical significance.

The Chi-square statistic, comparing the results of the two experiments, indicated that the forced-order scoring had a significant depressing effect on performance both for angular variance at the high level and number of turns at the low level. The prediction that forced-order scoring would yield more errors was therefore partially supported.

Experiment III was performed to determine what order subjects would score the variables if they were free to score them in any order they chose. Utilizing a Friedman non-parametric two-way analysis of variance the results indicated that the subjects'preferred order did not vary significantly from chance, although the data were in the direction predicted on the basis of Experiments I and II.

It may be assumed on the basis of other investigations and the present data that number of components is attended to first and remembered best with number of turns(sides) occupying second place, as the fewest errors were made on these factors. Angular variance and dissimilarity of average width of border accounted for the greatest portion of errors in the present experiments. Nothing can be stated on the basis of the present data concerning the "directional effect" of these four parameters, i.e., what level of the factors account for the greatest portion of errors.

A comparison of the results in Experiment I and Experiment II supports Lawrence and LaBerge (1956) in that the order of scoring the variables had a significant effect on the number of recall errors made. The order effect is believed to be due to memory and response factors rather than perceptual factors.

The practice of testing in groups, for visual perceptual research at least, was questioned. Further research was suggested using both shorter and longer exposure times. Methods for more adequate sampling were also discussed. The major value of the present research has probably been heuristic in nature; many implications and suggestions for further research were generated.

BIBLIOGRAPHY

Arnoult, M. D. Transfer pre-differentiation training in simple and multiple shape discrimination. J. exp. Psychol., 1953, 45, 401-409.

Arnoult, M. D. Prediction of perceptual responses from structual characteristics of the stimulus. Percept. Mot. Skills, 1960, 11, 261-268.

Attneave, F. Some informational aspects of visual perception. Psychol. Rev., 1954, 61, 183-193.

Attneave, F. Symmetry, information and memory for patterns. Amer. J. Psychol., 1955, 68, 209-222.

Attneave, F. and Arnoult, M. D. The quantative study of shape and pattern perception. Psychol. Bull., 1956, 53, 452-471.

Attneave, F. Physical determinants of the judged complexity of shapes. J. exp. Psychol., 1957, 53, 221-227.

Averbach, Emanuel and Coriell, A. S. Short-term memory in vision. Bell. Sys. tech. J., 1961, 40, 309-328.

Beaver, W. and Brown, L. T. The influence of visual complexity important to attentional behavior. Paper read at Okla. State Psychol. Assn., Oklahoma City, October, 1963.

Berlyne, D. E. Conflict, arousal and curiosity. New York: McGraw-Hill, 1960.

Boring, E. G. Attribute and sensation. Amer. J. Psychol., 1924, 35, 301-304.

Broadbent, D. E. A mechanical model for human attention and immediate memory. Psychol. Rev., 1957, 64, 205-215.

Broadbent, D. E. Perception and communication. London: Pergamon Press, 1958.

Broadbent, D. E. Invited address: Common principles in perception, reaction and intellectual decision. (ed) Geldard, Defence Psychol., London: Pergamon Press, 1962, 197-206.

Brown, D. R., Hitchcock, L., Jr. and Michels, K. M. Quantative studies in form perception: An evaluation of the role of selected stimulus parameters in the visual discrimination performance of human subjects. *Percept. Mot. Skills*, 1962, 14, 519-529.

Brown, J. L. The nature of set-to-learn and of intramaterial interference in immediate memory. *Quart. J. exp. Psychol.*, 1954, 6, 141-148.

Brown, J. L. Some tests of the decay theory of immediate memory. *Quart. J. exp. Psychol.*, 1958, 10, 12-21.

Brown, J. L. Evidence for a selective process during perception of tachistoscopically presented stimuli. *J. exp. Psychol.*, 1960, 59, 176-181.

Brown, J. L. Time required for detection of acuity targets following exposure to short adapting flashes. *J. engr. Psychol.*, 1964, 3, 53-71.

Brown, L. T. Quantitative description of visual patterns: Some methodological suggestions. *Percept. Mot. Skills*, 1964, 19, 771-774.

Brown, L. T. and Farha, W. Some physical determinants of viewing time under three instructional sets. *Percept. & Psychophys.*, 1966, 1, 2-4.

