DOCUMENT RESUME

ED 049 496 CG 006 307

AUTHOR	Frederickson, Edward W.
TITLE	Shape Perception Judgments as a Function of Stimulus Orientation, Stimulus Background, and Perceptual Style.
INSTITUTION	Human Resources Research Organization, Fort Bliss, Tex. Div. 5.
SPONS AGENCY	Office of the Chief of Research and Development (Army), Washington, D.C.
REPORT NO	HumRRO-TR-70-24
PUB DATE	Dec 70
NOTE	62p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Discrimination Learning, Nonverbal Learning, *Perception, Performance Factors, *Space Orientation, Stimulus Behavior, Visual Discrimination, *Visual Perception, *Visual Stimuli

ABSTRACT

Human recognition behavior is influenced by the phenomenon of shape constancy, which occurs when the shape of an object is correctly perceived regardless of the orientation of the object in space. The research reported here tests the validity of the shape-slant invariance hypothesis, a theoretical formulation of the phenomenon of shape constancy. Two experiments are reported. In one, individual differences were found to influence shape judgment performance, but stimulus shape did not. In the other, the shape and rotation of stimulus objects were found to influence judgments of shape and rotational orientation. The important implications of the results for recognition training in the army are discussed. Training for object recognition may be accomplished employing a limited number of views. (TL)

Shape Perception Judgments as a Function of Stimulus Orientation, Stimulus Background, and Perceptual Style

by

Edward W. Frederickson

Approved for public release;
distribution unlimited

December 1970

Prepared for:
Office, Chief of Research and Development
Department of the Army
Contract DAHC 19-70-C-0012 (DA Proj 2Q061102B74B)

HumRRO Division No. 5
Fort Bliss, Texas
HUMAN RESOURCES RESEARCH ORGANIZATION

Technical Report 70-24
Basic Research 16

The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

Published
December 1970
by
HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street
Alexandria, Virginia 22314

Distributed under the authority of the
Chief of Research and Development
Department of the Army
Washington, D.C. 20310

FOREWORD

This technical report is based on research conducted as part of a HumRRO basic research effort (BR-16) in determining important factors that influence pattern recognition. The results of this basic research will guide the design of more applied research in perception, especially in the area of recognition training.

The research was conducted at HumRRO Division No. 5, Fort Bliss, Texas, while HumRRO was part of The George Washington University, and was accomplished under the supervision of Dr. Robert D. Baldwin, then Director of the Division.

Assistance in data collection and analysis was provided by research assistants SP5 James E. Robyak and SP5 Harald L. Lohn. LTC John Feiger, Chief of the U.S. Army Air Defense Human Research Unit, coordinated military support for the research. The U.S. Army Air Defense Center provided enlisted personnel who served as test subjects.

Permission has been obtained for the use of copyrighted material in this report.

HumRRO research for the Department of the Army is conducted under Contract DAHC 19-70-C-0012. Basic Research is conducted under Army Project 2Q061102B74B.

Meredith P. Crawford
President
Human Resources Research Organization

PROBLEM

Recognition tasks that are performed by various kinds of observer personnel are influenced by a variety of factors. Much of human recognition behavior is influenced by the phenomenon of shape constancy. This phenomenon occurs when the shape of an object is correctly perceived regardless of the orientation of the object in space.

To account for this phenomenon, a theoretical relationship, called the shape-slant hypothesis, has been proposed between object shape and object orientation. Shape-slant invariance means that the perception of an object's shape and its orientation are tied together in such a manner that the relationship remains constant. That is, if an object's shape is perceived incorrectly, its orientation will also be perceived incorrectly to the same degree.

Several studies have been conducted to assess the validity of the shape-slant invariance hypothesis. Many of the results obtained have been inconclusive, ambiguous, and controversial for three reasons: (a) inappropriate methodology, (b) failure to obtain both shape and orientation judgments in the same experiment, and (c) inappropriate treatment of variance attributable to individual differences. The present study tested the validity of the shape-slant invariance hypothesis under experimental and statistical conditions that would minimize those factors which mitigated against the validity of previous research efforts.

