INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in "sectioning" the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.

University Microfilms International

300 N ZEER ROAD, ANN ARBOR, MI 48106
18 BEDFORD ROW, LONDON WC1R 4EJ, ENGLAND
POWELL, NANCY JANE

SPATIAL REPRESENTATION IN VISUAL IMAGERY AND PERCEPTION
FROM A REAL OBJECT DISPLAY AND A PHOTOGRAPHIC SLIDE

The Ohio State University

Ph.D. 1980

University
Microfilms
International
300 N. Zeeb Road, Ann Arbor, MI 48106

18 Bedford Row, London WC1R 4EJ, England
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark ✓.

1. Glossy photographs ✓
2. Colored illustrations ✓
3. Photographs with dark background ✓
4. Illustrations are poor copy ✓
5. Print shows through as there is text on both sides of page ✓
6. Indistinct, broken or small print on several pages ✓ throughout
7. Tightly bound copy with print lost in spine ✓
8. Computer printout pages with indistinct print ✓
9. Page(s) ✓ lacking when material received, and not available from school or author ✓
10. Page(s) ✓ seem to be missing in numbering only as text follows ✓
11. Poor carbon copy ✓
12. Not original copy, several pages with blurred type ✓
13. Appendix pages are poor copy ✓
14. Original copy with light type ✓
15. Curling and wrinkled pages ✓
16. Other
SPATIAL REPRESENTATION IN VISUAL IMAGERY AND PERCEPTION
FROM A REAL OBJECT DISPLAY AND A PHOTOGRAPHIC SLIDE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Nancy Jane Powell, B.S., M.F.A.

* * * * *

The Ohio State University
1980

Reading Committee:
John Belland, Ph.D.
Marlin Languis, Ph.D.
Dean Owen, Ph.D.

Approved By

[Signature]
Adviser
Education: Foundations and Research
ACKNOWLEDGMENTS

I wish to express my sincerest appreciation to the following persons for their involvement in this research effort:

- Dr. Stephen M. Kosslyn, Harvard University, for his encouragement.

- Dr. Steven Pinker, Massachusetts Institute of Technology, for sharing his ideas.

- the members of my Advisory Committee, Dr. John Belland, Dr. Marlin Languis, Dr. Dean Owen, for their continued support.

- Terrence Flaig for his assistance with the recording equipment and audio recording.

- Wesley Metz for his assistance with the construction of the apparatus.

- June Hahn, Statistics Consultant, Department of Psychology, Ohio State University, for her help with the data analysis.
VITA

July 14, 1943 ...................... Born - Massillon, Ohio

1961-1966 ....................... B.S., Occupational Therapy
Ohio State University

1966-1972 ....................... Staff Occupational Therapist
Cerebral Palsy School,
Belleville, New Jersey; and
Herrick Hospital, Berkeley,
California

1972-1974 ....................... M.F.A., San Francisco Art
Institute, San Francisco,
California

1975-1976 ....................... Graduate Research Associate,
National Center for Educational
Media and Materials for the
Handicapped, Ohio State
University

1976-1978 ....................... Graduate Research Associate,
Nisonger Center for Mental
Retardation and Developmental
Disabilities, Ohio State
University

1978-1980 ....................... Graduate Research Associate,
Teacher Education Lab,
College of Education,
Ohio State University

FIELD OF STUDY

Major Field: Educational Media and Communications
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>VITA</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF PLATES</td>
<td>ix</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. STATEMENT OF THE PROBLEM</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Research Problem</td>
<td>3</td>
</tr>
<tr>
<td>Definition of Imagery</td>
<td>4</td>
</tr>
<tr>
<td>Objectives</td>
<td>5</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>5</td>
</tr>
<tr>
<td>Discussion of Objectives and Hypothesis</td>
<td>6</td>
</tr>
<tr>
<td>Organization of the Report</td>
<td>7</td>
</tr>
<tr>
<td>II. LITERATURE REVIEW</td>
<td>8</td>
</tr>
<tr>
<td>Imagery</td>
<td>8</td>
</tr>
<tr>
<td>Individual Differences in Imagery</td>
<td>22</td>
</tr>
<tr>
<td>Pictorial Theory</td>
<td>26</td>
</tr>
<tr>
<td>Imagery and Education</td>
<td>37</td>
</tr>
<tr>
<td>Summary</td>
<td>42</td>
</tr>
<tr>
<td>III. METHOD</td>
<td>44</td>
</tr>
<tr>
<td>Introduction</td>
<td>44</td>
</tr>
<tr>
<td>Subjects</td>
<td>46</td>
</tr>
<tr>
<td>Materials</td>
<td>47</td>
</tr>
<tr>
<td>Procedures</td>
<td>49</td>
</tr>
<tr>
<td>IV. DATA ANALYSIS</td>
<td>56</td>
</tr>
<tr>
<td>Imagery Scanning Task</td>
<td>56</td>
</tr>
<tr>
<td>Perceptual Distance Estimation Task</td>
<td>68</td>
</tr>
<tr>
<td>Individual Differences</td>
<td>71</td>
</tr>
<tr>
<td>Summary</td>
<td>77</td>
</tr>
</tbody>
</table>

iv
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>80</td>
</tr>
<tr>
<td>Objectives and Conclusions</td>
<td>80</td>
</tr>
<tr>
<td>Recommendations for Future Research</td>
<td>83</td>
</tr>
<tr>
<td>Discussion</td>
<td>88</td>
</tr>
<tr>
<td>LIST OF REFERENCES</td>
<td>100</td>
</tr>
<tr>
<td>APPENDIXES</td>
<td></td>
</tr>
<tr>
<td>A. Figures</td>
<td>107</td>
</tr>
<tr>
<td>B. Testing Instruments</td>
<td>124</td>
</tr>
<tr>
<td>C. Data Collection Instruments</td>
<td>133</td>
</tr>
</tbody>
</table>
LIST OF TABLES

1. Correlations between Mean Scanning Times and 3-D and 2-D Interobject Distances for the Real and Photo Groups .................................................. 57
2. Correlations between Mean Scanning Times and 3-D and 2-D Interobject Distances for Stimulus Groups by Subgroups ........................................... 63
3. Correlations between Mean Scanning Times and 3-D and 2-D Interobject Distances for Subgroups by Stimulus Groups .................................................. 63
4. Mean False Scan Times ................................................................. 64
5. Scanning Rates in Msec/Cm for 3-D and 2-D Distances by Stimulus Group ........................................................................................................... 67
6. Correlations between Mean Perceptual Distance Estimations and 3-D and 2-D Interobject Distances ................................................................. 69
7. Comparison of Correlations in the Imagery Scanning Task and Perceptual Distance Estimation Task by Stimulus Groups and Subgroups ........................................ 70
LIST OF FIGURES

1. Kosslyn's Proto-Model for Imagery ................................. 18
2. Mean Scanning Times for 3-D Interobject Distances for
the Total Real Group .................................................. 108
3. Mean Scanning Times and 2-D Interobject Distances
for the Total Real Group ............................................. 109
4. Mean Scanning Times and 3-D Interobject Distances
for the Total Photo Group ........................................... 110
5. Mean Scanning Times and 2-D Interobject Distances
for the Total Photo Group ........................................... 111
6. Mean Scanning Times and 3-D Interobject Distances for
Scanners and Non-Scanners in the Real Group ................. 112
7. Mean Scanning Times and 2-D Interobject Distances for
Scanners and Non-Scanners in the Real Group ................. 113
8. Mean Scanning Times and 3-D Interobject Distances for
Scanners and Non-Scanners in the Photo Group ............... 114
9. Mean Scanning Times and 2-D Interobject Distances for
Scanners and Non-Scanners in the Photo Group ............... 115
10. Mean Perceptual Estimates and 3-D Interobject
Distances for the Total Real Group ............................... 116
11. Mean Perceptual Estimates and 2-D Interobject Distances
for the Total Real Group ............................................. 117
12. Mean Perceptual Estimates and 3-D Interobject
Distances for the Total Photo Group ............................. 118
13. Mean Perceptual Estimates and 3-D Interobject Distances
for the Total Photo Group ........................................... 119
14. Mean Perceptual Estimates and 3-D Interobject Distances
for Scanners and Non-Scanners in the Real Group ............. 120
15. Mean Perceptual Estimates and 2-D Interobject Distances
for Scanners and Non-Scanners in the Real Group ............. 121
16. Mean Perceptual Estimates and 3-D Interobject Distances for Scanners and Non-Scanners in the Photo Group 122

17. Mean Perceptual Estimates and 2-D Interobject Distances for Scanners and Non-Scanners in the Photo Group 123

18. Visual Media/Cognitive Process Continuum 96
LIST OF PLATES

I. Display Box ................................................. 48
II. Recording Equipment ................................. 48
CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

If memory and perception are the two key branches of cognitive psychology, the study of imagery stands precisely at their intersection. Ulric Neisser (1972, p. 233)

To elaborate on Neisser's words, it is generally accepted by most educators and psychologists today that at sometime during everyone's life, the process of imaging has occurred which links the external environment to thought—or perception to memory. The relative importance of imagery as a cognitive function, however, has been the subject of much debate. Whatever the role assigned to imagery in cognition, most researchers agree that mental images are at least partially influenced, if not totally based on, past percepts of the external world. These past visual percepts can either be first hand, sensory experiences of objects in the environment or a combination of first hand and second hand (mediated) experiences as when pictures (motion or still) are viewed (Gibson 1954, 1971). That is, the first hand perception occurs when the viewer recognizes the stimulus presented as a picture with all the attributes he/she associates with a picture, the surface grain, the frame, etc. The objects within a picture are not actually there as stimuli in the first hand sense; they are only represented in the picture. This can be thought of as mediated or second hand experiences as opposed to experiences registering first hand sensory impressions of real objects. This study will investigate
the relationship of first hand and second hand experiences to mental imagery.

In educational settings today, people are exposed to many slide presentations. Some educators are concerned about what people perceive and carry with them in the form of mental images from these presentations. Recently, researchers with adults (Hagen, 1974) and children (Rohwer, 1970; Pressley, 1978) have been concerned about the influence pictures have in thinking and learning. Photographic representations undoubtedly provide much stimulation for imagery. In our increasingly global society, people often react to images of far-away people, places and events based on visual mental images constructed from pictures. For example, pictorial images of the Vietnam war from magazines and television probably shaped most young American's thinking about the phenomenon of war.

Kosslyn (1973) has pointed out that most of the recent research (See Paivio, 1971) has stressed the functional aspects of imagery; for example, imagery as a mnemonic device (Paivio, 1972; Bower, 1972) or as a cognitive strategy (Huttenlocker and Higgins, 1972). Recently, however, a small but growing research effort in investigating the structure of images (Kosslyn, 1973, 1978a; Cooper and Shepard, 1972) has emerged. This inquiry into the structural nature of images and the comparison of imagery and perceptual structures is an important and unique approach in formulating a comprehensive view of the exact nature, and, ultimately, the function of imagery in human thought. Although we are far away from ascertaining the role of imagery in such cognitive functions as problem solving and creativity, the knowledge of the
structures of images will be an important link to discovering their functions. Thus Kosslyn (1978a), Pinker and Kosslyn (1978), Pinker (1979, in press), and others (Shepard, 1978b) are beginning to amass a body of theory as to the spatial characteristics of images. Pinker and Kosslyn (1978) and Pinker (1979, in press) have found evidence that a three dimensional "workspace" is preserved in images of real object displays. It is the intent of the present study to further this line of inquiry by investigating the spatial structure of images generated from photographic slides.

Research Problem

The present study attempts to describe the nature of visual mental imagery in relation to mediated and nonmediated experience--to see how the stimulus (real or mediated) can affect imagery. To investigate this problem, it is necessary to amalgamate the theories of imagery, media, and pictorial perception. First, in regard to imagery, a structural approach will be taken. The structural element in images to be investigated is the three-dimensional or two-dimensional spatial representation. A correlational study has been devised whereby the spatial characteristics of images can be studied in the mental images of persons who have viewed a display of real objects or who have viewed a photographic slide of an identical display of objects. By measuring the amount of "space" in images derived from these two sources, we can begin to form a theory about the relationship of media (specifically photographic slides) to cognition, and subsequently, to learning.
In regard to media theory, Salomon (1979) has shown in his research that media can have cognitive effects. Specifically, media components can mimic or substitute for cognitive functions (e.g., a zoom shot on television can supplant the cognitive process of relating parts to wholes for certain learners). Included in a theory of media can be, then, that media serves cognition, just as everyday perception serves cognition. In the research undertaken here, the effects of media on cognition are likewise explored, specifically the effects of slides on imagery.

Lastly, a theory of picture perception can contribute to explaining the media-cognition relationship as well. It seems reasonable to describe the percept, in this case a photographic slide, upon which the image might, at least in part, be based. By tying together the past research and theory in the areas of imagery, media, and picture perception, then an important step will be taken in assessing the worth of slides in the learning process as representations of reality and in assessing the role of imagery in cognition.

**Definition of Imagery**

Richardson (1969) proposed a definition which will be adapted slightly for use in this document:

Mental imagery refers to (1) all those quasi-sensory or quasi-perceptual experiences of which (2) we are self-consciously aware, and which (3) exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which (4) may be expected [in some instances] to have different consequences from their sensory or perceptual counterparts. (pp. 2-3)
In addition, the term imagery in this report of research refers only to visual imagery, not to imagery in other sensory modalities (e.g., auditory, olfactory, etc.), unless otherwise stipulated.

Objectives

This study was intended to build on the Pinker and Kosslyn (1978) and Pinker (1979, in press) studies in four ways. These ways stated as objectives are:

1) To replicate the findings of the imagery scanning experiments of Pinker and Kosslyn (1978) and Pinker (1979, in press) with a similar task in another location with a different population.

2) To describe the relationship between metric distance and mean reaction time scores derived from scanning between pairs of objects in a similar imagery scanning task involving photographic slides.

3) To describe the relationship between perceived distance and actual distance in a real object display and in a photographic slide of an identical display, and to compare this perceptual task with the imagery task.

4) To collect relevant data on individual differences that might indicate directions for future research.

Hypothesis

An hypothesis was made only in connection with objective number one above. The other objectives relate to descriptive research.

H - There will be a positive, linear correlation between mean reaction time scores of interobject distance scans and three-dimensional interobject distance for subjects able to scan images in an imagery scanning task using a real object display.
Discussion of Objectives and Hypothesis

Replication

This study attempts to replicate the findings of the Pinker and Kosslyn (1978) and Pinker (1979, in press) studies. The task in this study and the Pinker and Kosslyn and Pinker studies are basically the same. The imagery scanning tasks are identical; the positioning practice task (See p. 51) is different due to the static nature of the slides in which objects cannot be moved. Instead of positioning the object by allowing the experimenter or subject to move the object to a correct position as in the Pinker and Kosslyn and Pinker studies, the subject in this study was asked to view a series of positions to which the object had been moved by the experimenter and, then, to choose a position that matched his/her image, thus identifying the original or correct position of the object. The positioning practice procedure was, therefore, similar to that used by Pinker and Kosslyn and Pinker, and it is thought that any differences did not affect the outcomes. Other differences in this study from past research were the different display size corresponding to the dimensions of slides and the use of size relational objects.

Exploration

The purpose related to Objectives 2 and 3 above is to explore the way in which people perceive an image from slides. Since Pinker and Kosslyn (1978) and Pinker (1979, in press) have determined that images do preserve space analogically to the perceived space, then the image scanning task in the slide condition should indicate the amount of space being perceived in the slide. This was subsequently given
further scrutiny in a perceptual task which would determine if imagery scanning does reflect the true nature of the spatial percept.

Organization of the Report

Chapter II of this report contains a review of the literature in the areas of imagery, individual differences in imagery, pictorial theory, and imagery as related to education. Chapter III describes the experimental procedures used in the present investigation. In Chapter IV, the data analysis and findings are presented. Lastly, Chapter V includes a presentation of the conclusions, recommendations for future research, and a general discussion section.
CHAPTER II
REVIEW OF LITERATURE

Imagery

There are three main approaches or schools of thought concerning imagery which differ in respect to their definition of the nature and function of the imagery process. The approach adopted in this study is the structuralist view. The other two theoretical approaches— the associative and Gestalt views—will be briefly described to give perspective to the structuralist view.

Associationist Approach

Neisser (1967, 1972) has discussed the associative approach as one which stresses that images are stored in the memory as ideas which are linked together by bonds called associations. The idea or stored percepts can become associated if they occur in close temporal proximity. Neisser (1967) has labeled this notion of imagery as the Reappearance Hypothesis. Images and words are stored and can reappear over and over again. Freud based his ideas of cognition on associationist ideas. Horowitz (1970) has described Freud's primary and secondary processes of thought. Freud described primary thoughts as hallucinatory images developing in childhood that are magical, fantastic, and gratification oriented. Visual images are the primary thinking mode. Secondary processes of thought are analytical and logical, and develop later. Images are still used but are under the
influence of the secondary thought processes. Freud introduced the idea of an unconscious store of ideas (representations).