Brown, L. T. and O'Donnell, C. R. The attentional response of humans and squirrel monkeys to visual patterns varying in three physical dimensions. *Percept. Mot. Skills*, 1966, 22, 707-717.

Bruce, R. H. and Low, F. N. The effect of practice with brief exposure techniques upon central and peripheral visual acuity and a search for a brief test of peripheral acuity. *J. exp. Psychol.*, 1951, 41, 275-280.

Chapman, D. W. Relative effects of determinate and indeterminate Aufgaben. *Amer. J. Psychol.*, 1932, 44, 163-174.

Deutsch, J. A. and Deutsch, D. Attention: Some theoretical considerations. *Psychol. Rev.*, 1963, 70, 80-90.

Epstein, W. and Rock, I. Perceptual set as an artifact of recency. *Amer. J. Psychol.*, 1960, 73, 214-228.

Evans, S. H. Redundancy as a variable in pattern perception. *Psychol. Bull.*, 1967, 67, 104-113.

Fitts, P. M. and Biederman, I. S-R compatibility and information reduction. J. exp. Psychol., 1965, 69, 408-412.

French, R. S. Identification of dot patterns from memory as a function of complexity. J. exp. Psychol., 1954, 47, 22-26.

Garner, W. R. Uncertainty and structure as psychological concepts. New York: Wiley, 1962.

Gibson, J. J. The perception of the visual world. Boston: Houghton-Mifflin, 1950.

Hochberg, J. and McAllister, E. A quantative approach to figural "goodness". J. exp. Psychol., 1953, 46, 361-364.

Hoisington, L. B. and Spencer, Carol. Specific set and the perception of subliminal material. Amer. J. Psychol., 1958, 71, 263-269.

Hubel, D. H. and Wiesel, T. N. Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. J. Physiol., 1962, 160, 106-154.

Karlin, L. and Brennan, G. Memory for visual figures by the method of identical stimuli. Amer. J. Psychol., 1957, 70, 248-252.

Kaswan, Jacques and Young, S. Stimulus exposure time, brightness, and spatial factors as determinants of visual perception. J. exp. Psychol., 1963, 65, 113-123.

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

Lawrence, D. H. and coles, G. R. Accuracy of recognition with alternatives before and after the stimulus. J. exp. Psychol., 1954, 47, 208-214.

Lawrence, D. H. and LaBerge, D. L. Relationship between recognition accuracy and order of reporting stimulus dimensions. J. exp. Psychol., 1956, 51, 12-18.

Long, E. R., Reid, S. and Henneman, R. H. An experimental analysis of set variables influencing the identification of ambiguous, visual stimulus-objects. Amer. J. Psychol., 1960, 73, 553-572.

Lovejoy, E. P. An analysis of the overlearning reversal effect. Psychol. Rev., 1965, 72, 87-103.

Kendler, T. S. and Kendler, H. H. Reversal and nonreversal shifts in kindergarten children. J. exp. Psychol., 1959, 58, 55-60.

Krechevsky, I. A study of the continuity of the problem-solving process. Psychol. Rev., 1938, 45, 107-133.

Mackintosh, N. J. Selective attention in animal discrimination learning. Psychol. Bull., 1965, 64, 124-150.

Michels, K. M., Pittman, Gene G., Hitchcock, L., Jr. and Brown, D. R. Visual discrimination: Tree squirrels and quantified stimulus dimensions. Percept. Mot. Skills, 1962, 15, 443-450.

Michels, K. M. and Zusne, L. Metrics of visual form. Psychol. Bull., 1965, 63, 74-86.

Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychol. Rev., 1956, 63, 81-97.

Mooney, C. M. Recognition of ambiguous and unambiguous visual configurations with short and longer exposures. Brit. J. Psychol., 1960, 51, 119-125.

Morgan, C. T. Physiological Psychology. (3rd ed.) New York: McGraw-Hill, 1965.

Niesser, U. Decision time without reaction time: Experiments in visual scanning. Amer. J. Psychol., 1963, 76, 376-385.

Operating Manual, How to use your type PR-1 exposure meter, General Electric, West Lynn, Mass.

Postman, L. and Bruner, J. S. Multiplicity of set as a determinant of perceptual behavior. J. exp. Psychol., 1949, 39, 369-377.

Richard, J. F. Influence of response discriminability. J. exp. Psychol., 1965, 69, 30-34.