APPROACH

Two experiments were conducted. In the first experiment, 20 subjects were asked to judge the shapes of four two-dimensional rectangles. The purpose of this experiment was to obtain data that would permit the construction of a series of shape comparison stimuli for Experiment II that would provide a sensitive measure of shape judgment performance. An additional purpose was to demonstrate the significance of individual differences in shape judgment performance. Analysis of variance procedures were used to test the influence of stimulus shape and individual differences on shape judgment accuracy.

The second experiment tested the validity of the shape-slant invariance hypothesis. A requirement for this research stated that conditions would be created whereby shape constancy would occur; this requirement was achieved. The subjects in this experiment (68 U.S. Army enlisted personnel) were required to judge the shape and the rotation (around the vertical axis) of three-dimensional rectangular solids. The immediate background of the stimuli was varied from an unstructured, homogeneous visual field to a structured field. In addition to the three-stimulus variables—shape, rotational orientation, and background—the influence of the organismic factor defined as perceptual style was evaluated. Analysis of variance and correlational statistical procedures were used to test the 10 research hypotheses that provided an evaluation of the validity of the shape-slant invariance hypothesis.

RESULTS

In the first experiment, individual differences were found to contribute a significant amount of variance to performance accuracy, whereas stimulus shape did not significantly influence accuracy of judgment. In the second experiment, the mean errors of shape judgments did correlate with the mean errors of rotation judgments. The apparent projected shapes, computed from the shape and rotation judgments of the subjects were found to correlate significantly with the objective projections. The mean judgments of shape were made with less variation than were the mean judgments of rotation.

Stimulus shape and rotational orientation exerted similar influences on mean judgments of shape and of rotation. The perceptual style of the subjects resulted in significant effects on both dependent variables. The background variable did not produce the predicted effects on judgments of either shape or rotation.

CONCLUSIONS

The following primary conclusions were reached as a result of this study.

(1) The shape-slant invariance hypothesis was supported by the results obtained in this research.

(2) Individuals differed significantly in their shape perception performance.

(3) Stimulus shape and rotational orientation were significant factors in the judgments of shape and rotation of three-dimensional rectangular solids.

(4) The perceptual style of the subject significantly influenced shape and rotation judgments.

(5) The level of intellectual functioning of the subjects did not influence shape judgments.

CONTENTS

Tables

Shape Perception Judgments as a Function of Stimulus Orientation, Stimulus Background, and Perceptual Style

Chapter 1

INTRODUCTION

SHAPE AND PERCEPTUAL CONSTANCY

Shape constancy—perceiving the shape of an object correctly, regardless of the orientation of the object in space—underlies much of human recognition behavior. Learning to recognize classes of objects, such as people or airplanes, and being able to discriminate between the various members within classes—mother vs. teacher, B-52 vs. 707—is a function, in part, of recognizing the shape of the total object or the shape of one or several parts of the object. These are examples of perceptual learning that basically require differentiation of the stimulus situation (Gibson, 1).

Since objects appear within our visual field in various orientations, recognition of objects must be attempted using information available from various object aspects. When an object is recognized under such varying conditions, perceptual constancy is said to be occurring. When recognition occurs as a function of the shape of the object, shape constancy is occurring. This implies that there is a relationship between perceived shape and perceived orientation, but more specifically it implies that a given shape should be correctly recognized at any and all orientations.

There are many tasks that are based primarily upon both simple and complex shape perception. Military air defense personnel are training to recognize aircraft as a function of the perception of the shape of substructures. Photo interpreters pore over aerial photographs looking for specific structures and objects that may have been photographed at various camera angles. Air-rescue personnel must be able to recognize objects immediately at various angles to conserve time and be able to cover large search areas. Radar observers are required to recognize radar signals representing radar returns from objects under a variety of *noisy* background conditions.

During the training programs for personnel who will fill these and similar jobs, it is not feasible to present relevant stimulus objects at all possible orientations. Both training time and costs would become prohibitive if this were a necessary requirement for training. When shape constancy is assumed, it is superfluous to present an object at more than a few orientations during training, since it would also be assumed that once the shape of the object is recognized at one orientation it will be recognized at almost all orientations.

SHAPE-SLANT INVARIANCE HYPOTHESIS

In the shape-slant invariance hypothesis, it is proposed that the perception of an object's shape and its orientation are tied together in such a manner that the shape and orientation relationship remains constant. That is, if an object's shape is perceived incorrectly, its orientation will also be incorrectly perceived to the same degree and in a compensating fashion.