Paivio (1971) is perhaps the major researcher whose work emphasizes the associationist tradition. He presented the idea that images and words are stored in a dual coding system; the two coding units are associatively linked. Paivio (1971) has performed an experiment using concrete and abstract nouns to provide evidence that coding in both modes (when there is an association between modes) leads to easier learning. The concrete nouns are better recalled than abstract nouns, because they are dual coded; the abstract nouns are only coded verbally. Paivio has also produced evidence that paired-associate learning occurs more readily if imagery processes are used in the memory task. He also demonstrated that parallel processing occurs in the imagery mode, and serial processing occurs in the verbal mode.

**Gestalt Approach**

The Gestalt psychologists also accepted the Reappearance Hypothesis (Neisser, 1967). Percepts were recorded in memory as traces isomorphic to the original perceptions. These stored copies formed group traces; these wholes formed structures which could lose parts and gain others.

**Structural Approach**

The Gestalt and associationist psychologists accepted a similar stance toward imagery—that stored perceptual traces are associated during thought giving rise to images (Neisser, 1967). In contrast, the structuralist approach emphasizes that "perception itself is a combination of sensations (stimulation of receptors) and memory images (recollections of previous sensations)" (Paivio, 1971, p. 88).
Research by Perky (1910) and Segal and Fusella (1970) has supported what are perhaps the two core ideas giving rise to structuralism: 1) that imagery and perception use similar mechanisms, and 2) that sensory input interacts with imagery to determine perception (Paivio, 1971). These formed the basis of a new structuralist approach regarding imagery, that structure in perception and imagery ought to be examined to discover similarities and differences in their natures and functions.

Paivio (1971) points out that the constructionist view of imagery is an offshoot of structuralism. Scholars using this approach view perception as an active, constructive process. The Reconstruction Hypothesis (Neisser, 1967; Barlett, 1932) asserts that imaging is a process of reconstructing a percept from stored information. Perception and imagery are not static events of the appearance or reappearance of a stimulus. As is obvious, the information processing approach to perception underlies this view of imagery. Neisser (1972) states that a person is imaging whenever "he employs some of the same cognitive processes that he would use in perceiving, but when the stimulus input would give rise to such perception is absent" (p. 245).

Past Structural Imagery Research

Following Neisser's (1972) recent suggestion to "begin to study the nature of the construction [of the image] in more detail" (p. 233), several researchers have been investigating the structure of the image itself. Shepard and Metzler (1971) found that the time to recognize that one line drawing of a 3-D object matches another
increases linearly as the position of one deviates from the position of the other. Shepard and Feng (1972) asked subjects in a paper folding task to fold a picture of an unfolded cube so that the arrows drawn on two squares of the cube would meet. They found that verification times were positively linearly related to the number of folds made to enable the arrows to meet. Cooper and Shepard (1972) presented subjects with alphasegmentic characters in several orientations around a circle and asked them to determine whether they were normal or mirror versions. The time subjects took to mentally rotate the image was linearly related to how far the figure was from the normal, upright position. In other experiments (Attneave, 1972; Attneave and Pierce, 1978; Attneave and Farrar, 1977) when subjects were asked to mentally extrapolate a visible straight line segment behind their heads, they performed with extreme accuracy. These studies demonstrated that images contained the same 3-D structure as perception.

In 1973, Kosslyn began a series of imagery scanning experiments to address the issue of whether images were epiphenomenal, non-functional phenomena, of a more abstract (e.g., verbal) form of processing, and to give additional evidence to the structuralist view that images embody spatial structures. He asserted that the spatial properties of images would affect information processing. First, Kosslyn (1973) presented subjects with a set of drawings, and asked them to focus on one point and then "look" for another property of an object in his image. The results indicated that the further the looked-for point was from the original point of focus, the longer it took to "see" it.
Kosslyn, Ball, and Reiser (1978) performed four studies of image scanning investigating the spatial nature of visual images. First, in a letter scanning task, they demonstrated that distance is the same no matter how many items are scanned over. This explains why imagery is operating in scanning and not a verbal process where a subject forms a list. The subjects scanned a three-letter display, scanning over 0, 1, or 2 intervening letter(s) before reaching a target letter and identifying it. The target letters were spaced at different distances. The results showed that "the effects of distance are not simply an artifact of how many things must be scanned over" (p. 48).

In the next experiment, Kosslyn, Ball, and Reiser (1978) demonstrated that images contain metric information. This involved scanning between 21 possible pairs of seven locations on a map. Scanning times correlated with distances. In experiment 3, again using the map, they sought to determine if subjects did not scan, just shifted from one image to another, would the distance effects be the same. A non-imagery task was set up where subjects had only to focus on an object and decide if another object was on the map. The results indicated the scanning times did not increase systematically with distances. Also in experiment 3, it was demonstrated that "focusing in" on a location on the map and scanning to another location showed the same distance effects as keeping the whole display in view; therefore, "one may construct images such that portions are 'waiting in the wings' ready to be processed if necessary" (Kosslyn et al., 1978, p. 55). This is related to Neisser's notion (1976) that images are anticipatory.
Finally, the fourth experiment in the Kosslyn, Ball, and Reiser studies (1978), schematic faces (having only eyes, nose, and a mouth) were used to demonstrate that "more time is required to scan across subjectivity larger images" (p. 56). The subjects were asked to scan from the mouth to a pair of dark or light eyes placed at different distances from the mouth. They were to decide if a probe correctly identified the eyes as light or dark. The subjects were to subjectively change the size of the face in their mental image to either overflowing, full, or half size. Scanning times increased with the size of the face and with larger distances between eyes and mouth. Also, the evidence from this study indicated that no chunking or grouping of parts occurred as the size change was not presented until after the drawing from which they were imaging was removed; therefore, the size did not affect the encoding (closer objects encoded together).

Other experiments (Kosslyn, 1975, 1978a, 1978b) support a non-epiphenomenal role for imagery. These involved overflow of images and ease of detection (smaller images are harder to scrutinize). Kosslyn (1975, 1978a) also performed a series of experiments showing that images are not scanned after projecting them as pictures; images are generated, constructed. Subjects saw pictures of animals with either more or less detail. The more detailed pictures required more time to image (Kosslyn, 1978a).

Kosslyn (1978a) reports on two Gestalt experiments; one using matrices of letters arranged into groups or separated spatially in an equal manner. More time was used to image drawings requiring more units. Also, in a picture of an animal placed on one page, placed on
two pages, or in parts of five pages, subjects took more time to construct images on the more numerous pages. Thus, Kosslyn reasoned that imagery retrieves information in chunks, probably in memory.

Kosslyn (cited in Kosslyn, 1978a) performed another experiment to demonstrate that imagery is an interaction of perceptual and conceptual memories. He presented a 3 x 6 matrix of letters, and told subjects that it represented "6 columns of 3" or "3 rows of 6" (Kosslyn, 1978a, p. 304). When more units were mentioned first, it took subjects more time to image the matrix. He therefore reasoned that conceptual information influences imagery.

Recent Related Imagery Scanning Research

In 1978, Pinker and Kosslyn reported on a study they had performed which sought to demonstrate that 3-D spatial properties were preserved in mental images. Using a chronometric scanning technique, they presented 16 subjects with a visual display of either four or six objects and asked them to form as accurate a mental image of the display as possible. They used two practice tasks to make sure the subjects had the objects in the display in the proper position in their visual images. The subjects were then asked to mentally move objects one at a time and scan the paths between the objects by means of imaging a small black dot traveling at a constant rate of speed between the objects. The scans were recorded as reaction times (RT's) and were correlated with the actual 3-D distances. The results indicated that 1) scan times between objects and 3-D distances were highly correlated, 2) the scan times were not significantly correlated with 2-D distances, and 3) following mental moves of objects, scan times correlated better with the new interobject distances than the
original distances. They did not find evidence that the number of objects in the image had a lack of effect on the amount of time necessary to move an object.

Later, Pinker (in press) replicated part of the Pinker and Kosslyn (1978) study in an effort to get more stable data. Pinker felt that data from the first study did not contain high enough correlations to rule out the possibility that subjects might have just remembered whether the objects were near, far, or intermediate distances apart. More trials and subjects were used; and one of the position practice trials was dropped. False trials were included as a decoy to disguise the purpose of the experiment and to insure that the subject was imaging. Five objects were used instead of four or six. The subjects were not asked to move objects mentally, but were just to scan between objects at varying heights and distances. The data analysis showed a very high correlation ($r = .92$) between mean scanning times and 3-D distances. Once again it was shown that images contain a 3-D workspace. Pinker (1979) has reported fully his scanning experiments (including the Pinker and Kosslyn (1978) experiment above) in this doctoral dissertation.

In summary, Kosslyn (1978a) Pinker and Kosslyn (1978) and Pinker (1979, in press) have addressed some of the major issues concerning imagery. They have, in the sum of their experimentation, demonstrated that imagery is a process similar or analogic in important respects to perception: imagery contains spatial properties, chunking occurs as in perception (as also demonstrated by Gestalt theory), imagery is
influenced by stored/past ideas like perceptions, and images are constructed like perceptions.

**Imagery Model**

Kosslyn's imagery model does not deny any of the theoretical approaches to imagery reviewed above--the associationist, Gestalt, or constructionist--but is a more holistic, eclectic approach based on a computer-like, analogic information processing system. Kosslyn's Proto-Model for representation (Kosslyn, 1978a) explains visual images as displays on a cathode ray tube. He asserts "that images are temporary spatial displays in active memory that are generated from more abstract representations in memory. Interpretive mechanisms ("a mind's eye") work over ("look at") these internal displays and classify them in terms of semantic categories (as would be involved in realizing that a particular spatial configuration corresponds to a dog's ear, for example" (Kosslyn, 1978a, p. 295). For a graphic representation of Kosslyn's model, see Figure 1.

**Summary of Image Scanning Experiments**

Kosslyn (1978a) and Pinker and Kosslyn (1978) and Pinker (1979, in press) have made a significant contribution to the study of imagery by applying chronometrics and other scanning techniques. This creative approach has taken the study of imagery away from having to rely on verbal introspection reports with their subjectivity, and placed imagery in the more respectable position of near objective observation. Subjects are no longer required to verbally describe their mental imagery. As Neisser (1976) pointed out, "What seems to us like descriptions of images and cognitive maps are really . . .


descriptions of potentially perceivable objects, of what one would see if such-and-such a thing were present. Introospection is a kind of a preparation for exterospection" (p. 173). Criticisms of traditional introspective reports like Neisser's have been put forth by many. However, the structured introspection in the Pinker and Kosslyn (1978), and Pinker (1979, in press) studies have produced data that is hard to regard as highly subjective due to its consistency over subjects and the resulting high positive linear correlations. Although the methods in their experiments require mental effort, cooperativeness, and consistency on the part of the subjects, it isn't just by chance that data have displayed well-ordered relationships. In addition, in spite of the face that subjects still do "report" on their internal processes, a reaction time report does not rely on verbal ability and does not, therefore, change the nature of the imaging phenomenon as much (i.e., the image would remain more pure as the subject would not have to recode the image into a verbal mode).

Studies Relating Imagery and Pictorial Perception

Pinker (in press) recently has been exploring facets of 3-D perception and imagery which are related to the pictorial theory of J. J. Gibson (1971). He performed a series of experiments exploring the problem of how images contain 3-D structures and preserve perspective effects as well. He is concerned now with further specification of the medium in which 3-D mental images occur. Empirical evidence can be cited that supports the notion that perspective effects are components of images. Kosslyn (1978b) found that as the object appears nearer in an
Figure 1. Kosslyn's Proto-Model for Imagery
(Adapted from Kosslyn, 1978a)
imagined scene, the visual angle seems to increase linearly. Also, the Shepard and Metzler (1971) study cited above suggests that if people have to mentally rotate objects to determine shape, they must be imaging them from a particular perspective. Pinker (in press) obtained data from his experiments that 2-D distances are generated from 3-D structures. In Gibson's pictorial theory (1971), he suggests a duality of representation in pictures—the two concurrent surface and spatial perception. One can perceive an optic array from the picture surface and from the objects in the picture. In imagery, then, perhaps from learned perspective perception of pictures, one may image in 2-D as well as 3-D, or from 3-D construct a 2-D image due to past pictorial learning. This possibility will be explored in the present study. If the 2-D stimulus perceived and/or imaged gives rise to a 3-D image, then it can be assumed that 1) the optic information or mental layout theory of Gibson's is correct and depth is an invariant common to the imaged as well as the perceived scene, and that 2) 2-D images can give rise equally well to 3-D images/perceptions. It seems logical to assume that if people can construct 2-D images based on 3-D representations that this process may be reversible, that is, 2-D might be able to be reconstructed to the 3-D underlying medium. To reiterate, this theory relates to Gibson's theory (1971) that the "optic array from a picture and the optic array from a world can provide the same information without providing the same stimulation" (p. 31). In short, an expansion of the research question is: if 2-D representations can emerge from a 3-D internal medium, can 3-D image structures emerge from a 2-D representation? What needs to be determined is
whether stimulus attributes (e.g., surface features) will disrupt the imagery process and be destructive to the imagery process, or is the imagery process from a slide reconstructive or additive in some sense to fill in the missing depth/spatial structures not provided in the stimulus?

In another recent series of experiments by Pinker and Finke (in press) where subjects mentally rotated objects in a cylinder and then performed tasks demonstrating the ability to accurately discern two-dimensional patterns that would emerge, support was found for a model of space representation involving two structures: one in which two-dimensional space is preserved and one in which two-dimensional perspective properties specific to a vantage point are preserved. They assert that the human mind can compute perspective from any given angle. Interestingly, Pinker and Finke state that their model of dual two-dimensional and three-dimensional representation systems might only be applicable to Westerners who are familiar with pictorial representations.

Perceptual Distance Estimation Tasks and Imagery

Since interference research has shown that imagery and perception rely on similar structures in processing (Brooks, 1967, 1968; Segal and Fusella, 1970), and since the theory has been presented that imagery is analogic to perception (Pinker and Kosslyn, 1978; Shepard, 1978b), performance in a perceptual task should be comparable to that in an analogous imagery task. In perception, the notion that observers process a three-dimensional representation of a scene and not a two-dimensional retinal image is not novel (Attneave, 1972; Gibson,
Therefore, in this study, it would be of interest to find out if people perceive depth accurately and to devise a perceptual task to compare to the imagery task. Pinker (in press) found that eye movements exert a small influence in a three-dimensional perceptual scanning task, thus rendering it impossible to compare perceptual scanning and imagery scanning directly.

Another task of perceptual three-dimensional distance estimation could be used, however, to get an idea of whether subjects can perceive three-dimensional distance in both the real object and slide stimulus conditions. This would take the form of a "mental yardstick" task similar to that used in the Smith (1958) studies. (See Pictorial Theory section of this chapter, p. 32.) They used the human walking step as the measuring unit that subjects used to judge distances between objects in a corridor. Due to the smallness of the visual scene used in the present study, the step measure is not possible. An appropriate measure might be a 5cm. x .8cm. dowel rod segment. The subject, unaware of its metric length, would be asked to estimate how many of these rods could fit end to end between pairs of objects in the display. Since this task is different from the imagery scanning task, no direct comparison between the performance in the tasks can be made. However, a perceptual estimation task involving the same stimulus, real display or slide, can give information to possible differences in distance perception between stimulus conditions. If systematic differences occur, it can be determined if these were in any way similar to the systematic differences found in the imagery scanning task.
Vido, Drake, Clark, and Kounkoulos (1978) performed an interesting study involving distance estimation, perception, and imagery. They took two groups of undergraduate students to a mountain top where they learned names and locations of fifteen objects in the landscape. The next day they took half the subjects to the mountain top again and asked them to make perceptual estimates of the distances of the fifteen objects; the other half was instructed to visualize (image) the scene and give identical distance estimates. Their findings indicated that memory for distance in visualization was more compressive than for perception in relation to the actual physical distances. It should be noted in this study that decay of the image over time could account for the disparity in distance estimates between the imagers and perceivers in this task.