Siegel, S. Nonparametric statistics. New York: McGraw-Hill, 166-173.

Spence, K. W. Behavior theory and learning. Englewood Cliffs: Prentice-Hall, 1960.

Sprague, R. L. Effects of differential training on tachistoscopic recognition thresholds. *J. exp. Psychol.*, 1959, 58, 227-231.

Sutherland, N. S. Stimulus analyzing mechanisms. In, *Proceedings of a symposium on the mechanization of thought processes.* Vol. 2. London: Her Majesty's Stationery Office, 1959, 575-609.

Teichner, W. H., Reilly, R. and Sadler, E. Effects of density on identification and discrimination in visual symbol perception. *J. exp. Psychol.*, 1961, 61, 494-500.

Teichner, W. H. and Sadler, E. Effects of exposure time and density on visual symbol identification. *J. exp. Psychol.*, 1962, 63, 376-380.

Webster's New Collegiate Dictionary, Cambridge: G. & C. Merriman Co., 1961, 864.

Wyckoff, L. B., Jr. The role of observing responses in discrimination learning. Part I, *Psychol. Rev.*, 1952, 59, 431-442.

Zeaman, D. and House, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (ed.) *Handbook in mental deficiency: Psychological theory and research.* New York: McGraw-Hill, 1963, 159-223.

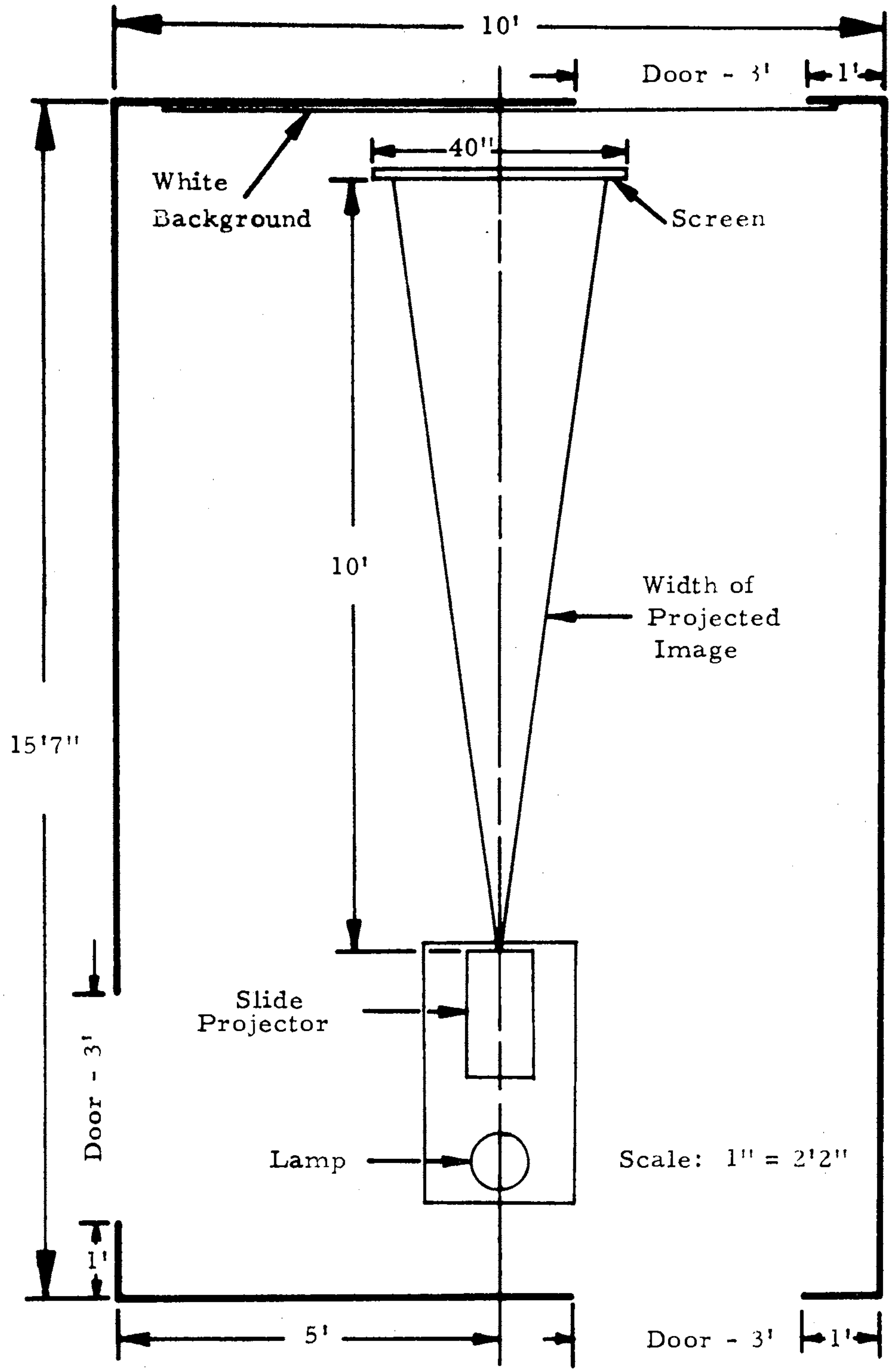
Zusne, L. and Michels, K. M. Geometricity of visual form. *Percept. Mot. Skills*, 1962, 14, 147-154. (a)