If the shape-slant invariance hypothesis is a valid description of behavior, then training procedures must be changed to compensate for the increased difficulty of veridical perceptions. Therefore, it is imperative that training program designers know whether or not the shape-slant invariance hypothesis holds. If it does hold, they need to know the conditions under which it holds and how various factors influence the relationship.

Another use of the information concerning the shape-slant invariance hypothesis is in theoretical modeling. The U.S. Army has tried to identify those factors that influence performance in many image perception and pattern recognition tasks. The ultimate goal is to develop a theoretical model that will describe and predict a variety of image-interpreter performances.

The invariance hypothesis was first expressed by Koffka (2) to replace the constancy hypothesis. As stated by Koffka the perceptual invariance hypothesis was not explicit, proposing only that relations between certain aspects of stimulation were invariant. Ittelson's (3) statement of the hypothesis was a little clearer about the relation between stimulation and perception; the kinds of invariant relations between certain aspects of stimulation are formulated in the specific invariance hypotheses.

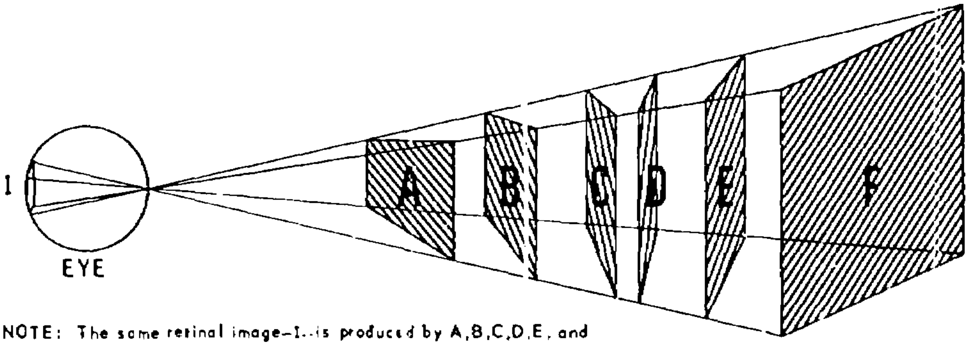
Since the primary interest in the present experimental study is the perception of object shape at some orientation, the shape-slant invariance hypothesis will be the central concept to be discussed.

The specific invariance hypothesis relating perceived shape to perceived orientation has been formalized using the term *slant* instead of *orientation*. It is understood that slant is a generic term referring to a specific dimension of orientation. That is, it refers to the rotation of an object around a specific axis. For the convenience of general discussion the term "slant" has been used, but in any specific study the exact orientation axis is usually defined.

Various investigators have based their research on the following Beck and Gibson (4), or some similar, hypothesis: "... a retinal projection of a given form determines a unique relation of apparent shape to apparent slant."

Simply stated, the shape-slant invariance hypothesis specifies that for any one retinal image there is a set of an infinite number of real objects capable of projecting that one image onto the retina (Figure 1). To project that retinal image, each object in the set would necessarily have to be at a specific orientation in space relative to the retina. Therefore, there would be an exact physical relationship between object shape and object orientation to produce a specific retinal image.

Set of Objects That Project the Same Image Onto the Retina



NOTE: The same retinal image—I—is produced by A, B, C, D, E, and F when their sizes and distances are arranged as shown.

Figure 1

According to the invariance hypothesis, an individual in a shape perception task who reports an apparent shape—that is, how an object's shape appears to him—should also report that object's orientation necessary to result in such a projected shape. In other words, any error in reported shape (with reference to the distal stimulus) should result in a corresponding error in reported orientation.

In stating the Gestalt position, Koffka (2) accepted the assumption of general covariance of the accuracies of shape and slant judgments. He also pointed out that the invariance hypothesis as applied to the shape-slant relation was incomplete. He stated that a specific apparent shape will be seen if a specific apparent slant is also perceived, but he did not say under what conditions the *second effect*, perception of apparent slant, will occur.