Individual Differences in Imagery

Past Research

Since the inception of the scientific study of visual imagery in modern times, investigators have sought to explain visual imagery in relation to individual differences. In an effort to explain the function of visual imagery processes in human thought, researchers have attempted to differentiate people on several imagery dimensions such as vividness of imagery, control of imagery, or simply the amount of visual imagery a person would experience. In other words, it was thought by early researchers that if the nature of imagery differed between subjects, then the abilities that these subjects displayed could be correlated to these imagery differences (e.g., high vividness of daydream imagery might be associated with creative writing ability).
The research in the areas of individual differences in imagery is large, but will only be summarized briefly in this document as the major research effort here is not individual differences in imagery. (See Paivio, 1971; Marks, 1972, for more detailed accounts.) Early studies produced few consistent results due possibly to their reliance on subjective reports as measures. This approach began with Galton in 1883 with his breakfast table questionnaire which asked subjects to rate their images of what was on their breakfast table in several areas--illumination, color, definition, etc. He found scientists were more abstract, verbal, and reported little use of visual imagery, but concluded that imagery "types" did not exist. Despite this, other early researchers (Fernald, 1912) pursued the imagery typing path, culminating with Griffits (1927) who conducted a study to distinguish visual-verbal types. He concluded that visual types are concrete thinkers and auditory-motor are verbal thinkers. Thus, the dichotomy between visualizers and verbalizers began. (Paivio, 1971)

Recent researchers continue to utilize subjective ratings, and, in addition, objective measures have been employed. Ernest and Paivio (1969, 1971) and Kuhlman (1960) are researchers who have used the objective measures approach. They have found high imagery subjects to be superior in recognition for pictorial material, in speed of imagery associations to abstract words, in associative learning and recognition memory with pictorial items, and in incidental recall of visual items. Another study (Paivio, Rogers and Smythe, 1968) using both objective measures and subjective questionnaires found no difference in pictorial recall between high and low imagers.
Surprisingly, although a factorial study of imagery (Paivio, 1971) has indicated that spatial relations (objective) measures and verbal self-report (subjective) measures do not relate to the same imagery factors, researchers using self-reports of vividness of imagery (Marks, 1972), Sheehan (1966), and Sheehan and Neisser (1969) have reported similar findings related to accuracy of pictorial recall. Marks (1973a) reported a study which concluded that more vivid imagers had fewer eye movements when scanning a mental picture. However, Marks and Barron (cited in Marks, 1972) found that good visualizers showed more eye movements when scanning a mental image. Other imagery tasks such as imagination, memory, or changing a mental image did not show differences in eye movements.

In summary, evidence is not consistent across tasks in establishing a relationship between performance and individual differences in imagery. Marks (1972) and others (Richardson, 1969) concluded that everyone has a potential for imagery skills, but abilities to generate and use imagery vary across people.

There has also been an attempt to associate imagery ability and other personalological variables such as sex. Studies (Marks, 1972, 1973b; Ernest and Paivio, 1971) have shown a significant effect on sex in favor of females in imagery and recall tasks; Forisha (1978) also found some association between creativity and imagery for female subjects only.

Haber and Haber (1964) have described in certain children and adults images that are very vivid; these individuals can look at a picture for a few seconds, then cast an image of it in front of their
eyes that is in positive color and high detail. These images are called eidetic and appear to be a combination of afterimages and memory images. Haber (1969) states that they can be scanned; afterimages require eye fixation. He further asserts that since eidetic images can be scanned, this differentiates them from afterimages and memory images. The functional significance of eidetic imagery, however, is unclear. Several researchers (Oswald, 1960; Haber, 1969; Leask, Haber and Haber, 1969; and Doob, 1964) have found that eidetikers are not particularly accurate in recall. Other evidence has shown higher accuracy of visual details for eidetic children as opposed to non-eidetic children (Haber and Haber, 1964); Siipola and Hayden (1965) and Stromeyer and Psotka (1970) have reported great accuracy and duration of eidetic images in adults. Leask et al. (1969) found no differences in intellectual abilities between eidetic and non-eidetic children; others (Siipola and Hayden, 1965; Doob, 1966) conclude that developmental factors may produce eidetikers.

In this study, an eidetic task similar to the one used by Haber (1969) and described by Absen (1977) was included to investigate the relationship of eidetic imagery in young adults to spatial representation in imagery.

Selected Individual Differences

From the brief report of findings concerning individual differences in imagery, one can discern the controversial nature of this area of research. A few measures of individual differences were selected to be investigated in this study to further research in this area. Past research has not attempted to correlate individual
differences with spatial representations in images in this type of task. Thus, research questions arise: do people who have a low amount of three-dimensional space in their images differ in some attribute from those whose images contain much three-dimensional space, and do those who cannot scan differ from those who can on other variables? In this study, the selected individual difference variables and their measures are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Field dependence-independence</td>
<td>Group Embedded Figures Test</td>
</tr>
<tr>
<td>2. Verbal ability</td>
<td>Raw ACT score (English)</td>
</tr>
<tr>
<td>3. Math ability</td>
<td>Raw ACT score (Math)</td>
</tr>
<tr>
<td>4. Overall scholastic ability</td>
<td>Composite raw ACT score</td>
</tr>
<tr>
<td>5. Cerebral dominance</td>
<td>Handwriting position classification (Levy and Reid, 1976)</td>
</tr>
<tr>
<td>6. Eidetic imagery ability</td>
<td>Eidetic imagery scanning task</td>
</tr>
<tr>
<td>7. Vividness of imagery</td>
<td>Vividness of Imagery Questionnaire (Marks, 1973b) and five-point rating scale related to imagery scanning task</td>
</tr>
</tbody>
</table>

Other variables included in the data collection are sex, handedness, and familial history of handedness.

**Pictorial Theory**

Attneave (1972) has stated "it is obvious that very good impressions of a tridimensional world may be obtained from a photography or from a monocular view of one's surroundings" (p. 283). To investigate the possibility of 3-D images from a photographic stimulus, a theory of pictorial perception which could explain depth perception
from slides is indicated. Two such theories will be described which are felt to have the most relevancy to this study--cue theory and J. J. Gibson's theory of perception and pictorial perception (Gibson, 1966, 1971).

**Cue Theory**

In line with the cue theory of perception, Kaufman (1974) has described physiological and kinetic cues. The physiological cues determined by the visual system apparatus include accommodation and convergence (which are oculomotor adjustments) and binocular disparity (the integrated retinal image derived from the slightly different viewpoint of each eye). The kinetic cues are motion parallax, motion perspective, and kinetic depth effect. Motion parallax and motion perspective refer to the movement of objects in the visual field in relation to the movement of the observer. In motion parallax, objects near one appear to move against one, and objects in the distance move with one. In motion perspective (Gibson, 1950, 1966) as the observer moves forward, nearer objects at the bottom of a visual scene move at a greater velocity than objects on the horizon which seem stationary. The kinetic depth effect refers to the motion of objects.

In viewing 2-D pictures, the cues described above are not operating. As Dember and Warm (1979) point out, these are the primary dynamic cues to depth in perceiving the environment. However, in pictorial perception, Dember and Warm (1979) describe several pictorial cues which are of a static and secondary nature to depth perception. These are:

1) Size - retinal size (larger object looks bigger) and relative size (more familiar larger object assumed to be bigger)
2) Linear perspective - parallel lines converging as they are approach the horizon line

3) Texture density gradients

4) Relative height - the higher an object is in a picture the further away it looks

5) Brightness - brighter object looks nearer

6) Occlusion - one object overlapping another

7) Aerial perspective - distant objects in landscapes look blurred

These cues are called monocular cues as they are most potent when viewed with one eye in a picture; when binocular vision is used, this will give information as to the flatness or picture quality of the stimulus and tend to "defeat" or lessen the effect of pictorial cues. Moreover, the monocular pictorial cues are associates with past experience. The picture/cue theory is associationist. Some theories (Piaget) have explained image and positional cues as based on past tactile-motor experience (e.g., a partially occluded block is touched and grasped further from the body than a closer object). Helmholtz called these higher order associations "unconscious inference" (Neisser, 1972).

From cue theory, then, the present study would be affected in two ways: 1) the slides would not be expected to be perceived as accurately as the real objects, 2) if images are analogic to perceptual experience, it would seem unlikely that viewed binocularly that images derived from pictures would contain all the necessary information to replicate a real experience, although imagery might be constructive and "fill in" for the impoverishment.

The cues to be used in the slides in this study are:

1) Retinal and relative size
2) Linear perspective
3) Texture density gradients
4) Relative height
5) Brightness

Gibson's Theory of Pictorial Perception

An alternative theory of pictorial perception has been proposed by J. J. Gibson (1966). He asserts that perception of real images and pictured images involves direct registration of visual data, and does not involve any processes which add to that data. All the information necessary for the perception of real or pictured objects is contained in the structured light reflected from the picture or object. There are not internal, learned processes which change a flat retinal image to one corresponding to reality. The information contained in reflected light is a model of the layout or environment which has reflected the light. Gibson (1971) defined a picture as "a surface so treated that a delimited optic array to a point of observation is made available which contains the same kind of information that is formed in the ambient optic arrays of an ordinary environment" (p. 31). He asserts that pictures are structural and therefore informational equivalents to scenes as they reflect light in the same way. Earlier, Gibson (1954) defined a faithful picture as "a delimited physical surface processed in such a way that it reflects (or transmits) a sheaf of light-rays to a given point which is the same as would be the sheaf of rays from the original to that point" (p. 14). This theory was similar to what Gibson (1971) called the point projection theory of pictorial information. He rejected this limited
notion that there is a point-to-point correspondence between spots in the light rays and on the picture surface because this could not explain the perception of line drawings and caricature. Gibson's theory of pictorial perception (1971) is aligned with information processing in that it describes perception in informational terms and does not rely on replication of sensation. As he states "it assumes that two perceptions can be the same without their accompanying sensations being the same" (Gibson, 1971, p. 31). His concept of optical information defines information as formless and timeless invariants. Kennedy (1974) explains that "an invariant is a property that is constant across a change" (p. 44). In optics this includes changes in illumination on the scene, change in station points, or in some rotation of the object. Gibson (1971) states that an informative picture presents the same invariants as the real scene from our perspective. His idea is that in pictorial perception an adult can either adopt a naive or perspective attitude, that is, notice or not notice perspective. The essence of his theory of representation is that one can perceive both the picture as a thing with surface features, etc., or the things pictured. He cites that his experimentation has demonstrated that in a photomural one can, from the proper station point, perceive "perceived" distance in the photo as well as the distance of the photo (e.g., height). Gibson stops short of asserting that pictures can ever in a real sense replace reality--be identical to reality. However, one could speculate that information such as spatial relationships might be identical in pictures and reality from his theory.
The further specification of the nature of information as presented in a pictorial array is the challenge of Gibson's theory. The fact that he rejects all higher processes of perception and, hence, part of the constructive informational processing view of perception and imaging is not warranted or a logical assertion. As Neisser (1972) has commented "between the existence of information is an optic array and perception of the layout which it specifies there is a long step" (p. 236). By admitting that adults can adopt a perspective attitude in regard to pictures and that a child must learn to draw perspective, higher order processes do, then, come into play in pictorial perception. It seems as though higher level processes could interact with and influence the information in an optic array. As Neisser (1972) points out, another notion extending from Gibson's perceptual theory (1966) is that images are mental layouts derived from the optic information of the environment.

As Pirenne (1970) has noted, photos, slides, or paintings "do not, whatever the sense of depth they may seem to give, appear in three dimensions like stereoscopic pictures" (p. 95) or a real object display. Pictures are 2-D representations from which depth can be sensed second hand. Several studies involving different tasks have supported the fact that people can "see depth" in different kinds of realistic depictions--line drawings, photographs, and slides. Gibson (1960) in a recognition task presented, side-by-side, a photo mural and a real scene of a long, dimly-lit corridor. Subjects looked at each through a peephole, monocularly, at the same viewing angle; one third could not tell the difference. According to Gibson's pictorial theory, the
information in the optic array in the real and photograph conditions were similar. In a distance estimation task, Smith (1958) presented the same corridor photomural monocularly to subjects and asked them to judge distances between objects by estimating the distance (number of paces) between objects. The subjects could judge the distances accurately; Smith also found a magnification effect—as the photomural was viewed further away, perceived depth increased. Smith and Gruber (1958) studied the magnification effect further and found a geometrical relationship—as viewing distance increased, the image was smaller and perceived distance greater. Hagen (1974) has related these magnification findings to the importance of correct station point. Smith, Smith, and Hubbard (1958) compared corridor pictures—a black and white photo, a very detailed line drawing, a moderately detailed line drawing, a lesser line drawing with end parts darkened, and a line drawing without the darkening. The subjects judged the corridors as equidistant in length and width. Thus line drawings of various detail and photographs do not differ from each other in perceived depth. These were not compared to a real corridor scene, however.

Kennedy (1974) points out, in contrast to Pirenne (1970), that photos could be made that are undetectable from reality in peephole viewing. Pirenne (1970) states that the "possibility of producing a complete, perfect, imitation of a visible reality is a myth" (p. 153). They are both, perhaps, slightly conservative in their predictions. With what we can observe already in the form of motion picture holographs gives one a sense that the "pictured" representation of an exact indistinguishable copy of reality is not far off technically.
However, for the foreseeable future we are constrained to learning from lesser presentations.

The evidence for the amount of depth possible in the normal viewing of slides is presented by Hagen (1974). She presents the hypothesis that flatness and depth perception might be in conflict when developing depth perception; and if a person cannot see depth accurately in a picture it is because they are not in a pictorial mode--being able to discern enough flatness and seeing it as a picture. When one is confused about whether a scene is real or a picture, this is when lack of proper perception of picture information (e.g., depth) is presented.

E. J. Gibson (1969) asserts a different theory: that flatness information in a picture should be minimized for depth perception for the young or untutored. To test this minimization theory, Yonas and Hagen (1973) presented a relative size judgment task to three-year olds, and seven-year olds, and adults using front-projected slides. Half the subjects in each group were in a conflict situation where flatness and depth were preserved, and half were in a non-conflict condition where flatness cues were minimized. A control condition was used with real objects viewed through a peephole. There was no difference in the two conditions with adults and three-year olds; seven-year olds performed poorly in the conflict condition. The subjects reacted to the slides in both conditions as flat without depth. Adults made no errors in the real object condition, three percent on viewing slides through a peephole with equal visual angle, 12.5% when viewing with an 80 percent visual angle, and 27 percent with a 70 percent visual angle.
Hagen (1974) performed another size judgment task involving a comparison between back-projected slides and prints. Two similar shapes were photographed against a textured background at different visual angles—equal, 85 percent, and 70 percent. This comparison study among adults, seven-year olds, and four-year olds looked at the effects of station point and pictorial mode (surface). The results showed no significant Age x Surface x Station Point interaction. Slides viewed from the correct station point produced the best pictorial depth responding in adults, about an 83 percent rate of correct responses. Hagen concluded that no pictorial mode was triggered in this instance. However, prints and slides viewed from the wrong station point, which is the more normal occurrence in life, are about equal in depth perception produced, about 70 to 75 percent of that which could be expected in real-world perception. Prints viewed from the correct station point—also an abnormal situation, such as when slides are viewed from the correct station point, places correct depth perception at near chance. Hagen's point is that the normal viewing station of prints and slides (in this instance, forty degrees to the left of center) triggers the pictorial mode. For prints this is advantageous, as it reduces conflict and allows depth to be perceived. She states that the slides were a pseudo-trompe l'oeil situation in which no conflict was presented. According to E. J. Gibson's theory, the back-projected slides minimized the flatness feature the most, so better depth was perceived. This appears to be the case from the correct station point for adults and seven-year olds. However, it would not be supported by Hagen's findings in the more normal mode of perceiving
(from the wrong station point). Hagen does not state clearly whether the pictures were viewed monocularly through a peephole, but is is assumed that they were.

The above Hagen studies show that adults get more information from a picture than children; the question arises, is pictorial perception learned or is it an innate ability? Those that align themselves with Gibson's theory (1971) assert that it is not learned. Hagen (1974) reduced the cross-cultural research and child research that would reveal the effects of pictorial learning; she concludes that the recognition studies involving the untutored indicates "an unlearned responsiveness to impoverished representations" (p. 483). For example, picture identification of objects not present can be performed with no difficulty by young children (Hochberg and Brooks, 1962; Liddicoat and Koza, 1963).

As for cross-cultural studies, Pick and Pick (1978) point out that problems of ambiguous communication in the testing situation cloud the results of cross-cultural studies in pictorial depth. These are ambiguities in the drawings themselves (e.g., familiar size of objects), in the questions asked about the pictures (e.g., whether near means in the picture plane or in the scene), and in the respondent's answer (e.g., language interpretation problems). Researchers (Hudson, 1960; Deregowski, 1972) have obtained results reflecting no cultural difference in pictorial perception. Cross-cultural studies in a recognition matching task involving photos and real objects indicate that this task can be performed with high accuracy by naive subjects (Deregowski, 1968). Nevertheless, Pick
and Pick (1978) conclude that the numerous cross-cultural studies do indicate that some rules for representation may be culture specific and that learning of these rules is significant. Other theorists (Brunswick, 1956; Sigal, 1978) review equally supporting evidence that higher order processes are involved in pictorial perception, and certain pictorial rules must be learned.

The review of pictorial research indicates that there must be a great deal of information in optic arrays which influences and shapes higher order processes, that interact at all stages of information processing. Depth information appears to be an invariant in the array which is both innately observed and learned as exemplified in relating this phenomenon to drawing.