Zusne, L. and Michels, K. M. More on the geometricity of visual form. *Percept. Mot. Skills*, 1962, 15, 55-58.

Zusne, L. and Michels, K. M. Nonrepresentational shapes and eye movements. *Percept. Mot. Skills*, 1964, 18, 11-20.

Zusne, L. Moments of area and of the perimeter of visual form as predictors of discrimination performance. *J. exp. Psychol.*, 1965, 69, 213-220.

APPENDIX A



Schematic Diagram of Test Facilities

Scoring Sheet

	Borders		Turns		Figures		Angles	
	Similar	Dis-similar	3	12	3	18	Alike	Dif-ferent
1.								
2.								
3.								
20.								

MASTER SCORING KEY FOR SLIDES

(0 = Low Level; 1 = High Level)

Slide Number	A(AV)	B(DAWB)	C(NT)	D(NC)
2	0	1	0	1
6	0	1	0	0
11	1	1	0	0
15	0	1	1	1
20	1	1	1	1
21	1	1	0	1
25	1	1	1	0
31	0	1	1	0
1-5-7	0	0	0	0
3-4-19	0	0	0	1
8-16-30	0	0	1	0
9-10-13	1	0	0	0
12-14-18	0	0	1	1
22-23-17	1	0	0	1
24-26-32	1	0	1	0
27-28-29	1	0	1	1

APPENDIX B

EXPERIMENT I

FACTORIAL DATA - BY GROUPS

Group	Treatments 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Sum
1	0	1	0	0	0	0	1	1	0	0	1	0	2	0	0	0	6
2	2	0	4	0	0	0	5	1	1	3	2	1	3	2	0	2	26
3	0	1	0	0	1	0	1	0	1	1	2	1	2	2	3	2	17
4	0	0	2	0	0	0	1	0	2	2	1	1	3	2	1	1	16
5	0	0	1	0	0	0	1	0	0	0	2	0	0	0	2	0	6
6	1	1	1	1	1	0	0	0	0	0	3	3	1	0	1	0	13
7	1	2	0	4	1	1	4	0	1	1	3	3	3	0	0	1	25
8	0	4	0	1	0	1	3	1	0	1	3	3	3	2	0	1	23
Sum	4	9	8	6	3	2	16	3	5	8	17	12	17	8	7	7	132

EXPERIMENT I (continued)

Group	Treatments 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Sum
9	0	0	2	0	0	0	3	1	1	2	2	0	3	1	0	1	16
10	0	1	2	0	1	1	0	0	0	1	1	1	1	1	0	2	12
11	2	4	1	3	2	0	3	3	2	0	1	1	1	1	2	1	27
12	1	0	1	1	1	0	4	3	1	1	3	1	0	1	1	1	20
13	2	0	0	0	1	1	0	0	2	1	2	2	4	1	1	1	18
14	2	0	3	2	1	0	1	1	2	2	0	0	1	0	1	2	18
15	2	0	1	0	2	1	1	1	1	0	2	0	0	1	1	1	14
16	1	1	1	3	0	1	2	0	1	0	3	0	1	0	1	2	17
Sum	10	6	11	9	8	4	14	9	10	7	14	5	11	6	7	11	142
Total	14	15	19	15	11	6	30	12	15	15	31	17	28	14	14	18	274