Koffka was trying to explain, or at least attempting to understand, normal everyday behavior of shape constancy. He concluded, after considering previous experimental results (Eissler, 5; Klimpfinger, 6; Thouless, 7), that shape is not behaviorally perceived as veridically constant, but rather as only relatively constant. Further, there will be less variation in the perception of an object as its orientation changes than there will be in the retinal projection, with the perception approximating the distal (objective) stimulation. Thouless called the concept *phenomenal regression to the real object.*

Koffka's invariance formulation led to a great deal of perceptual research, but not actually along the lines of his initial thinking and conceptualization. Essentially, experimental psychologists took the formulation of the shape-slant invariance hypothesis out of Koffka's conceptual structure, and then proceeded to reduce and to control the conditions of investigation to lessen the ambiguity and complexity of the behavior Koffka was attempting to understand. This created an experimental problem and an atmosphere in which the research psychologist could establish specific relationships. However, this process also eliminated the possible discovery of the multi-variate conditions under which the *second effect* (perception of apparent slant in this discussion) of Koffka's formulation occurs.

FACTORS IN SHAPE-SLANT INVARIANCE

No single theory has yet led to the specifications of the functional relationships between shape constancy and relevant independent variables. All three theoretical approaches discussed above have proposed, either explicitly or implicitly, that shape and orientation perception are functionally related. The shape-slant invariance hypothesis research reflects a prevalent interest by psychologists in the stability of the perceptual world. However, the experimental history of the invariance hypothesis has produced only relatively few direct tests of the proposed invariance relationship between perceived shape and orientation. Many studies have been conducted that have indirectly attempted to assess the validity of the hypothesis.

Typically, the experimental evaluation of the shape-slant invariance hypothesis has been through an examination of the shape constancy phenomenon. Although it has been generally assumed that those factors influencing shape perception also influence slant perception, very few experimental studies have examined this assumption.

In the review of the literature for this study, this assumption was examined. Where possible, those studies of the influences of specific variables on shape perception and on slant perception have been brought together for comparison. Where this was not possible, the influence of variables on shape perception alone was examined with the intent of identifying those conditions under which shape constancy does clearly occur. The purpose of this latter review was based upon the contention that the shape-slant invariance hypothesis could only be tested under conditions which allow veridical perception of either shape or orientation or both. Since more research has been conducted on shape perception than on perception of object orientation, it was decided that the conditions under which shape constancy occurs could be more validly identified in the literature.

The independent variables that have been experimentally examined in previous research can be grouped into three general, but meaningful categories: focal variables, contextual variables, and organismic variables.

FOCAL VARIABLES

This class of independent variables is composed of those variables that describe the physical characteristics of the stimulus object(s) and their relation to the surround. Included are the monocular and the binocular depth perception cues, which relate the object to the perceiver. The primary stimulus variables to be discussed are shape, orientation, and depth cues.

Shape

The stimulus attribute that is most obvious, but one that has created a great deal of difficulty in the evaluation of shape and orientation perception, is the shape or form of the stimulus object. Because shape is a multi-dimensional stimulus, ecological validity (the correlation between the proximal and distal stimulation) is difficult to achieve (Brown and Owen, 8, Eriksen and Hake, 9, Koch, 10). Proximal stimuli provide the cues that allow the determination of the distal properties of objects. As the complexity of the stimulus shape increases, ecological validity decreases and the perception of distal properties becomes probable rather than certain (Koch, 10). For this reason, experimenters have tended to use stimulus shapes that are relatively simple for the study of shape and orientation. However, even when simple forms have been used, the shape of the stimulus has been found to influence both shape and slant perception.

Beck and Gibson (4) reported differences in shape constancy for rectangles and triangles. Arnoult (11), using nonsense forms, found differences in shape discrimination when the forms were presented at various orientations. Smith (12, 13) found that individuals could distinguish between the slants of rectangles and trapezoids at various orientations, but could not discriminate between slants of various trapezoids. Smith (13) also reported that phenomenal shape was found to be more stable than phenomenal slant, when these judgments were compared across studies.

When three-dimensional objects have been used as shape stimuli, additional conclusions have been reached. Woodworth and Schlosberg (14) reported that slant judgments were more accurate for simple geometric forms than for complex three-dimensional stimuli in an investigation of shape constancy. The results indicated that three-dimensional stimuli apparently have perceptual properties that simple surfaces and projected images do not have. A similar conclusion was reached by Johansen in studies reported by Cronback (15).

Gibson (16) had pointed out these possible difficulties when he noted that many conclusions about perception in general were based upon the results of studies using two-dimensional stimuli, and the results from these studies might not actually generalize to the three dimensional stimuli. Brown and Owen (8) reaffirmed this problem in 1967.