**Summary of Pictorial Perception Research**

In summary, the pictorial research does not give clear indications of how observers will perform in a distance scanning task involving slides. The Hagen studies give some indication that adults will perceive depth, but different tasks will be used in this study from those used in the Hagen studies. In the task in the present study which involves binocular vision, there is no research known to this author that would indicate how much depth would be preserved in slides. If perception shares spatial properties with imagery, as the Pinker and Kosslyn (1978) and Pinker (1979, in press) studies indicate, then the imagery scanning task should give a good indication of the 3-D information being preserved in the perception. However, it may be that images are constructive due to higher order processes (past learning) that might "inflate" the 2-D representation to a 3-D
representation in images. We can get a clue to this by using the perceptual estimation task, an analogous task, as a perceptual control. If it is found in this task that the subjects cannot perceive 3-D as accurately in the imagery task, one could begin to question the assertion that imagery is a process totally dependent on percepts and perceptual processes, but may be constructive in nature. If, however, the results of the present descriptive studies indicate that imagery scanning in slides correlates with 2-D, then it can be hypothesized that people will perceive in this task in 2-D as well; and, therefore, perceptual spatial properties will be shown to be analogic to imagery spatial properties.

**Imagery and Education**

**Pictures as Learning Aids**

As Pressley (1977), Rowher (1970), and Reese (1970) have pointed out, pictures (or imposed imagery) have demonstrated their effectiveness as learning aids. Pressley (1977) has amassed and reviewed the literature related to children's learning and imagery. Some of his more salient findings are:

1) "Imposed pictures are almost always learned better than words" (Pressley, 1977, p. 613).

2) Rohwer's contention (1970) that imposed pictures increase in potency in age may be correct, but at this time this increase is viewed as task specific and taps ability to make rich associations with pictures.

3) The Brunerian hypothesis (Bruner, Olver, and Greenfield, 1966) that children decrease in their memory ability for the superiority of pictures over words is not substantiated by research.
4) Self-produced internal visual elaborations increases with age and can be used in prose learning by age 8.

5) Individual differences in imagery effects occur in imagery research.

6) Electromyographic studies have shown that children label pictures, and eye scan studies show that children scan pictures.

7) Regarding prose learning: If pictures accurately depict information, pictures can increase learning; if not accurate can decrease learning.

Other learning tasks that involve imagery include recognition. Imagery processes are thought to be involved in studies (e.g., Standing, Conezio, and Haber, 1970) where subjects are shown a great number of pictures for a short amount of time each and then can recognize most of them when reshown later.

**Mnemonics**

The use of mnemonic devices involving visual imagery as a tool in educational settings for lectures and verbal learning is a well-known fact. Researchers (Bower, 1972; Paivio, 1971; Ross and Laurence, 1968) have demonstrated that tasks such as paired-associate learning and method of loci can be accomplished quite effectively by using visual imagery. Recently, Neisser and Kerr (1973) performed an interesting experiment demonstrating that a mnemonic can be performed equally effectively by utilizing an image of a concealed object as would be expected by using a pictorial interacting visual image as used by Paivio (1971). The authors attributed this ability to Gibson's (1966) theory of perception which asserts that percepts are informational
about the layout of the environment. Since research has shown that perception and imagery share the same mechanisms because they interfere with each other (Brooks, 1967, 1968; Atwood, 1971; Segal and Fusella, 1970), Neisser and Kerr maintain that theories of perception pertain to imagery also. Therefore, they asked subjects to use imagery in learning pairs of objects in various spatial layouts--an interacting picture layout, a separate image layout, and a concealed layout where one object was concealed within another. Since the subjects were able to recall equally well in a concealed and pictorial layout condition, this gives support to the notion that it is not the mental picture engendered that is important but the information in the layout of the environment that is functional in imaging. This experiment demonstrates that imaging and pictorial theory can be integrated to have a functional educational outcome.

**Imagery Structures and their Relation to Learning**

Although associational aspects of imagery can be useful in learning situations, the area of research represented in the present study--the identification of the properties/invariants of images--will perhaps be of more import in the future. First we must recognize the fact that mental images, pictorial images, and percepts all contain similar properties (e.g., spatial properties) which are used in cognition. Pinker and Kosslyn (1978) argue that "Presumably problems may often be converted to a form that can take advantage of the special properties of imagery, and then the resultant image is processed in various ways" (p. 70). They maintain that it is necessary to examine the properties of images before we will be able to understand how these properties
interact and contribute to problem solving. Pinker and Kosslyn (1978) and Pinker (1979, in press) have demonstrated that 3-D is preserved in images. Surely, this spatial property is invaluable in imaging courses of action involving spatial manipulation tasks. A medium exists in images for spatial relations problems to be worked on. Pinker and Kosslyn (1978) and Pinker (1979, in press), among others, have recently begun to formulate computer programs which are concerned with duplicating the imagery process. It is astonishing to imagine how these systems might be used to solve problems for learners. For example, learners could feed in spatial information regarding a problem and get an answer in verbal or mathematical symbols. Conversely, problems could be verbally fed in about a spatial problem and a spatially depicted answer from the imaging processes could be extracted.

Also, along the same lines as problem solving, is the important area of the relationship of imagery to creativity. Shepard (1978a) asserts that creations 1) derive from nonverbal spatial representations and 2) constitute an "externalization" of subjective images. He explains that the explanation of the detailed nature of images themselves has relevancy to the study of the imagery process. He cites the cases of great scientists—Einstein, Watson, Kekule, and others—where nonverbal processes involving visual imagery have played a decisive role in acts of creativity. The structural isomorphic relationship of the concrete visual imagery to the represented object or event "may permit the noticing of significant details and relationships that are not adequately preserved in a purely verbal formulation" (Shepard, 1978a, p. 156). Also, he cites innate spatial intuition
mechanisms that give rise to spatial competencies; one such competency is mental rotation (Shepard, 1975). In addition, he cites the emotional impact that vivid images can arouse and the private, nontraditionally bound nature of imagers as reasons that imagery can contribute to exceptionally creative thought.

An interesting suggestion by Shepard (1978a) relevant to those in educational media, is that one way to externalize or capture mental nonverbal phenomenon is to take a picture of it—as in film and photography. This is not to equalize mental images as pictures. In such a case, the media specialist could help creative persons in such a process; also, they could then analyze these externalizations for similarities and differences in an attempt to identify structures associated with creativity. Of course, they are limited by the nature of the media. Some properties such as depth, vividness, and color could be minimized by media.

Related to the work of Pinker (1979, in press) and Pinker and Kosslyn (1978) the initial identification of the properties of imagery is of primary importance. In other research, self-reports of imagery have been found to be related to objective tests of spatial memory or manipulation (Gur and Hilgard, 1975; Marks, 1973; Paivio, 1971; Richardson, 1969; Shepard, 1975). Forisha (1978) has studied college men and women in relation to imagery and creativity. She found no significant correlations between imagery and creativity for men, but numerous low positive correlations for women.
Summary

The literature in the area of imagery has been reviewed describing the nature of the structuralist approach and presenting the research validating the structural study of images. The research presented has shown that the structure of images can be studied in objective ways that produce results which demonstrate that imagery processes are analogic to perceptual processes. The relationship of imagery to pictorial stimuli was discussed as an area requiring further investigation. Finally, the area of relating perceptual estimation tasks to imaginal ones was presented.

Next, the research in individual differences in imagery was briefly reviewed. The lack of findings and inconsistency of findings of individual differences in imagery ability was noted. However, some objective findings have shown that individual differences in imagery ability relate to specific abilities (e.g., pictorial recall). The dearth of studies investigating individual differences in relation to more specific imagery abilities or structures (e.g., spatial representation) was evident in this literature review, and is, therefore, a concern in the present investigation.

The review of pictorial theory has indicated that there is a need to relate research findings to the two pictorial perception theories outlined: the cue theory, and Gibson's pictorial perception theory. Past research has not provided answers to the conflicts between these theories. Further investigation into the relationship between imagery and pictorial processes was also indicated.
The review of literature in the area of imagery and its relation to education has indicated that imagery is important in the education process. That imagery can be a useful tool for educators in recall tasks with some individuals has been established. Also the role of imagery in problem-solving and creativity (two major outcomes of a successful educational program) was discussed. The need to begin investigation of the structure of images and their relationship to the functional nature of imagery was presented. Research of the type undertaken in this study is aimed at extending knowledge of the structural nature of imagery, integrating imagery and pictorial perception theories, and examining individual differences and their relationship to the structure of mental imagery and pictorial perception.
CHAPTER III

METHOD

Introduction

Derived from research, a correlational study was devised whereby spatial representation in images derived from a real display and from a photographic slide could be compared. One group of twenty college students viewed a small, three-dimensional display of four plastic objects hung from near invisible threads in a display box (See Plate I, p. 48). Another group of twenty subjects viewed a rear-projected photographic slide of the identical display of object. The two groups viewed the display or slide from the same visual angle; the slide was projected to the same size as the display. Other aspects of the two stimulus conditions such as illumination and color of the objects in the real display or photo were kept as identical as possible. Other than for the fact that one stimulus was a slide and one was a real display, subjects perceived an identical stimulus. The subject’s heads were positioned in a chinrest the same distance from the front of the display or screen, allowing the subjects to gaze at the center of the visual stimulus. After performing a task to ensure that each subject had the objects placed in the correct position in his/her image, the subjects performed an imagery scanning task; they scanned mentally by imaging a small, black dot traveling at a constant rate of speed between pairs of objects in their mental image. The time it takes to scan between pairs of objects reflects the psychological
"distance" between objects. These scanning times were recorded as reaction times on a milleseccond timer. (See Plate II, p. 48). Correlations were derived between mean scanning times between pairs of objects and the actual, physical three-dimensional and two-dimensional interobject distances for subjects in both groups. In this way, the relationship between the amounts of distance in the subject's visual images and the real or actual distances between objects in the real or photographed display can be described.

Another set of correlational data was derived from a perceptual estimation task. After performing the imagery task described above, the subjects were asked to view the real or photographed display from the identical viewing position as in the imagery task and to estimate distances between pairs of objects. Correlations were calculated between mean perceptual estimates and three-dimensional and two-dimensional interobject pairs. Although a different task representing psychological "distance" differently, the correlations in the two different tasks, one imaginal and one perceptual, can be compared.

An aspect of this study which differentiates it from past research is the inclusion of data collection in regard to individual differences. Among these differences is eidetic imagery ability; a task was performed to describe eidetic imagery and its relationship to the imagery task under investigation. In a final group testing session, subjects were tested for field dependence--independence using the Group Embedded Figures Test.
Data Collection

Several other characteristics related to specific individual differences were assessed during the study for which no objectives or hypotheses were stated. These were, however, variables which were thought to have a special relationship to the phenomena under investigation. The purpose of this data collection, therefore, was exploratory and will perhaps provide bases for future research. Data was collected for the following variables: sex, cerebral dominance, familial history of handedness, handedness, field dependence-independence, vividness of imagery, and eidetic imagery ability.

Subjects

The subjects were male and female undergraduate University student volunteers ranging in age from 18 to 22 years. They were drawn from the Introductory Psychology 100 course pool and received credit toward their final grade for their participation in the study. Forty subjects were randomized into two stimulus testing groups. Twenty formed a group which was exposed to the real display of objects (the Real Group), and the other twenty formed a group which was exposed to the photographic slide of the display of objects (the Photo Group). Each group contained ten male and ten female subjects. All subjects were checked to determine that their vision (visual acuity) was corrected (a verbal report from the subject) and sufficient to perform the tasks.

Each subject was tested individually in an approximately two-hour testing session. At a later date, all subjects attended one of four group testing sessions where the Group Embedded Figures Test was
administered. A small pilot study was conducted prior to the actual study involving six male and female subjects from the University community to ensure proper functioning of the recording equipment and to finalize procedures. These subjects viewed the real object display only.

**Materials**

**Display Box**

A plywood display box was constructed and lined with textured cardboard; the inside dimensions of the cardboard scene measured 40 x 60 x 75 cm. (See Plate I, p. 48). The box was open at the front and top, and had an adjustable chinrest mounted in front of the center of the box so that the subject viewed the display from a distance of 65 cm. A slot at the front of the box held a sheet of black cardboard which was used as a cover.

**Screen**

A rear-projection screen mounted on a piece of clear glass was masked to allow a screen size of 40 x 60 cm. which was equal to the front planar projection of the real display. The subjects were stationed at an identical viewing distance (65 cm.) and angle (center) in front of the screen to those who viewed the box. A Kodak Carousel projector was used to rear-project the slides.

**Objects**

Four small plastic toys—a dog, a man, a chair, and a grill—were suspended at different positions in the display from near invisible nylon threads from 87.5 x 3 cm. strips of wood laid across the top of the display box (See Plate I, p. 48). On the center of
PLATE I. Display Box.

PLATE II. Recording Equipment
each was fixed a gold star 1.25 cm. in diameter. The objects were hung in the display so that the two and three-dimensional interobject distances were poorly correlated (r=.30), and so that the interobject distances were approximately an integral number of lengths apart.

Photographic Slides

Color 35mm slides of the four object display and twenty practice configurations of the display which were used in the positioning practice phase were rear-projected onto a rear-projection screen mounted on glass. Ninety-five slides in total were used.

Measuring Materials

1. Two pushbutton keys, one labeled TRUE, the other FALSE
2. A relay controllable stereo tape recorder
3. An electronic millisecond timer
4. A 5 x 8 cm. dowel rod

Introduction

The procedures were divided into four phases to aid in execution and description. Phases I, II, and III involved the eidetic scanning task, the image positioning practice task, and the imagery scanning task respectively. Phase IV involved the collection of individual differences data and the perceptual estimation task. Prior to beginning each testing session, the experimenter read to the subject a description of the study and procedures that were to follow (See Appendix B, p. 125). In all phases, instructions were read to the subjects.
Phase I. Eidetic Imagery Scanning Task

All subjects were shown a 25 x 25 cm. red square on a neutral gray piece of cardboard; they were asked to stare at the center of the red square for 15 seconds. The square was removed after this interval, and the subject was asked to continue looking at the neutral card and to report what he/she saw. The experimenter recorded whether or not the subject saw a green square afterimage. Next, a picture of a spice rack with a varying number of bottles on three shelves was shown to the subjects (See Appendix C). Some bottles were full, some empty. After 15 seconds the picture was removed, and the subject was asked if he/she "saw" the picture on the gray card in the same way he/she "saw" the green square. Although the eidetic image of the spice rack would be positive and not negative as in the afterimage of the red square, the viewing of the image projected onto a surface is the same in both tasks. (If subjects didn't see the green square in the task involving afterimaging the red square they were just asked if the "saw" the picture.) Then, he/she was asked to close his/her eyes and image the picture. Next, he/she was asked to count the number of bottles filled on each shelf by scanning the picture by row, top to bottom, left to right. He/she then was asked to count the total number of bottles on each shelf. Scores were recorded for each row of filled bottles, the total number of bottles filled, and the total number of bottles. Finally, he/she was asked whether he/she used an imagery strategy (i.e., searching his/her mental image for information) or a verbal strategy (i.e., counting the number of bottles and remembering the number).
Phase II. Image Positioning Practice Task

This Phase involved a practice task similar to the Pinker and Kosslyn (1978) and Pinker (1979, in press) procedures of having the subject calibrate the accurate position of each object in his/her mental image, so that a consistent position of the objects in the image was established to form the basis for a reliable scanning procedure which followed. In the real object stimulus condition, the display was viewed by the subject. After a sufficient time, when the subject reported that he/she was able to form an accurate image of the entire display, an object in the display was pointed out by the experimenter; the subject was asked to form a precise mental image of this object's position. Then the object was moved to one of a set of randomly selected positions by the experimenter. The subject was asked to close his/her eyes when the experimenter was moving the object; there was approximately a 5 second interval between each move. The randomly selected positions were at three, 5cm. intervals to each side (horizontally); at two, 5cm. intervals forward and backward; and at two positions at 45 degree angles forward; and at two 45 degree angles backward of the original position. The subject was asked to indicate when the experimenter moved the object to a position that matched the original one he/she had fixed in his/her image. This procedure was repeated for each object; then, all of the objects were moved to randomly selected positions simultaneously. The subject was required to select from a series of groupings where all the objects were moved, a grouping which matched the original configuration he/she had memorized. A record of the number of trials to correct
placement for each object and the group of objects was kept for each subject.

In the slide stimulus condition, the same procedure was followed as above, except that the subject viewed a color slide of the configuration of the same objects in identical positions as in the real object stimulus condition. An important difference in the instructions to the subject's who viewed the slides was that they were instructed to view the scene as if it were real; they were instructed to image the pictured scene. (See Image Positioning Task Instructions--Photo Group in Appendix B, p.129.) The subject was asked to position each object and the entire configuration of objects as in the above Group; an identical randomly selected sequence of positions varying similarly in 5cm. intervals within an identical span forward, backward, sideways, and at 45 degree angles was presented in a series of slides. The slides were presented at approximately 5-second intervals, and the subject was asked to close his/her eyes between slide changes. The number of trials to correct placement was recorded as above.