EXPERIMENT I

FACTORIAL EXPERIMENTAL DATA -

RESPONSE, NUMBER OF ERRORS

				A 0		A 1		Sum
				B		B		
				0	1	0	1	
C	0	D	0	14	10	15	28	57
			1	15	6	14	14	49
	1	D	0	17	30	31	14	92
			1	18	12	18	18	66
Sum				64	58	78	74	274

EXPERIMENT II

FACTORIAL DATA - BY GROUPS

	Treatments																
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Sum
1	0	0	1	0	0	2	1	1	2	3	1	2	3	2	2	0	20
2	0	0	0	0	1	4	1	1	1	3	0	3	2	2	0	4	22
3	3	2	2	3	1	1	1	1	1	3	3	3	2	2	1	0	29
4	3	1	5	1	2	1	3	2	2	2	4	5	2	2	1	1	37
5	0	1	1	2	1	1	1	1	3	0	1	0	3	1	3	1	20
6	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	4
Sum	6	5	9	6	6	10	7	6	9	11	9	13	12	9	8	6	132

EXPERIMENT II

FACTORIAL EXPERIMENTAL DATA - RESPONSE, NUMBER OF ERRORS

				A 0, B 0	A 0, B 1	A 1, B 0	A 1, B 1	Sum
C	0	D	0	6	6	9	12	33
			1	5	10	11	9	35
	1	D	0	9	7	9	8	33
			1	6	6	13	6	31
Sum				26	29	42	35	132

EXPERIMENT II

Raw Data for Preferred Scoring

n = 18

Order of Scoring*

Ss	I	II	III	IV
1	3	4	2	1
2	4	2	1	3
3	4	3	1	2
4**	4	2	1	3
5**	1	2	3	4
6**	4	2	1	3
7	4	3	1	2
8**	2	3	4	1
9**	1	2	3	4
10	3	4	1	2
11	1	2	3	4
12	4	3	1	2
13	4	3	1	2
14**	1	2	3	4
15**	2	3	4	1
16	1	3	2	1
17	2	1	3	4
18	2	3	4	1

* AV = 1
DAWB = 2
NT = 3
NC = 4

** Preferred same scoring as during testing session

EXPERIMENT III

Raw Data for Preferred Scoring
n = 12

Order of Scoring*

Ss	I	II	III	IV
1	4	1	2	3
2	4	1	3	2
3	4	1	3	2
4	2	3	4	1
5	2	1	3	4
6	2	4	3	1
7	1	2	4	3
8	1	4	3	2
9	1	4	2	3
10	4	3	1	2
11	4	3	1	2
12	1	2	4	3

* AV = 1
DAWB = 2
NT = 3
NC = 4

VITA

Daun Hackett Adams

Candidate for the Degree of

Doctor of Philosophy

Thesis: SOME PHYSICAL DETERMINANTS OF ATTENTIONAL BEHAVIOR: A MEMORY APPROACH

Major Field: Psychology

Biographical:

Personal Data: Born in Western Mills, New York, January 13, 1939, the daughter of John Maynard and Elnor White Hackett; wife of David Michael Adams; mother of one daughter, DeKristie Marie Adams.

Education: Attended grade school at Ceres, and Bolivar, New York, Russellville, Missouri; graduated from Springfield Township High School, Holland, Ohio, in 1955; received college credit from the University of Toledo, Toledo, Ohio, Concord College, Athens, West Virginia, Florida State University, Tallahassee, Florida, and received the Bachelor of Science degree from Oklahoma State University, Stillwater, Oklahoma, in May, 1962, with a major in psychology; received the Master of Science degree from Oklahoma State University, Stillwater, Oklahoma, in May, 1964, with a major in psychology; completed requirements for the Doctor of Philosophy degree from Oklahoma State University in May, 1967.

Professional Experience: Worked at Parsons State Hospital and Training Center, Parsons, Kansas, as a Psychologist-Trainee from June, 1963, until August, 1963; taught at Oklahoma State University as a graduate assistant from September, 1964, until January, 1965, and as an Instructor of Psychology at the University of Alabama from September, 1965, until February, 1966; presently a Consulting Psychologist at the Madison County Mental Health Clinic, Huntsville, Alabama, from April, 1965.

Professional Organizations: Member of the American Psychology Association; the Alabama Psychology Association; and Psi Chi, National Honorary Society in Psychology.