Stimulus form would appear to be a variable that influences both shape and slant perception. However, it is not yet clear whether the influence of stimulus form on shape perception correlates with the influence of form on slant perception.

Orientation

The stimulus variable of orientation is of considerable importance to the evaluation of the shape-slant invariance hypothesis. It provides the basis for the hypothesis. The shape-slant invariance hypothesis requires that the influence of orientation on shape judgments should covary with its influence on slant judgments.

Eissler (Lichte, 17) found that as the angle of rotation around the vertical axis increased, shape perception did not remain exactly constant. However, Eissler's work has been criticized for methodological reasons, such as inappropriate response measurement and the use of a one-eyed subject in a binocular task. Similar results, however, were reported later by several investigators (Sheehan, 18, Moore 19).

In a more recent report, Lichte (17) presented the results of a study of shape constancy as a function of the angle of rotation. The results were in general agreement with previous research, which indicated a linear negative relation between shape constancy and angle of rotation around the vertical axis. The variance of judgments was also found to increase as rotation increased.

Winnick and Rogoff (20) conducted a study to determine whether shape constancy was a function of the perception of slant. In the first experiment, overestimation of small angles and underestimation of large angles were found. In the second experiment, approximately the same estimation and angle relationships were obtained for shape judgments that were found for slant judgments in the first experiment. These results were comparable to and in agreement with those of Nellis (21). Winnick and Rosen (22) reported the results of a study in which they found limited support for a hypothesis relating shape and slant perception.

Stavrianos (23) conducted one of the more complete experiments while attempting to establish functional relationships between shape and slant. She found that with monocular viewing under reduced stimulus conditions the errors of judgments of shape and of slant did not covary exactly, but that an approximate relation did exist for some subjects. Epstein (24) in a similar study reported that orientation of the stimulus did influence shape judgments, resulting in reduced constancy at large viewing angles for binocular viewing; but slant judgments were fairly accurate under all conditions.

Epstein and Park (25) thoroughly reviewed the shape-slant literature. They concluded that experimental attempts to obtain a precise relationship between the perception of shape and the perception of slant had been unsuccessful, and that a function relating shape constancy to spatial orientation has not been found. Several experiments have failed to support the shape-slant invariance hypothesis, because it was found that shape constancy did not remain constant as the angle of orientation increased. Epstein and Park suggested that these changes in constancy may occur as a result of changes in the perception of slant as the angle of orientation increases. To test this hypothesis, judgments of shape and slant must be obtained in the same experiment—something few studies have done.

Depth Cues

Another line of investigation that has been pursued in the examination of the shape-slant hypothesis is concerned with the influence of both the binocular and monocular depth cues on shape and slant judgments. An effort has been made to demonstrate that either shape constancy occurs in the absence of cues to slant or that it does not occur under such conditions.

Various procedures have been used to control the effect of depth cues. The most often used procedure has been to limit judgments to monocular vision. Stavrianos (23) compared binocular with monocular viewing and found that the influence of depth cues varies with the orientation of the stimulus.

Epstein (24) found significant differences for binocular vs. monocular viewing for shape judgments, but not for slant judgments. The findings of shape judgments were the opposite of those reported by several researchers (Leibowitz, *et al.*, 26, Thouless, 7). Epstein found monocular judgments were more veridical than binocular judgments, whereas binocular viewing resulted in more accurate judgments in other studies.

Kaiser (27), in a well-controlled but small sample study, assumed that any changes in shape judgments obtained when going from binocular to monocular viewing would be primarily due to changes in slant perception. The results generally supported this assumption and thus provided evidence in support of the shape-slant invariance hypothesis.

Another technique used to reduce depth cues has been to eliminate the edge or contour of the stimulus, thereby eliminating its relation to the field. This effect could be achieved by having the subjects view the object through a reduction tube. Stavrianos (23) did use this procedure and found that the results of reducing binocular cues vary as a function of the angle of slant of the standard stimulus.