Phase III - Image Scanning Task

The image scanning trials consisted of seven blocks of eight trials each, six interobject scans plus two false trials (where the second object named in a pair was not in the display). (See Image Scanning Trials Form in Appendix B, p.130.) Trials in the first block served as practice and were not counted as data; a total of thirty-six scan times in the next six blocks were recorded for analysis. The false trials in which the second object named was not in the display served as a decoy and as a control. The trials were
randomly ordered and counterbalanced as to object named first within blocks; two constraints were that no destination object could appear in two consecutive trials and no object could appear in three consecutive trials.

Instructions were given to the subject to close his/her eyes, to image the display, and to place his/her nondominant hand on the button marked FALSE and his/her dominant hand on the button marked TRUE (the buttons were placed on the appropriate side of the subject). The subject was told that the names of pairs of objects in the display would be played on a tape recorder. Upon hearing the first word of the pair, the subject was instructed to "focus" his/her attention on that object in the display, keeping the entire display in view in his/her mental image (just like they were "seeing the display). Upon hearing the second name of the pair, if the object was in the display, the subject was to immediately scan to the second object by following an imagined, small black dot, moving smoothly at a constant rate of speed from the star on the first object to the star on the second object. When the imaged moving dot arrived at the star on the second object, the subject was instructed to depress the TRUE button. If the second object named was not in the display, the subject was instructed to depress the FALSE button.

After the instructions were read to the subject, the subject was given four to six practice trials. Then, the subject was asked to repeat the instructions to the experimenter. After the experimenter was certain that the subject understood how to perform the task, the experimenter started the tape. The first name of an object pair was
recorded only on one channel of the tape; after four seconds duration, the second name was recorded on channels one and two. The output from channel two stopped the tape recorder after a slight delay, and simultaneously started the millisecond timer. When either button was depressed by the subject, this stopped the millisecond timer and restarted the tape recorder proceeding to the next trial (pair of object names). There was approximately a five second interval between each trial. The experimenter then recorded the reaction time and reset the millisecond timer (See Plate II, p. 48). Instructions for both the Real and Photo Groups were identical except that the Photo Group was instructed to perform the task on their image of the pictured, real scene. (Otherwise, it was confusing as to whether they were to scan the picture surface or between the objects pictured.)

Phase IV. Perceptual Distance Estimation Task

After Phase III, the subjects were given approximately a fifteen-minute break during which they were asked to fill out the Post-test Questionnaire (See Appendix C, p.135) which assessed their performance in the imagery scanning task and which was used to collect individual difference data. Also, they were asked to complete a vividness of imagery questionnaire. Their sex and writing position (a test of cerebral dominance) were recorded by the experimenter at the time they filled in the questionnaire (See Personal Data Sheet in Appendix C, p.134). The writing position assessment simply involved noting the position in which the pencil was held when writing and was scored
categorically as either right hand normal, left hand normal, right hand inverted, or left hand inverted by the experimenter.

After the break, all subjects were asked to perform a perceptual distance estimation task. The subject was asked to pick up and examine a 5 x .8 cm. segment of a wooden dowel rod. The dowel rod segment was then placed near where the subject could see it. The subject was then asked to view either the real object display or the slide (according to the stimulus group they were in), and to estimate the number of rods that could fit end to end between all object pairs to the nearest half rod. These pairs of objects were in a preset random order. Their answers were recorded in centimeters (See Personal Data Sheet in Appendix C, p. 134).

After Phase IV, each aspect of the study and the subject's performance in the study was discussed in detail with each subject, and any questions concerning any part of the study were answered by the experimenter. Also, at that time, the Post-test Questionnaire was reviewed by the experimenter and subject to clarify the subject's answers, and to ask the subject to elaborate on his/her answers, if necessary. Finally, each subject was asked to sign a permission slip allowing the experimenter to have access to his/her American College Test scores (See ACT Score Permission Form in Appendix C, p. 138).
CHAPTER IV
DATA ANALYSIS

Imagery Scanning Task

Results for the Total Real and Photo Groups

Although former studies, Pinker and Kosslyn (1978) and Pinker
(1979, in press), did not report data from all subjects (subjects
were deleted if they could not perform the scanning task), the cor-
relations for the total group of subjects in each stimulus group (those
exposed to the real object display, the Real Group, and those exposed to
the photographic slides, the Photo Group) will be reported in this
study. This will allow for comparison of the results from a total
sample of subjects in each group with the results of subgroups formed
within each group according to ability to scan.

The Pearson product-moment correlations for all subjects in the
Real Group (N=20) between the mean interobject scanning times and the
three-dimensional (3-D) interobject distances is .95 (p<.01) (See
Figure 2 in Appendix A, p.108). The correlation between the mean
scanning times and the mean interobject distances in the two-
dimensional (2-D) plane perpendicular to the line of sight is lower
and not significant, r=.56 (See Figure 3 in Appendix A, p.109). The
partial correlation between mean scanning times and 3-D interobject
distances, holding the 2-D distances constant, is even higher, r=.99
(p<.001); the partial correlation between mean scanning times and
2-D distances, holding the 3-D distances constant is lower, r=.86
(p<.05).

56
In the Photo Group (N=20), the Pearson product-moment correlation between the mean interobject scanning times and the 3-D interobject distances was low, $r=.36$ (See Figure 4 in Appendix A, p.110). The correlation between mean scanning times and 2-D interobject distances on the planar projection was $.93$ ($p<.01$) (See Figure 5 in Appendix A p.111). The partial correlations are $.61$ for the mean scanning times and 3-D interobject distances, holding the 2-D distances constant, and $.93$ ($p<.01$) for the mean scanning times and 2-D distances, holding the 3-D distances constant.

See Table 1 below for a summary of the findings for the overall stimulus groups. These findings demonstrate that the type of stimulus from which images are derived (in this case a real object display and a photographic slide) has a very different effect on the spatial representation in visual mental images.

**TABLE 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>Correlations for MST$^1$ and 3-D Interobject Distances</th>
<th>Correlations for MST$^1$ and 2-D Interobject Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real</td>
<td>.95*</td>
<td>.56</td>
</tr>
<tr>
<td>Photo</td>
<td>.36</td>
<td>.93*</td>
</tr>
</tbody>
</table>

MST$^1$ = Mean Scanning Times  
*$p<.01$
Results for Scanners and Non-Scanners

The Real Group (those who performed the imagery scanning task while viewing a display of real objects) and the Photo Group (subjects who performed the imagery scanning task while viewing a photographic slide) were further broken down into subgroups on the basis of whether they were able to perform the imagery scanning task. Based on the following criteria, subjects in both stimulus groups were classified as Scanners (N=10 in the Real Group; N=13 in the Photo Group):

1) Ability to perform the scanning in at least 60 percent or more of the trials.

2) Ability to use a visual imagery strategy only (e.g., picture the display mentally and scan using a small, imaginary black dot)

3) Ability to follow scanning instructions properly.

Subjects who did not meet one or more of the above criteria were classified as Non-scanners (N=10 in the Real Group; N=7 in the Photo Group). The classification of subjects to these subgroups was determined by questions 1, 2, and 3 on the Post-test Questionnaire (See Post-test Questionnaire in Appendix C). Criteria 1 and 2 above are identical to those used by Pinker and Kosslyn (1978) and Pinker (1979, in press) in their studies; subjects who did not meet Criteria 3 above scanned in curved paths and scanned 2-D distances, although they were aware of the instructions to scan the actual metric distances. This deliberate 2-D scanning occurred in both Groups, Photo and Real; it is a question for future research, however, to investigate why some persons who view a real 3-D display opt to scan 2-D distances in this type of task. Perhaps the pictorial nature of the
scene (i.e., integrating many pictorial cues into a display as was done here) or the poor correlation between the 3-D and 2-D inter-object distances is associated with the 2-D scanning of the real display. Subjects who did scan 2-D deliberately in both stimulus conditions stated that they did not know why they scanned 2-D or that they did this because it was "easier."

Steven Pinker (personal communication) stated that he discarded approximately two out of every ten subjects due to the fact they did not meet his scanning criteria; twenty percent were dropped from studies he has been involved with. In this study, 42.5% of the subjects could not perform the imagery scanning tasks adequately. Factors in the populations or in the research methodology in the two different studies that might account for this difference have not been identified.

Research Hypothesis. In support of the research hypothesis in this study, the Pearson product-moment correlation between mean scanning times and the 3-D interobject distances for the Scanners in the Real Group was in the predicted positive, linear direction and was very high, \( r = .98 \) (\( p < .001 \)). Individual subject's correlations between scanning times and 3-D interobject distances ranged from .51 to .98. In contrast, the correlation between mean scanning times and 2-D interobject distances in the planar projection for this subgroup was only moderate and not significant, \( r = .44 \). Individual subject's correlations between scanning times and 2-D distances ranged from -.45 to .81. The partial correlation between mean scanning times and 3-D distances, holding the 2-D distances constant, is .99 (\( p < .001 \)).
projection is a high, positive and linear one, r=.96 (p<.01). The correlations of individual subjects for these two variables ranged from -.34 to .92. The partial correlation between mean scanning times and 3-D distances, partially out the 2-D distances, is .42. In contrast, the partial correlation between mean scanning times and 2-D distances, partialling out the effect of 3-D distances, is .96 (p<.01). Thus, strong evidence is presented for the relationship of 2-D distance in the images of persons viewing a photographic slide, although the subjects exposed to the photographic stimulus displayed a greater amount of variability in the relationship of their scanning times to both the 3-D and 2-D distances (See Figures 8 and 9 in Appendix A, pp. 114 and 115 respectively).

The Non-scanners in the Photo Group held even less 3-D in their images; the Pearson correlation between mean scanning times and 3-D interobject distances was only .28, and was not significant. In this subgroup, subjects ranged from -.50 to .55 in their correlations with 3-D. The correlation for this subgroup between mean scanning times and 2-D interobject distances was lower than that for the Scanners, but was still significant, r=.86 (p<.05). Individual subject's correlations ranged from -.56 to .86. The partial correlation between mean scanning times and the 3-D interobject distances, holding the 2-D distances constant, is .04. In contrast, the partial correlation between mean scanning times and 2-D distances, holding the 3-D distances constant, is .85 (p<.05) (See Figures 8 and 9 in Appendix A, pp. 116 and 117 respectively).
holding the 3-D distances constant, the correlation between mean scanning times and 2-D distances was not significant, \( r = .79 \) (See Figure 6 in Appendix A, p. 12).

For the Non-scanners in the Real Group, the Pearson product-moment correlation between the mean scanning times and the 3-D inter-object distances was not significant, \( r = .78 \). Individual subject's correlations between these two variables indicated great variability, ranging from \(-.72\) to \(.80\). The correlation between the mean scanning times and the 2-D interobject distances was identical, \( r = .78 \). Individual subject's correlations ranged from \(-.65\) to \(.72\) for these variables. The partial correlations, holding the 3-D and 2-D distances constant, are \(.93\) (\( p < .01 \)). In summary, the Non-scanners in the Real Group displays moderately high but nonsignificant amounts of 2-D and 3-D in their images (See Figures 6 and 7 in Appendix A, pp. 112-113).

Descriptive research. In accordance with descriptive research goals outlined above (See Chapter III, p. 44), this study sought to describe the relationship between mean scanning times between pairs of objects (the amount and type of psychological "distance" between pairs of objects in a mental image) and the actual metric 3-D or 2-D inter-object distances represented in a photographic slide. For the Scanners in the Photo Group, the correlation between the mean scanning times and the 3-D interobject distances is in the low-moderate, positive linear direction, but is not significant, \( r = .40 \). The individual subject's correlations for these variables ranged from \(-.50\) to \(.55\). In contrast, the correlation for this subgroup between mean scanning times and 2-D interobject distances in the planar
Summary. The major findings in terms of Pearson product-moment correlations are summarized in Tables 2 and 3. Table 2 allows for easy comparison of scanning ability and stimulus condition. Scanning ability was not related to distance held in images when a slide was the stimulus as much as it was when the stimulus was real; scanning ability did make a difference in explaining the relationship of stimulus to distance when the stimulus was real. In Table 3, it is easy to discern how the Scanners versus the Non-scanners performed in the two stimulus conditions. The correlations for the Non-scanners are much less meaningful due to the lack of homogeneity in scanning ability among these subjects (e.g., they did not meet the scanning criteria for a variety of reasons). The Scanners in this analysis, then, are more homogeneous; owing to this fact, it is interesting to note almost complete reversal in correlations for the Scanners by stimulus group. Lastly, because the Non-scanners in the Photo Group exhibited a significant relationship between scan times and actual metric distance and the Non-scanners in the Real Group did not, perhaps a pictorial mode such as a slide produces a stronger relationship between distance and imagery.
Summary. The major findings in terms of Pearson product-moment correlations are summarized in Tables 2 and 3. Table 2 allows for easy comparison of scanning ability and stimulus condition. Scanning ability was not related to distance held in images when a slide was the stimulus as much as it was when the stimulus was real; scanning ability did make a difference in explaining the relationship of stimulus to distance when the stimulus was real. In Table 3, it is easy to discern how the Scanners versus the Non-scanners performed in the two stimulus conditions. The correlations for the Non-scanners are much less meaningful due to the lack of homogeneity in scanning ability among these subjects (e.g., they did not meet the scanning criteria for a variety of reasons). The Scanners in this analysis, then, are more homogeneous; owing to this fact, it is interesting to note almost complete reversal in correlations for the Scanners by stimulus group. Lastly, because the Non-scanners in the Photo Group exhibited a significant relationship between scan times and actual metric distance and the Non-scanners in the Real Group did not, perhaps a pictorial mode such as a slide produces a stronger relationship between distance and imagery.
### TABLE 2

Correlations between Mean Scanning Times and 3-D and 2-D Interobject Distances for Stimulus Groups by Subgroups

<table>
<thead>
<tr>
<th>Group</th>
<th>Subgroup</th>
<th>Correlations for MST(^1) and 3-D Interobject Distances</th>
<th>Correlations for MST(^1) and 2-D Interobject Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real</td>
<td>Scanners</td>
<td>.98(^{*})</td>
<td>.44</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.78</td>
<td>.78</td>
</tr>
<tr>
<td>Photo</td>
<td>Scanners</td>
<td>.40</td>
<td>.96(^{**})</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.28</td>
<td>.86(^{***})</td>
</tr>
</tbody>
</table>

\(^{1}\)MST = Mean Scanning Times  
\(^{*}\)p < .001  \(^{**}\)p < .01  \(^{***}\)p < .05

### TABLE 3

Correlations between Mean Scanning Times and 3-D and 2-D Interobject Distances for Subgroups by Stimulus Groups

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Group</th>
<th>Correlations for MST(^1) and 3-D Interobject Distances</th>
<th>Correlations for MST(^1) and 2-D Interobject Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanners</td>
<td>Real</td>
<td>.98(^{*})</td>
<td>.44</td>
</tr>
<tr>
<td></td>
<td>Photo</td>
<td>.40</td>
<td>.96(^{**})</td>
</tr>
<tr>
<td>Non-Scanners</td>
<td>Real</td>
<td>.78</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td>Photo</td>
<td>.28</td>
<td>.86(^{***})</td>
</tr>
</tbody>
</table>

\(^{1}\)MST = Mean Scanning Times  
\(^{*}\)p < .001  \(^{**}\)p < .01  \(^{***}\)p < .05
Results for False Scan Trials

False scanning trials in which the subject was asked to scan an object that was not in the display were included in the testing to disguise the exact nature of the study and to provide some indication of the subject's attentiveness. Since no scanning was required during these trials, reaction times in the false scan trials should be shorter than the reaction times in the true scan trials on the average. The mean false scan times are presented in Table 4 below.

<table>
<thead>
<tr>
<th>Real Photo</th>
<th>Real Group</th>
<th>Photo Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanners</td>
<td>Non-Scanners</td>
<td>Scanners Non-Scanners</td>
</tr>
<tr>
<td>828.9 918.8</td>
<td>795.8 862.6</td>
<td>887.7 978.4</td>
</tr>
</tbody>
</table>

All of the mean false scan times of all the groups are below the mean scanning times for object pairs within each group. Between groups, however, this is not the case; the one exception is that the mean scan false time for the Non-scanners in the Photo Group is equal to the mean scanning time for the shortest distance object pair in the Real Scanners Subgroup (X=978.4). It is inconsistent that a reaction time requiring no scanning time would be equal to a reaction time plus a scanning time of even a short distance. Two factors might account for this discrepancy: a difference in information processing time due to factors related to a non-real stimulus (e.g., a photographic slide) such as lack of vividness, or inattentiveness. Lack of concentration or inattentiveness was a
frequent reason given in the post-test interview for scanning less than 60 percent of the time and may account to the slow reaction times for Non-scanners in interaction with stimulus related factors. Analysis of variance procedures were performed to see if significant differences in reaction times for false scans existed between Groups and Subgroups; there were no significant findings.