The elimination of object form or outline leaves only surface texture available as a cue to object slant. Gibson and his followers have stressed that information from texture cues is essential in the perception of slant which, in turn, is required for shape constancy to occur. Beck and Gibson (4) demonstrated a reduced tendency (not an elimination) toward shape constancy in a study that eliminated cues for surface slant. In a second experiment, when cues to slant were provided shape constancy was observed. They concluded that boundaries and texture may not be independent factors, but rather are probably interrelated, which would suggest that reduced stimulation conditions *are not appropriate* for studying shape constancy. This conclusion was supported by the findings of other studies (Beck, 28, Flock and Moscatelli, 29).

The results of the various studies in which depth cues were eliminated or reduced seemed to support a generalization made by Leibowitz and Meneghini (30) that "When adequate cues are present, subjects tend to preserve the invariant features of the test object regardless of the shape of the object or its angle of inclination."

In summary, it appears that the experimental evidence concerning the influence of focal stimuli on shape and orientation perception is not at all unequivocal. Generally, it might be concluded that the conditions under which shape constancy has been demonstrated indicate that adequate cues to orientation and depth must be present.

This conclusion was reached by Beck and Gibson (4) when they summarized much of the previous research in shape constancy by their objection to the conditions under which it has been studied. Instead of textureless, single (monocularly viewed), and static stimuli used in many experimental studies, the kind of shape that shows constancy was said by them probably to be *textured, disparate, and mobile.*

CONTEXTUAL STIMULUS VARIABLES

Bevan (31) discussed various studies designed to investigate the influences on behavior that can be attributed *to the properties of the stimulus setting—both immediate surround and pattern of prior inputs—in their relation to the focal stimulus.* Although he does not directly discuss the context effect on shape or slant perception, it is pointed out that perceptual constancy cannot be fully understood without the consideration of context. This point is emphasized by the fact that an individual has difficulty in drawing what he sees when a circle is presented at some slant within a structured environment, but when the contextual stimulation is removed and the retinal image becomes the *real* object to the subject, he readily draws the projected image to represent what he believes he sees.

Epstein and Park (25) reported that a few studies (Langdon 32, Nelson and Bartley, 33, Thouless, 7) in which no background was used (a stimulus presented in a darkened room) found that the retinal image determined the perceived shape. Nellis (21), using a white background, found that the tilt of the background interacted with shape judgments when the focal stimulus was tilted around the horizontal axis and rotated around the vertical axis. She reported that as the tilt of the background increased, so did its influence on judgments.

ORGANISMIC VARIABLES

Psychologists generally agree that individuals through personal experiences develop a perceptual set, which is unique with each individual. Brunswik has proposed that perception is an achievement of each individual organism and that the degree of achievement is a function of the correlation between perceptual judgment and the distal stimulation (Koch, 10). Bartley (34) put it another way by saying that there are as many perceptual worlds as there are perceivers.

Prentice (35) pointed out that perception is *idiosyncratic* and is a primary contributor to individual differences in behavior. Several other researchers have stressed that perceptual behavior should not be studied without a consideration of the uniqueness of the organism, because behavior is directly affected by need, motivation, learning, past experience, and the general sensory state of the organism (Bruner and Goodman, 36, Bruner and Postman, 37). Bevan (31) restated this concern by stressing the importance for the researcher to realize that the individual organism brings with it to any perceptual situation, either in the environment or in the perceptual laboratory, a set of organizing and categorizing assumptions.

The concern about the influence of organismic differences is not new. Kulpe noted this same problem at the very beginning of the modern study of perception. His contention was that the attribute that an observer is set to see (either by instructions from experimenter or from past experience) may be all that exists in his mind during an observational task (Boring, 38). Even though this problem has been known for a long time, only a few attempts have been made to specify the influence of organismic variables on shape and slant judgments. Intelligence and past experience have been two organismic variables examined by several investigators. Perceptual style and pattern analysis have also been identified as abilities that differ between individuals and influence shape perception.

Intelligence

Epstein and Park (25) reported that the results of Thouless (39) and Leibowitz *et al.* (26) indicated an inverse relation between intelligence and shape constancy. The suggestion being made was that the more intelligent subjects would adopt a more analytical approach to shape by paying more attention to the projected image, thus resulting in lower constancy scores. Investigators, who have varied instructions of analytical set, have supported this hypothesis (Gottheil and Bitterman, 40, Epstein, Bontrager, and Park, 41)

Past Experience

Past experience and learning level are unique sources of variance within individuals, and have been assumed in the past to be random effects in the populations sampled. This becomes an erroneous assumption when the sample size per treatment condition is small. Only a few investigators in perceptual research have studied the effects of prior familiarity with the stimulus. Hake (42) discussed this problem and proposed that individuals performing a perceptual task use at least two sources of information for selecting the appropriate responses: (a) information from the present situation, and (b) information from the past during which successful ways of perceiving were developed.

Borreson and Lichte (43) attempted to assess past experience by varying stimulus familiarity. Using nonsense shapes, they varied the number of times the shapes were seen by subjects and found that shape constancy did increase with familiarity. Epstein and Mountford (44) found contrary results in a test using a representational form vs. a nonrepresentational form. They found that there was no difference in the perception of the shape of the Jack of Spades (representative stimulus) vs. a blank white rectangular card (nonrepresentative stimulus). Epstein and Mountford also reported no differential effect of representativeness of the stimulus on slant judgments. Epstein (24) reported similar results earlier using the same stimuli.

From the results of the research examined here, a definite conclusion concerning past experience cannot be made. In the light of this ambiguity it must be assumed that past experience might be a significant source of variance. Until evidence can be obtained, one way or the other, past experience should be controlled either experimentally or statistically in experimental tests.

Perceptual Style

Work has been described by Witkin *et al.* (45) which specified a personality variable termed *perceptual style.* Essentially, the experimental work assessed the influence of bodily and environmental orientation on the performance of perceptual tasks. The results of the research led to the conclusion that field factors influence some individuals more than others.

Witkin and his associates have defined a continuum of perceptual field dependency to describe this personality factor. Those individuals who are influenced to a great extent by field factors, such as observer and stimulus orientation, and complexity of physical structure are designated as field dependent, and those who are only slightly influenced by physical structure are said to be field independent. These two groups of individuals have been described as follows:

> ". . . field dependent persons tend to be characterized by passivity in dealing with the environment; by unfamiliarity with and fear of their own impulses, together with poor control over their primitive, undifferentiated body image. Independent or analytical perceptual performers, in contrast, tend to be characterized by activity and independence in relation to the environment; by close communication with and better control of their own impulses; and by relatively high self-esteem and a more differentiated mature body image."[1]

The work leading to the concept of perceptual style was begun by Gottschaldt (Witkin, 46). The purpose of his initial work was to demonstrate that contextual factors influence perception. The results of the research led to the conclusion that contextual factors alone could not fully explain the perceptual process represented in Gottschaldt's and later in Witkin's experimental tasks. The consistent and stable individual differences that were observed in the perceptual performances were hypothesized to be an important factor in understanding the perceptual process.

The basic task in these studies was to find a simple figure that was embedded within a more complex pattern. The field-dependent individuals experienced difficulty in extracting the hidden figure from the complex visual stimulation, whereas this was a relatively easy task for the field-independent subjects. An embedded figures test (EFT) similar to the one used by Witkin was adopted as the operational instrument for identifying the perceptual style of individual subjects.

---

[1] Permission for use of this copyrighted material granted by Herman A. Witkin (45).

Thornton, Barrett, and Davis (47) used the EFT in a study of individual differences in a shape discrimination task. Subjects were differentiated on the basis of their perceptual style, as defined by the EFT. Two experiments were conducted in which photo interpreters were required to find various targets in aerial photographs. Significant positive correlations were obtained in both studies between EFT scores and target discrimination performance. The field-dependent interpreters had greater difficulty discovering the targets in the aerial photographs than did the field-independent individuals.

Cronback (15) reported a similar individual factor found by Johansen. In an experimental task using three-dimensional stimuli, Johansen found that some subjects were able to visualize how the three-dimensional figure would appear if it were to be viewed from a different aspect, whereas other subjects could not visualize this. The individuals who did not have this imaginative ability were termed *frontal bound* by Johansen.

In summary, organismic variables can be concluded to have a significant influence on perception of shape and slant. Typically, this source of variance has been ignored. In a review of 137 articles reporting target identification and form perception performances Kause (48) found that individual differences were consistently treated as sources of random error.

The review of the literature for this study indicates that instead of being random, there are systematic differences between individuals in shape perception performance, and some sources of these differences can be identified. This conclusion is in agreement with various researchers who have indicated that the individual perceiver must be taken into account just as much as the thing being perceived (Prentice, 35, Flock and Moscatelli, 29, Bevan, 31, Eriksen, 49, Leibowitz and Meneghini, 30).