The false scans may have been effective as a decoy, because no subjects were able to deduce the exact nature of the hypothesis under investigation. When queried as to why they performed the scanning on the Post-test Questionnaire (See Appendix C, p.135), no subject stated clearly that his/her scanning was related to an interval of time that was being measured to be subsequently correlated with interobject distances. Seven subjects stated that distance was related to scanning, but time was not mentioned by these subjects as a factor. Two subjects mentioned a relationship between distance and time, and only one related these two factors to time of pressing the button. It is doubtful that these two subjects adjusted their scanning times during the task; one of these subjects could not even perform the scanning 60 percent of the time. The other subject did not report adjusting her times deliberately. Because the number of subjects who possibly deduced the exact nature of the testing was so small, coupled with the findings of Pinker and Kosslyn (1978) and Pinker (1979, in press) that dropping subjects who deduce the nature of the task does not lower correlations, it was decided by the experimenter not to exclude these subjects from the data pool. The
evidence seems to exist that this imagery scanning task does not allow for adjusting times deliberately during the task.

Results for Image Positioning Task

The image positioning task required subjects to position each object in the display in his/her mental images. The number of trials necessary to position each object and the group of objects correctly was recorded for each subject. A significant difference between the Real and Photo Groups was found for the positioning of the first object only which was the chair, $F(1,38) = 4.50, p<.05$. The mean number of trials for the Real Group (N=20) was 2.35; the mean number of trials for the Photo Group was 1.25. The Photo Group was almost twice as accurate in the positioning task involving the first object. There were no significant findings between the Scanners and Non-scanners within the stimulus groups. It appears easier to position an object on a 2-D surface relying on planar surface/pictorial cues than cues in a 3-D display. (See Chapter V, p. 92 for a more complete explanation.) A practice effect for the subjects in the Real Group may account for the lack of differences for the subsequent positioning of objects.

Image Scanning Rates

The slopes of the best fitting lines in the correlations for the Scanners in the Real and Photo Groups are estimates of the image scanning rate. These are presented in Table 5.
### TABLE 5
Scanning Rates in Msec/Cm for 3-D and 2-D Distances by Stimulus Group

<table>
<thead>
<tr>
<th>Group/Subgroup</th>
<th>Scanning Rates for 3-D Distances</th>
<th>Scanning Rates for 3-D Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Scanners</td>
<td>8.33</td>
<td>24.43</td>
</tr>
<tr>
<td>Photo Scanners</td>
<td>2.19</td>
<td>33.98</td>
</tr>
</tbody>
</table>

The image scanning rate of 8.33msec/cm is much slower than expected from past research. Pinker and Kosslyn (1978) reported a scanning rate of 35msec/cm; Pinker (in press) reported a 34msec/cm scanning rate. The 3-D scanning rate for the Real Group and the 2-D scanning rate for the Photo Group are the scanning rates of real significance because these are the distances that the majority of the respective group/subgroup members actually scanned. The 33.98msec/cm scanning rate for the Scanners in the Photo Group is much nearer that reported in past research. This is due to shorter distances scanned in the Photo Group. These distances are more comparable to those used in past research; Pinker and Kosslyn's (1978) longest distance was 40 cm. The longest distance in this study was approximately 59 cm. The evidence suggests, then, that the longer the distance scanned (i.e., the distances scanned by the Scanners in the Real Group), the slower the scanning rate.
Perceptual Distance Estimation Task

In order to compare the amount of distance in perception to the amount of distance in visual mental imagery, subjects were asked to give distance estimates between identical pairs of objects in a perceptual distance estimation task, and the data from this task was subsequently analyzed in a similar way to that of the imagery scanning task. Pearson product-moment correlations were calculated by stimulus groups, Real and Photo, and subgroups according to scanning ability, Scanners and Non-scanners. These correlations between mean perceptual estimations and 3-D and 2-D interobject distances are presented in Table 6 below (See Figures 10-17 in Appendix A, pp. 116-123.)

Table 7 below presents a comparison of the correlations between two sets of mean psychological "distances," one derived from a scanning technique and the other from a mental "yardstick" technique, and actual metric 3-D and 2-D interobject distances. One can discern that the effect of the stimulus is the same regardless of the cognitive function--imagery or perception. In the real object display, more 3-D space is represented in perception/imagery; with the photographic stimulus, more 2-D distance is represented. In addition, it is interesting to note that the subjects classified as Non-scanners in the Real Group performed quite predictably in the perceptual task; their problem in the imagery task was most likely not lack of depth perception. Some unknown factor in the demand characteristics of the imagery task or in their imagery ability (or a combination of these) is to account for the lack of distinct space in their images. Also, the higher correlation for the 3-D perceptual task as compared to the
### TABLE 6
Correlations between Mean Perceptual Distance Estimations and 3-D and 2-D Interobject Distances

<table>
<thead>
<tr>
<th>Group</th>
<th>Subgroup</th>
<th>Correlations for MPE and 3-D Distances</th>
<th>Correlations for MPE and 2-D Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real</td>
<td></td>
<td>.99*</td>
<td>.31</td>
</tr>
<tr>
<td>Photo</td>
<td></td>
<td>.61</td>
<td>.92**</td>
</tr>
<tr>
<td>Real</td>
<td>Scanners</td>
<td>.98*</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.99*</td>
<td>.25</td>
</tr>
<tr>
<td>Photo</td>
<td>Scanners</td>
<td>.68</td>
<td>.89**</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.44</td>
<td>.94**</td>
</tr>
</tbody>
</table>

\( ^1 \text{MPE} = \text{Mean Perceptual Estimations} \)

* \( p < .001 \)  ** \( p < .01 \)
<table>
<thead>
<tr>
<th>Group</th>
<th>Subgroup</th>
<th>Correlations with 3-D Distances - Imagery Task</th>
<th>Correlations with 3-D Distances - Perception Task</th>
<th>Correlations with 2-D Distances - Imagery Task</th>
<th>Correlations with 2-D Distances - Perception Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real</td>
<td>Scanners</td>
<td>.98*</td>
<td>.98*</td>
<td>.44</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.78</td>
<td>.99*</td>
<td>.78</td>
<td>.25</td>
</tr>
<tr>
<td>Photo</td>
<td>Scanners</td>
<td>.40</td>
<td>.68</td>
<td>.96**</td>
<td>.89**</td>
</tr>
<tr>
<td></td>
<td>Non-Scanners</td>
<td>.28</td>
<td>.44</td>
<td>.86***</td>
<td>.94**</td>
</tr>
</tbody>
</table>

*p<.001  **p<.01  ***p<.05
3-D imagery task for the Scanners in the Photo Group gives evidence that images are flatter than percepts when derived from a Photo stimulus.

Individual Differences

One of the objectives of this study was to investigate how spatial representation in mental visual imagery would relate to several individual differences. Two different approaches were possible in this study. The first was to search within the Scanners in the Real and Photo stimulus conditions. For example, it might have been possible to search for individual differences in the Real Scanners subgroup between subjects who had a high amount of 3-D space in their images and those who had an insignificant amount; unfortunately, there were not enough subjects who fell into the low category to investigate individual differences in this manner. In the Photo Group, there also were not enough subjects who had low amounts of 2-D space in their images to warrant investigation. Instead, grosser kinds of analyses were done such as looking for individual differences between stimulus conditions, between Scanners and Non-scanners, and between sexes. The variables related to individual differences in imagery investigated in this study were: sex, vividness of imagery, field dependence-independence, scholastic abilities (math, English and overall), eidetic imagery ability, handedness, and cerebral dominance.

Vividness of Imagery

The major finding related to individual differences in this study was in the area of vividness of imagery. On the Post-test
Questionnaire, subjects were asked to rate their vividness of imagery of the objects in the imagery scanning task they had just completed. (See the Post-test Questionnaire in Appendix C). The rating scale was a 1-5 point scale of vividness of imagery (1 being the most vivid, 5 the least vivid) which was identical to the scale used in the Vividness of Imagery Questionnaire (Marks, 1973b). A one-way analysis of variance indicated no differences between the Real and Photo Groups. However, when the subjects were broken down into Scanners and Non-scanners across groups, a one-way analysis of variance revealed a significant difference in favor of the Scanners, $F(1,38) = 5.78$, $p<.05$. A three-way analysis of variance between sex, stimulus group, and scanning ability (Scanners and Non-scanners) showed main efforts for scanning ability only, $F(1,32) = 4.60$, $p<.05$, and no interactions. Further analysis was necessary to see if the effect of vividness of imagery was due to sex differences, since more females were able to scan and females have been shown to have more vivid imagery in past research. A two-way analysis of variance revealed a significant main effect for scanning ability only, $F(1,36) = 4.61$, $p<.05$; main effects for sex approached but did not reach significance.

The Vividness of Imagery Questionnaire (Marks, 1973b) revealed less about the relationship between spatial representations in images and vividness of imagery. The VVIQ consists of vividness ratings (a 1-5 point scale) pertaining to situations that the subject has experienced (e.g., imaging a store window of a shop that one frequents). It appears that this instrument measures a combination of the vividness
of daydream (anticipatory) and memory type of imagery. There are 16 items to be rated on the VVIQ, so the range of possible scores is 16-80. The mean score for the overall sample was 34.4. The range was 19-62, S.D.=11.41. Pertaining to subgroups, there was almost twice as much variance in the Non-scanners as scores as in the Scanners. The mean score for Scanners was 32.2; the mean for Non-scanners was 36. One-way analysis of variance procedures showed no significant differences between groups, subgroups, or sexes. Curiously a cross tabulation indicated that a larger percentage of subjects who used an imagery strategy as opposed to a verbal strategy in an eidetic imagery scanning task also scored in the low range (were high imagers) on the VVIQ. There may be a relationship between predisposition to use an imagery strategy in recalling pictorial material and vividness of daydream/memory type of imagery.

Related to the issue of vividness of imagery is ease of imaging. On the Post-test Questionnaire (See Appendix C), each subject was queried as to which object or objects were easiest to image and why. The dog was mentioned 19 times as the easiest to image for reasons such as association (e.g., they had a dog that looked like it), color, and closeness to the grill. The chair was mentioned 17 times as easy to image due to the color, size (larger), closest object to subject, and other reasons related to its position. The grill was mentioned 12 times as easy to image for reasons related to closeness to the dog, dark color, or position. The man was the least easy to image and was mentioned 11 times for reasons relating to associations (e.g., he
looked like my cousin), to size, to color, to position, and to realism. Four subjects said that the objects were equally easy to image. One said none was easy to image.

Pertaining to the reasons why an object was easy to image, subjects gave color as the reason for easy imaging 16 times—more than twice as often as any other reason. These color-related reasons varied as to differences about the color that made imaging easy. Answers included brightness of the color, solidness of the color, and darkness of the color. Seven subjects mentioned the dog and grill were easiest to image because these objects were close together and could be "chunked" together. Other reasons given that objects were mentioned as easy to image were closeness to subject (6 times), associations with real objects (5 times), complexity/detail of object (4 times), size (3 times), position of object in scene (4 times), realism (1 time), and commoness of object (1 time).

Sex

The Real and Photo Groups were equally divided by sex, 10 males and 10 females in each. Their performance in the imagery scanning task, however, assigned them to scanning ability groups, Scanners or Non-scanners. More males (N=7) were classified as Scanners in the Photo Group as in the Real Group (N=3). This difference for males in favor of them being better Scanners when a slide is the stimulus approached significance, Fisher's Exact Test = .09. Females were more often Scanners in the Real Group (N=7); in the Photo Group, they were about equally often Scanners (N=6) and Non-scanners (N=4).
Field Dependence-Independence

The Group Embedded Figures Test (GEFT) was given to all subjects in group testing sessions to test for field dependence-independence. This test involves tracing a simple geometric form hidden in a more complex geometric line drawing. The total score possible is 18. Subjects at the low end of the range are considered more field dependent, and those at the high end are more field independent. The range of scores obtained was 17 (1 minimum, 18 maximum). The mean was 11.8, mode 17. The sample was skewed positively, 45 percent of the scores falling between 14-18. The mean score for males was 14.15; the mean score for females was 9.5. This finding was significant, $F (1,38) = 9.88, p<.01$, and consistent with data found by Witkin, Oltman, Raskin, and Karp (1971) for sex differences for the GEFT. A three-way analysis of variance for the GEFT by stimulus group, scanning ability, and sex revealed significant main effects for sex only, $F (1,32) = 8.70, p<.01$, and no interactions.

Eidetic Imagery Scanning Task

An eidetic imagery scanning task was given to each subject before the main task (the imagery scanning task). There were two scores in this task—the total number of filled bottles and the total number of bottles in a line drawing of a spice rack (See Appendix C). Twelve subjects did not use an imagery strategy during the task and their data were discarded. Of the 23 subjects who used an imagery strategy in the task, only 5 scored correct answers on the first eidetic task, and only 3 scored correctly on the second task. Broken down into Scanner and Nonscanner subgroups in the two stimulus conditions (Real and Photo),
there are too few correct scorers in each to analyze their results in relationship to other variables. Four subjects responded in the task in an eidetic manner (stated they could see the picture like the green square). These subjects varied greatly in their responses on the imagery tasks; they did not perform significantly different from others in their group.

A curious finding in the eidetic task was that of the 40 subjects, 13 did not see the green square afterimage. Seven of these were Scanners, and six were Non-scanners. More Scanners (N=16) could see an afterimage than Non-Scanners (N=11). These differences, although not significant, might indicate a trend that would warrant further investigation to see if these peripheral processes might be associated with central processing tasks.

Other Individual Differences Findings

There were no significant findings for the ACT scores in relation to any of the variables related to imagery scanning. A three-way analysis of variance between the Math ACT score and stimulus condition, scanning ability, and sex revealed a main effect for sex only, $F(1,31) = 4.01, p<.05$.

Only seven subjects were left-handed (N=2) or ambidextrous (N=5). Five of these were Scanners, and two were Non-scanners. Levy and Reid (1976) found that people who write holding the pencil in an inverted position have hemispheric dominance ipsilateral to the preferred writing hand. Those who write holding their pencil in a normal position show contralateral hemispheric dominance to the
preferred writing hand. Using this method, only 3 right-hemisphere-
dominant subjects were identified in this study; all of these subjects
used an imagery strategy in the eidetic task, but the number is too
few from which to draw conclusions.

Scanners included 157 right-handed family members, 5 left-handed
family members, 2 ambidextrous family members, and 35 members of un-
known handedness. The Non-scanners had 101 right-handed family
members, 9 left-handed family members, 0 ambidextrous members, and 27
family members of unknown handedness. Because the Non-scanners had
an unexpectedly larger number of family members who are left-handed,
perhaps further investigation of family handedness and imagery ability
and imagery scanning ability is warranted.

**Discriminant Function Analysis**

A Discriminant function analysis procedure was done to see if
there were any distinguishing characteristics between Scanners and
Non-scanners in both the Real Group and the Photo Group. Discriminant
functions were calculated to investigate how groups/subgroups differed
on the following variables: GEFT, VVIQ, English ACT score, Math ACT
score, and the composite raw ACT score. The findings showed no
significant differences between the Scanners and Non-scanners in the
Real Group or between the Scanners and Non-scanners in the Photo
Group.

**Summary**

The major findings of the study are listed below:

1) There was a high, positive, linear correlation between mean
scanning times and 3-D interobject distances for the Total Real Group.
2) There was a high positive, linear correlation between mean scanning times and 2-D interobject distances for the Total Photo Group.

3) There was a high positive, linear correlation between mean scanning times and 3-D interobject distances for subjects able to scan images derived from a real object display.

4) There was a high positive, linear correlation between mean scanning times and 2-D interobject distances for subjects able to scan images derived from a photographic slide.

5) The longer the distance scanned in an imagery scanning task, the slower the scanning rate.

6) There were high positive, linear correlations between mean perceptual estimates and 3-D interobject distances for Scanners and Non-scanners who viewed a real object display.

7) There were high positive, linear correlations between mean perceptual estimates and 2-D interobject distances for Scanners and Non-scanners who viewed a photographic slide of a display of objects.

8) In an imagery scanning task, there was a positive relationship between ability to scan images (and, therefore, accurate spatial representation in imagery) and vividness of imagery of objects in the display.

9) Color was reported most often as the reason for ease of imaging; color may be related to ease of imaging.

10) There was a significant difference in favor of females on the Group Embedded Figures Test.
11) There was a main effect for sex and Math ACT scores.
12) The Non-scanners had more familial history of left-handedness than Scanners.
CHAPTER V
CONCLUSIONS

Introduction

The present correlational research was undertaken to determine spatial representation in the visual mental imagery of subjects who viewed a real display of objects or a photographic slide of an identical display of objects. More specifically, the overall objective was to describe the relationship between spatial representation in images and actual three-dimensional (3-D) and two-dimensional (2-D) distance resulting from different stimuli, one unmediated (a real, live display) and one mediated (a photographic slide). First, the conclusions related to specific objectives will be summarized below. Next, directions for future research will be presented. Finally, theoretical implications in the areas of imagery, pictorial perception, and educational media will be discussed.

Objectives and Conclusions

The first objective was to replicate the findings of past research (Pinker and Kosslyn, 1978; Pinker, 1979, in press). Initially, the question arose as to whether other studies in other locations with different populations and and experimenters could expect to find the same spatial representation in imagery as was found by the original experimenters. Was this a phenomenon that would be found in similar subjects universally? The answer to this question is affirmative with one qualification. The qualification arises from the number of
subjects (50%) who could not perform the scanning in this study. But, in the Real Group, even when subjects who could not perform the task were included in the data analysis, findings comparable to past research were found. Thus, the research hypothesis that there would be a positive, linear correlation between mean reaction times for interobject scans and metric 3-D interobject distances for subject able to scan images in an imagery scanning task using a real object display was confirmed. Although one might speculate about possible differences in overall intellectual ability between subjects at Harvard and at Ohio State (the Harvard subjects being higher due to admission criteria), it did not appear in this study that factors relating to verbal, math, and overall scholastic ability exerted an influence on performance in the imagery scanning task.

Apparently, the small differences in the task used in this study as compared to past studies (Pinker and Kosslyn, 1978; Pinker, 1979, in press) which were larger display size, different image positioning task, different display size, the use of relational size objects, and the pictorial way the objects were displayed did not affect the outcome. The largeness of the display, the longer interobject distances, may account for the slower scanning rate of subjects in this study. This size/distance conclusion was reached because the shorter scans of the Photo Group and those of past research (Pinker and Kosslyn, 1978; Pinker, 1979, in press) were much faster. This positive replication finding was an important initial step in this research, because a basis for comparing the performance of another group of similar subjects using a different stimulus (a photographic
slide) could, then, be performed. It seems reasonable to conclude that in undergraduate populations, ages 18-22, that metric space is preserved in mental images in direct proportion to actual 3-D space when viewing a real, 3-D display.

The second objective of this study was to assess the correlations found between spatial distances in the images of a group of subjects and actual metric distances when the stimulus viewed was a photographic slide. A high, positive relationship was found between mean reaction times (scanning times in msec) and 2-D distances in the planar projection in the images of persons who viewed a photographic slide. As with the Real Group, regardless of whether the subjects could perform the task, the data showed a strong, positive correlation between psychological distance (the mean scanning times between objects) and 2-D interobjects space.

One possibility for the above finding for objective 2, that images from a slide are two-dimensional, is that subjects might perceive in two dimensions, thereby explaining that images are dependent on past percepts and are not constructive in their own right. To explore this possibility, Objective 3 was aimed at comparing a perceptual task with the imagery task to shed light on the question of whether imagery is the same as perception. For the most part, subjects perceived and imaged very nearly the same amounts of distance (3-D for the Real Group subjects, 2-D for the Photo Group subjects). However, in the Photo Group, 3-D perceptual distance estimates were more highly correlated with actual 3-D distances than were their 3-D imagery scans with the actual 3-D distances. A tentative conclusion from the
comparison of the two tasks is that imagery may be slightly destructive; images may hold less space than perception when viewing a slide stimulus. In the imagery scanning task, the Photo Scanners had a lower correlation between mean scanning times and 3-D distances than they had between mean perceptual estimates and 3-D distances. Thus, images from the Photo stimulus was flatter (See page 70). Their percepts had more 3-D space. This finding is related to the Vido et al. (1978) mountaintop study (See p. 22) where visualization was found to be more compressive than perception for estimating distances. Since the imagery scanning and perceptual estimation task in this study were not identical, task differences could account for differences in correlations. Comparisons, then, must be done cautiously, and conclusions drawn should be regarded as tentative.

The fourth and final objective in this study was to collect pertinent data to indicate directions that could be taken to further identify the relationship of individual differences to spatial representation in mental images. The only notable findings was the positive relationship of vividness of imagery during the task as measured on a 5-point scale to scanning ability (Scanners or Non-scanners). Persons who were able to scan images and who were able to hold more 3-D or 2-D space in their images had more vivid imagery of the objects in the task.

Recommendations for Future Research

Based on the results and conclusions of the present research, recommendations for future research can be divided into four major areas: further related replications, individual differences,
structural components of imagery, and comparison studies with other media.

Further Related Replications

Since a replication of the original studies has been successful, larger studies and replications with other ages (e.g., children and older adults) and populations (e.g., illiterates) need to be performed. Also, other tasks/techniques need to be devised to see if there are other methods of measuring the same variable--spatial representation in images. Other methods might be more appropriate than the chronometric technique used in this study for other populations. For example, children might be able to perform a distance estimation task to study space in their images rather than a scanning task which would be too difficult. Presented with a real display of objects, a child could perform a simplified image positioning task to insure that he/she has the objects placed correctly in his/her image. Then, the child could be shown a small familiar object such as a toy car of a known length. In an imagery task, the child could be asked how many of the toy cars could fit in between pair of objects in the display. This estimation could be correlated with the actual metric 3-D and 2-D distances. Two equal groups of children could be used in such a study, one performing the distance estimation task via imagery and the other via perception.

A related replication involving a series of delayed testing might be investigated for persons who can scan real images. This would give information as to the effect of time on space in images, to determine if space shrinks in images in relation to decay time. Subjects could
be tested immediately, a day later, a week later, etc. This design might clarify the question raised by the Vido et al. (1978) study: does the image become compressed due to decay of the image over time or are images more innately compressed. The Pinker and Kosslyn (1978) and Pinker (1979, in press) studies and the replication part of this study involving real objects are evidence that images are not more innately compressed. The Photo Group performance gave some doubts as to the theory: the Photo group displayed a smaller correlation between scanning times and 3-D distances in the imagery task than in the perceptual task. The images held less "workspace." Since no time elapsed after the stimulus viewing, the stimulus is more likely associated with the compression here, however.

Individual Differences

This study has indicated that more investigation of the relationship of vividness of imagery and spatial representation in images is warranted. In this study, the subject's responses on the vividness scale might have been biased by how they felt they performed on the imagery scanning task; a better procedure for future studies would be to assess vividness of imagery in a pre-test. (See Marks, 1972 for a discussion of this procedure.)

Although findings for the interaction of stimulus and sex indicated that males were better scanners when viewing a slide stimulus as opposed to a real object display. It seems warranted to investigate why this was so. A larger study involving males only might shed light on this question.
Replications controlling for spatial relations ability are indicated. Subjects could be divided into high, medium, and low spatial relations ability groups on the basis of one or more spatial relations test. The amount of space in the images of the spatial relations ability groups could then be compared.

In summary, individual differences appear to be evident in the present research study as evidenced by two factors. First, some subjects were not able to or were not disposed to scan 3-D; these were the subjects in the Non-scanner groups who scanned 2-D or who found the task too difficult. These subjects need to be studied in more detail for possible individual differences. Secondly, some individuals who were able to perform the task still did not have positive, linear correlations between their mean scanning times and the actual 3-D distances in their images. As with the first factor above, larger samples need to be studied in terms of individual differences.

Structural Components of Imagery

Other structural components of images might be explored that can be found in perceptual displays--color, shape, intensity of illumination, or textural components, for example. Objective measures and self-report (or a combination) might be employed to describe these structures in images. A combined objective and self-report measure similar in nature to the one used in this study in the form of a matching task might be used to study illumination in images. Subjects could be exposed to a display of objects or a natural landscape display. Then, in an identical display, based on their visual mental images, they could adjust spotlights on the objects to match the amount of
illumination in their images. Correlations could be calculated between amount of illumination in images and actual illumination as measured in footcandles. A self-report measure/post-test interview might be used to assess the vividness of the objects in imagery, control of mental imagery, and history of use of imagery.

Color was revealed in this study to be an important aid to imaging objects. The exact nature of the color factor was not determined. Future research could investigate the effect of color on the spatial manipulations of objects or the amount of distance between imaged objects varying in different color dimensions. Also, a matching task similar to the one described above might be devised where subjects could match color hues to imaged ones.

Comparison Studies with Other Media

In relation to the discussion of the structural components of imagery above, other structural components of imagery (e.g., texture, color) could be investigated in images from other mediated experience such as film, television, and still pictures. More research needs to be done to determine the spatial representation in images derived from other media. In regard to realia, a more natural landscape (one that might be found in a diorama in a classroom) might be investigated by an imagery scanning method such as the one used in this study. Pictorial cues could perhaps be more directly investigated in these.

Television could be used in an interesting way to study movement of objects in mental imagery. A short videotape segment could be recorded of objects moving in different paths, at different rates, and in different ways (e.g., tumbling as opposed to straight). From his/
her image, subjects could move similar objects on a television computer graphics display where he/she could control these factors. Rates, directions, and ways of moving on this reproduction could then be correlated with the original sequence. Perhaps these factors studied in this manner would give more information as to the nature of space in images than the present study. This movement imaging ability might even relate more to problem-solving abilities. As educational technology increases, better methods could be devised to investigate imagery.

Discussion

Imagery Theory

The results of this study will be discussed in terms of related imagery theory, pictorial perception theory, and educational media theory. First, in respect to imagery theory, the structural approach to the investigation of imagery has again been demonstrated in the present study. The nature of mental visual imagery in terms of its spatial characteristics has been described with different subjects, experimenters, locations and stimulus conditions. The finding that images can have structural components identical to percepts in some young adults has an important implication. Imagery can substitute as an alternative process to perception in cognition. Some people have the means to solve spatial problems via imagery. What about the people in this study who could not perform the task, and who do not display 3-D in their images via this technique? Can they solve spatial problems as easily? This study, as well as past studies involving the structures of images, has failed to demonstrate the specific functional significance for the structural characteristic investigated
in this study. The correlation of the amount of spatial representation and specific cognitive abilities (e.g., spatial problem-solving, divergent thinking) is imperative to determine the importance of this structure of imagery. Although Shepard (1978a) has described the role of imagery in problem-solving from a case study approach, and Durndell and Wetherick (1976) have shown that high controllability of visual imagery and self-rated use of imagery during performance are associated with performance on divergent thinking tasks, this investigator is aware of no studies linking achievement to spatial representation in imagery. In fact, spatial features of imagery could be viewed as invariants in the imagery process present in all people to a greater or lesser degree, and as non-essential in problem-solving or other cognitive/psychomotor events. Perhaps verbal process (See Pylyshyn, 1973, regarding propositional aspects of imagery) are just as effective for any spatially-involved endeavor (e.g., math, science, creativity). A subject in this study who claimed to use a verbal (propositional) strategy did not display much depth in her imagery. Now that the chronometric technique of scanning images has proved reliable, more studies need to be done relating space in images to other cognitive abilities.

This investigation supports Neisser's (1972) assertion that equates imagery and perception as identical visual information processors, the only difference being the lack of stimulus input in the former. The persons in this study who were able to scan images demonstrated that similar processes were occurring when they performed the scanning task imaginally as would be occurring if they performed
the task perceptually. This was evidenced by their high correlations between their imagery scans and the actual 3-D distances. Further support was found for the theory that imaginal processes are similar to perceptual processes when in a separate perceptual task they perceived distances between the objects very nearly equal to the actual interobject distances and imagery scans. Also, as noted above, when a subject used a different strategy from an imaginal one in the imagery scanning task, her correlation was not significant, $r = -0.72$.

This study did not attempt to discredit associationist or Gestalt ideas as to the nature of imagery. Several persons in the study reported that the ease of imaging an object was associated with a past memory; some subjects said objects were easiest to image because they were closer together (or "chunked" according to Gestalt theory). What function ease of imaging has to do with the task is unclear; but that past memory images are associated with present percepts and images is evident, and these could affect vividness which was found to increase the likelihood of having 3-D or 2-D space in images depending upon what stimulus is viewed.

Richman, Mitchell, and Reznick (1979) have criticized the Kosslyn (1973) and the Kosslyn, Ball, and Reiser (1978) studies and have suggested the mental travel paradigm biases subjects to use images rather than verbal cues. Richman et al. (1979) performed a study to assess the effect of verbal labels on distance estimates in an imagery task; they found that mileage labels had a strong effect on scanning reaction times. It is a valid argument that subjects may opt to use another strategy than imagery, but that the mental travel paradigm
is a tool which is used to describe the nature of images has been clearly demonstrated. Subjects can use an imagery only strategy.

Richman et al. (1979) also suggested that there are demand characteristics inherent in the model. They performed a non-experiment where subjects were asked the outcome of a mental scanning experiment after reading instructions about how to perform the task. Their results were consistent with a demand characteristics interpretation. This is not the case, however, in the present research because subjects did not realize that scanning was a measurement device; and they did not admit to consciously being aware of altering their scan times and were surprised to find out the true nature of the task. Also, the decoy of false scans aided in diverting their attention on adjusting scan times.

Pictorial Perception Theory

The findings of the present research indicate that undergraduate students when presented with a photographic slide of a scene do not perceive or image the scene in 3-D. The pictorial cues in the slide/display were object height, texture, perspective, relative object size, and brightness. These cues were not effective in aiding subjects in perceiving/imaging depth. This indicates that binocular vision can defeat monocular depth cues even though the subjects were adults with a history of pictorial perception. The objects in the display/photo were not placed in a landscape or layout commonly seen in pictures, so this aspect of past pictorial perception could not apply to this picture. The findings support a "non-reality" theory of pictorial perception, that people cannot perceive depth accurately binocularly
from monocular cues when viewing from the correct station point. The perception of reality that one receives from a slide is not the same as the perception one receives from the real scene.

The findings of this research can be explained in terms of Gibson (1979) and Hagen (1974) theories of pictorial perception, specifically the notion of the two kinds of apprehension—one from the surface of a picture and the other from what is pictured. The subjects who viewed the photo could indicate in the post-test interview the positions of the objects relative to their depth in the display box, despite the lack of depth in their percepts/images. Also, they were instructed to perceive and image the real scene, implying that they should disregard the surface features of the photographic slide and, in fact, the 2-D projection. It is curious, then, why they did not perceive/image more depth.

Part of the answer to the above question may lie in the task itself. The finding of a significant difference in favor of the photo subjects to position the first object in the image positioning task may be related to object size and amount of horizontal placement which are changes which can readily be perceived (imaged) on the surface of the 2-D planar projection (screen). This practice task may have increased the surface features of the slide and, thus, biased the responses in the subsequent image scanning task. That is, the subjects may have gotten so used to "working on" the surface that they were unable to get rid of surface effects when performing the next task. In future research of this nature involving media such as film or photography, the elimination of the object positioning task might be
advised. Perhaps another way of making sure the subject had an accurate mental image of the display of objects could be devised such as a drawing task.

Gibson's view of pictorial perception (Gibson, 1979) states that pictures present a limited optic array. Only some invariants that exist in a real scene can remain in a picture. The present research indicates that 3-D distance which is present in the percept of the real scene is one invariant that is not preserved in a photographic slide of the scene in this instance. In a more familiar scene, with objects placed in a real landscape, perhaps the layout might be such that 3-D would be preserved in the percept and, therefore, in the mental image as well.

Gibson (1979) asserts that imagery is perceiving which goes on without "the constraints of the stimulus flux" (p. 256); imagery is viewed as a perceptual process continuing after the fact, so to speak. He explains that images cannot be scrutinized like mental pictures, and no invariants can be added to the original percept upon which the memory image is based. His imagery theory is constant with a structural approach to imagery, that the structures of the percept appear in the image as well. The present research and the studies of Pinker and Kosslyn (1978) and Pinker (1979 , in press) have shown that the 3-D structures perceived are preserved in the mental image of a real scene, and the 2-D structures perceived in a picture are preserved in the mental image of the picture.
The present study is one of many recent research efforts which aims at investigating the relationship of media to cognition. Specifically, this study has pointed out the relationship of imagery to media (slide photography). The study has shown that a mediated presentation does make a difference as to the amount of 3-D "workspace" that is represented in imagery; a mediated pictorial representation (a slide) lessens the amount of 3-D space in images. It can be extrapolated from this study that if viewers were presented a view of the real world via slides, they would not carry much 3-D space away with them in the form of mental images to work with in cognitive functions such as problem-solving. This form of mediated experience does, then, have cognitive effects.

Other researchers have been formulating theories of media's effects on cognition. Clark (1979) has gathered evidence in a comparison study of different media experiences to support Paivio's dual-coding hypothesis. He demonstrated that spatial geometric designs could be reproduced more accurately when the presentation involved auditory and visual stimuli (as compared to those that were only visual, only auditory, verbal with non-redundant visuals, or print).

The present research can be viewed in relation to Edgar Dale's "cone of experience" (Dale, 1946, 1969). This cone is a visual representation of learning experiences from concrete, direct experiences moving through the various mediated experiences to the most abstract, verbal experience. Dale did not make any assertions about which experiences were better for learning. The findings of the present
study, however, allow us to take one small cautious step toward expanding this cone theory of realism to one relating learning to specific mediated experiences. The caution comes from not yet knowing the nature of individual differences in relation to spatial representation. But, based on the results of this study, one could assert that real, direct experiences are better for learning involving spatial kinds of data than slides.

Derived from Dale's "cone of experience," and Dwyer's realism continuum (Dwyer, 1972) a model for future research and classification in educational media experiences is presented below which combines media, imagery, and realism on a continuum (See Figure 18 below). This representation differs from Dale's in that this continuum of experience does not extend into verbal symbolic experiences; this continuum is a visual iconic one. It expands Dwyer's realism continuum into visual media other than line drawings and photographs; and, it is not, as Dwyer's realism continuum is, a continuum of efficiency in learning. It is a research-related realism continuum. Along this continuum, the specific structure of the visual mental image and its perceptual counterparts could be studied. Spatial representation, color, texture, illumination, and other structural elements of images derived from the different media stimuli along the continuum could be analyzed for their differences and similarities amongst each other, for their differences and similarities in relation to reality, and in terms of their different effects on types of learning. This last research objective will remain the most elusive. Only in the distant future will the experimenter
Figure 18. Visual Media/Cognitive Process Continuum
investigate, for example, whether the hues of color in images relate to a measure of creativity.

With respect to learning, it is important to note that the above paradigm does not relate to a type of learning continuum. At this juncture in media research, there is very little research that indicates that people perform some kind of learning better from different kinds of media from a cognitive processing point of view.

Dwyer's work (1972) has shown that subjects displayed more achievement in recall tasks from a simplified line drawing than from color photographs or a real model of a heart in externally placed instruction. He accounts for this by the theory that there is too much detail in the model and photographs which crowds the limited capacity of the information processing mechanism. Lesser detail was more effective for learning in this instance. But for different kinds of learning as learning the creative process or problem-solving, other types of representation with more detail might be more effective.

In internally paced instruction, Dwyer (1972) found that moderate realism in illustrations was most effective in improving achievement on some recall measures. Some detail is not detrimental to learning, then, if sufficient processing time is allowed.

In 1976, Dwyer performed an aptitude-treatment interaction study to investigate the effects of IQ on different levels of realism in media and on the use of color in visuals. He tested students in recall and comprehension of the human heart learned from simple line drawings, detailed line drawings, photographs, and a model—each in black and white and in color. He found that an increase in
realism (and, therefore, the number of cues present in the stimulus) was not related to student achievement and the visuals did not interact with IQ. The simple line drawing (color) was most effective in increasing student achievement. Interestingly, the fact that color in a picture was a factor in increasing learning gives significance to the subject's reports in this study that color was a major factor in ease of imaging an object. Perhaps there is an association between color, imagery, and learning. Other studies (Norman and Reiber, 1968) have found that color may enhance learning when used to emphasize relevant cues and aid in making discriminations.

The 1976 Dwyer study has two main problems. First, one of the criterion measures was drawing a reproduction. Drawing an image of a simple line drawing would be easier than drawing an image of a model, realistic photograph, or a detailed line drawing. Secondly, IQ is too broad and ill-defined as a measure from which to expect an aptitude-treatment interaction. In contrast, the present study attempts to bridge a gap in such media research—the gap between the media stimulus and response, between the media presentation and learning. In the gap between the media stimulus and learning behavior are cognitive processes—perception and imagery. Thus, in this research in contrast to many previous media research efforts, an attempt is being made to describe the effects of media on the cognitive processes involved upon which the subsequent learning (recall, problem-solving, or creativity) is based. Perhaps this approach will help explain why learning occurs in some individuals with some stimuli
and does not occur in others. The jump from stimuli (media form) to learning seems too broad from this researcher's point of view.

In summary, this research has been directed at showing the interrelation of the medium, the learner, and the cognitive process of imagery. A specific model for the investigation of imagery in relation to media was generated from the results of this study. This study has supported the number of cues/realism theory related to cognitive processes, that a more realistic presentation (the real object display) is more effective than a photographic slide in providing 3-D "workspace" in imagery. Lastly, this research has successfully addressed itself to the problem under investigation—to begin the define the role of imagery in relation to media. Thus, we may be one small step closer to discovering the function of imagery in the human learning process.
LIST OF REFERENCES


Fernald, M. R. The diagnosis of mental imagery, Psychological Monographs, 1912, No. 58.


Haber, R. N. Eidetic images. Scientific American, 1969, 220, 36-44.


Pinker, S. Personal communication, October, 1979.


Pinker, S. Mental imagery and the third dimension. Working manuscript, revised version to appear in Journal of Experimental Psychology: General, in press.


Shepard, R. The mental image. American Psychologist, 1978, 33, 125-137. (b)


Smith, O. W. & Gruber, H. Perception of depth in photographs. 

Smith, O. W., Smith, P. C., and Hubbard, D. Perceived distance as 
a function of the method of representing perspective. 

Standing, L., Conezio, J., & Haber, R. N. Perception and memory for 
pictures: single trial learning of 2500 visual stimuli. 

Stromeyer, C. F. & Psotka, J. The detailed texture of eidetic 

Vido, D., Drake, B., Clark, C., Kounkoulas, C. A comparison of 
the perceived and remembered locations of objects in a natural 

Witkin, H. A., Oltman, P. K., Raskin, E., & Karp, S. A. A manual for 
the embedded figures tests. Consulting Psychologists Press: 

Yonas, A. & Hagen, M. A. Effects of static and kinetic depth 
information on the perception of size in children and adults. 
Figure 2. Mean Scanning Times and 3-D Interobject Distances for the Total Real Group
Figure 3. Mean Scanning Times and 2-D interobject Distances for the Total Real Group
Figure 4. Mean Scanning Times and 3-D Interobject Distances for the Total Photo Group
Figure 5. Mean Scanning Times and 2-D Interobject Distances for the Total Photo Group
Figure 6. Mean Scanning Times and 3-D interobject Distances for Scanners and Non-Scanners in the Real Group
Figure 7. Mean Scanning Times and 2-D Interobject Distances for Scanners and Non-Scanners in the Real Group
Figure 8. Mean Scanning Times and 3-D Interobject Distances for Scanners and Non-Scanners in the Photo Group
Figure 9. Mean Scanning Times and 2-D interobject Distances for Scanners and Non-Scanners in the Photo Group
Figure 10. Mean Perceptual Estimates and 3-D Interobject Distance for the Total Real Group
Figure 11. Mean Perceptual Estimates and 2-D Interobject Distances for the Total Real Group
Figure 12. Mean Perceptual Estimates and 3-D Interobject Distances for the Total Photo Group
Figure 13. Mean Perceptual Estimates and 2-D Interobject Distances for the Total Photo Group
Figure 14. Mean Perceptual Estimates and 3-D interobject Distances for Scanners and Non-Scanners in the Real Group.
Figure 15. Mean Perceptual Estimates and 2-D Interobject Distances for Scanners and Non-Scanners in the Real Group
Figure 16. Mean Perceptual Estimates and 3-D Interobject Distances for Scanners and Non-Scanners in the Photo Group.
Figure 17. Mean Perceptual Estimates and 2-D Interobject Distances for Scanners and Non-Scanners in the Photo Group
APPENDIX B

TESTING INSTRUCTIONS
Initial Instructions to Subjects

Description of the Study

The purpose of this experiment is to study the spatial properties of visual imagery and perceptions. You will be required to perform several tasks using visual imagery and perception. The first task is an eidetic imagery scanning task, sometimes called "photographic memory," in which you will look at a picture and then scan an image of it. Next, you will be asked to look at either a real display of objects or a photographic slide of a display of objects and perform a task to position the objects precisely in your mental images of the real object display or the slide of an identical display. Then, you will be asked to perform an imagery scanning task with the objects in the display.

During a break, you will be asked to fill out a vividness of imagery questionnaire and a Post-test Questionnaire which asks about your familial history of handedness. I will note your handwriting position to determine cerebral dominance. The final task involves looking at the real object display or the photographic slide and judging the distance between objects. At a later date, you will be asked to take the Group Embedded Figures Test to determine style of thinking.

You will benefit personally from the study by increasing your awareness of your own imagery and perceptual processes, as well as educationally by increasing your knowledge of imagery and perception. You will be debriefed about the entire experiment at the end. There are no "tricks" in the experiment. Please do not discuss this
experiment with any of your friends who will be participating in this experiment. If you have any questions about the nature of the experiment and/or the tasks to be performed, please ask me at this time. If you have no further questions, let's proceed.
Instructions for the Eidetic imagery Scanning Task

First, I am going to ask you to perform an eidetic imagery scanning task in which you will be asked to look at a colored square and a picture, and, then, be asked questions about your mental images of them. Please stare at the center of this red square until I tell you to stop. (15 sec., then square is removed.) Now, look at the gray card where the square was. What do you see? Describe what you see fully. Now, look at this picture. (15 sec., then picture is removed.) Look at the gray card where the picture was. What do you see? Do you see the picture there like the square? Describe what you see, if anything. Now close your eyes and form a mental image of the picture. Count how many bottles are filled in the picture from top to bottom by row. Next, how many total bottles are there in the top row, middle row, bottom row? How many bottles total? O.K., now take a look at the picture and see if you were right.
Instructions for Image Positioning Task - Real Group

I am going to ask you to put your chin on this chin rest, and then I'll adjust it for you. Please keep your chin on the chin rest at all times during the experiment except when I tell you not to. (Remove display cover.) I want you to look at this display as long as necessary until you feel that you can form a good mental image of it in your mind. (Subject indicates he/she is ready.) Now, close your eyes and form a mental image. Next, open your eyes and pay particular attention to the chair. Study its position in the box; close your eyes and study its position in your mental image. Keep your eyes closed while I explain what I am going to do. I am going to move the chair through a series of positions. I will ask you to open your eyes after each of these moves, and you are to tell me whether the chair is in the correct or original position, the one you have now in your image, or if it is in an incorrect position, a different position than you now have. Now look at the original scene again, and reformulate your mental image. Close your eyes. (Object now moved by experimenter if indicated.) Open your eyes. Is the chair in the same, original position or a different position? (Procedure repeated for the grill, dog, and man.) Next, I am going to position one or more of the objects in different positions. When you open your eyes, tell me if the configuration of objects is the same as the one you have in your mental image.
Instructions for Image Positioning Task - Photo Group

I am going to ask you to put your chin on this chin rest, and then I'll adjust it for you. Please keep your chin on the chin rest at all times during the experiment except when I tell you not to. (Remove cover.) I want you to look at this display as long as necessary until you feel that you can form a good mental image of it in your mind. (Subject indicates he/she is ready.) Now, close your eyes. Try to image the pictured scene which is a display of object. Get an image of the real scene that is pictured. Next, open your eyes and pay particular attention to the chair. Study its position in the box; close your eyes and study its position in your mental image. Keep your eyes closed while I explain what I am going to do. I am going to show you a series of slides where the chair may or may not move in various directions, forward, backward, to the sides, etc. I will ask you to open your eyes after a new slide is presented, and you are to tell me whether the chair is in the correct or original position, the one you now have in your image, or if it is in an incorrect position, a different position than you now have imaged. Now, look at the original scene again, and reformulate your mental image. Close your eyes. (Slide is now changed by experimenter.) Open your eyes. Is the chair in the same, original position or a different position? (Procedure repeated for the grill, dog, and man.) Next, I want you to memorize the objects as a group; tell me if the grouping or configuration in the next series of slides is the same or different as the original, the display you have in your mental image now.
Instructions for the Image Scanning Task

Next is the image scanning task. Your dominant hand must be placed on the TRUE key, and your non-dominant on the FALSE key. If you are left-handed, the keys need to be switched now. (Experimenter switches keys if necessary.) In this task, with your eyes closed you will image the display (Photo subjects are told--In this task, with your eyes closed, you will image the pictured scene containing the objects.) Then, you will hear on a tape the name of one object in the display. Then, a few seconds later, the name of a second object which may or may not be present in your image of the display will be heard on the tape. When you hear the name of the first object, attend to that object in your mental image, keeping the image of the entire display in your mind's eye. If the second object named is in the display, scan from the gold star on the first object to the gold star on the second object by imaging a small black dot moving smoothly in a straight line, at a constant rate of speed, from the star on the first object to the star on the second object. You must "see" the small black dot in your image at all times as it moves along its path between objects; keep your eyes mentally on the dot as it travels through space from the star on the first object to the star on the second. (Photo Group are told--Scan the real scene which is pictured.) As soon as the moving black dot arrives at its destination, the star on the second object, press the TRUE key. Then, be ready immediately for the next trial. If the second object named is not in the box, press the FALSE key with your non-dominant hand. Then, be ready immediately for the next trial. Try to perform the scanning with the dot moving as
quickly and accurately as possible. It is necessary to concentrate as hard as possible; there are quite a few trials. Any questions? O.K., form a mental image of the display, now that you've just seen it again, and let's try a few practice trials. (4 to 5 practice trials are given to the subject.) Let's go over the instructions again. Repeat the instructions to me. (Subject repeats instructions and any misconceptions are cleared up.) Do you need any more practice? (4 to 5 more trials given if necessary.) Now take one last look at the display with your chin on the chin rest; next, I'll go into the adjoining room and start the tape. I'll let you know when the trials are to begin. Don't forget to keep your eyes closed during the trials and your chin in the rest.

O.K., the tape is starting; get ready for the first trial.
Instructions for Perceptual Distance Estimation Task

For the last task in this session, I want you to look at the display for a few seconds with your chin in the rest. Now look at this wood rod. Pick it up, and look at it closely; now put down on the table out here in front of you where you can see it. I am going to ask you to estimate how many of these rods to the nearest half rod will fit in between the stars on pairs of objects in the display. First, how many of these rods to the nearest half rod will fit between the star on the man to the star on the chair in a straight path? The star on the man to the star on the dog? (Repeated for the other four paths.)

Thanks. That's the end of the experiment.

(Subject is debriefed about the experiment and asked to sign permission slip to obtain ACT Scores.)
APPENDIX C

DATA COLLECTION INSTRUMENTS
Subject Data Sheet

Name_______________________________Date________________________Major__________

Phone no._________________________Condition______________________________

Sex_________Age_____________Handwriting Position__________________________

Normal vision?_Nearsighted?_Farsighted?_Glasses worn during experiment?_

Eidetic imagery scanning task

Able to see green square? yes__no____

See eidetic image of spice rack? Yes__no____

# of bottles filled in top row? middle row? bottom row? total filled_____

Image positioning practice: # of trials to correct placement

Dog_________

Grill_________

Man__________

Chair_________

Group_________

Distance estimation task

man-chair_________

man-dog___________

dog-chair_________

chair-grill_________

dog-grill_________

man-grill_________

Comments:

Use back if needed
Post-test Questionnaire*

1. In what percentage of the tape trials that you just finished did you follow the instructions to scan? Circle one:
   0——10——20——30——40——50——60——70——80——90——100%

2. If you did not follow the instructions in some of the trials, what did you do instead?

3. Did you use any special tricks or strategies? If so, please describe.

4. What do you think the reason was for performing scanning in the experiment?
5. During the tape trials, most of the time my images of the display were: (Circle one.)

1. Perfectly clear and as vivid as normal vision.
2. Clear and reasonably vivid.
3. Moderately clear and vivid.
4. Vague and dim.
5. No image at all, I only "knew that I was thinking of the object."

6. I am left/right-handed.

List the handedness of all the members of your blood relatives as far back as possible.

Mother: __________
Father: __________
Brothers: _____________________________________________________________
Sisters: ____________________________________________________________
Maternal grandmother ____________ Maternal grandfather ____________
Patrial grandmother ____________ Paternal grandfather ____________

7. The object(s) I found it easiest to form an image of in the display was (were): ______________________

Why? __________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

*(Adapted from the questionnaires used by Pinker & Kosslyn, 1978; and Pinker, 1979, in press; and Question 5 above adapted from the Marks VVIQ (Marks, 1973b).)*
VVIQ Answer Sheet

Name

Item

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16
I, __________________________________________, give my permission to release to Nancy J. Powell my American College Test scores for use in her dissertation research. I am giving my permission voluntarily; I understand that my scores will be kept confidential and reported only as part of composite data.

Signed ________________________________
<table>
<thead>
<tr>
<th>Practice</th>
<th>3</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>chair-dog</td>
<td></td>
<td>dog-pig</td>
</tr>
<tr>
<td>dog-grill</td>
<td></td>
<td>man-chair</td>
</tr>
<tr>
<td>man-chair</td>
<td></td>
<td>man-dog</td>
</tr>
<tr>
<td>grill-cat</td>
<td></td>
<td>grill-chair</td>
</tr>
<tr>
<td>dog-lamp</td>
<td></td>
<td>chair-dog</td>
</tr>
<tr>
<td>man-grill</td>
<td></td>
<td>dog-grill</td>
</tr>
<tr>
<td>dog-man</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>chair-grill</td>
<td></td>
<td>grill-tree</td>
</tr>
<tr>
<td>grill-man</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>chair-grill</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>grill-man</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>chair-dog</td>
<td></td>
<td>man-chair</td>
</tr>
<tr>
<td>dog-grill</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>grill-tree</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>man-dog</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>dog-cat</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>chair-man</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>grill-chair</td>
<td></td>
<td>grill-man</td>
</tr>
<tr>
<td>grill-man</td>
<td></td>
<td>grill-man</td>
</tr>
</tbody>
</table>

Name ________________________________

Trials Form
Eidetic Imagery Scanning Task

Spices