Chapter 2

SHAPE-SLANT INVARIANCE HYPOTHESIS EXPERIMENTS

RESEARCH PROBLEM

After considering the results of experiments which have investigated shape constancy, generally, and the shape-slant invariance hypothesis specifically, it was concluded that the existence or nonexistence of a shape-slant invariance relationship had not been explicitly demonstrated. In addition, it was concluded that the conditions under which shape constancy occurs are generally agreed upon.

One reason for a lack of unequivocal results in many studies could be the fact that judgments of apparent shape and apparent slant were not obtained in the same experiment. Another reason could have been that the conditions of the experimental study were such that veridical perceptions were not possible for either shape or slant. In fact, few previous studies have stated a requirement for veridical perception of shape or orientation in order to test the shape-slant invariance hypothesis.

An additional postulate could be that systematic organismic variables (large but stable individual differences) may have masked significant and correlated treatment effects on the perception of stimulus shape and orientation. Several recent articles have been concerned with this problem of controlling errors in measurement, and have offered both experimental and statistical solutions (Fine, 50, Cox, 51, Owens, 52, Eisenhart, 53, Levi, 54, Norrie, 55, Grose, 56, Jarrett and Henry, 57, Henry, 58). The postulates offered here were in agreement with Epstein and Park (25) who concluded from their review of the literature that relatively few good studies of the shape-slant invariance hypothesis had been conducted prior to their survey.

PURPOSE OF RESEARCH

The purpose of the present research was to test the shape-slant invariance hypothesis under conditions that would allow shape constancy to occur. The requirement for shape constancy was used in order to lessen the possibility of organism-bound responses and increase the possibility of stimulus-bound (Fine, 50) responses so that the shape-slant invariance hypothesis could be more objectively tested.

The research was also designed to evaluate the influence of focal and contextual variables on the perception of stimulus shape and orientation. Once the requirement for shape constancy was met, the influence of focal and contextual variables on judgment of shape and slant could be more objectively tested. Based upon the invariance hypothesis, it would be assumed that the influence of these variables under the established conditions would be very similar on both shape and slant judgments. It was believed that a demonstration of the importance of individual performance should be included because of the possibility that large individual differences could mask significant and correlated treatment effects.

RESEARCH METHOD

This research was designed primarily to address the validity of the shape-slant invariance hypothesis, and secondarily to address the problem of individual differences in the perception of shape. Two experiments were conducted. The first experiment was essentially a pilot study producing data necessary for establishing some procedures for the second experiment, which was designed to test the invariance hypothesis.

U.S. Army enlisted men stationed at Fort Bliss, Texas, served as subjects in the experiments. The enlisted men were provided through the U.S. Army Air Defense Center which designated various units at Fort Bliss to provide personnel to support this research.

EXPERIMENT I

Experiment I was conducted to determine the magnitude of error in the judgment of shape and secondarily to demonstrate that there are constant and variable errors of shape judgments. It was felt that this was necessary in order to realistically construct the shape comparison stimuli for Experiment II.

It was desired that the size of the interval between comparison stimuli should not be so small that the individual could not distinguish between the shape of the two adjoining stimuli in the series. Conversely, it was desired that the size of the interval should not be so large that the individual would not have a choice of any two stimuli for a response. One problem with many past studies was that the interval sizes between comparison stimuli was so large that the individual virtually had no choice between comparison stimuli for a response; that is, the comparison stimuli which were provided were either similar to the retinal image or the objective shape, and there was no possibility of the apparent shape falling between these two extremes.

The secondary purpose of Experiment I was to demonstrate that individuals do differ in their performance and that these differences are a significant source of variance. It is felt that these demonstrations were necessary in order to provide empirical evidence for the use of statistical techniques to take this source of error into account. Most previous research has essentially ignored this source of error.

Subjects

The 20 enlisted men from Fort Bliss who served as subjects ranged in age from 18 to 26 years. The request for personnel stated that the enlisted men should come from basic training units, and should have 20/20 vision (corrected acceptable).

Each subject was requested to bring a record of his aptitude scores from his personnel file. The general technical (GT) score of each subject was recorded from this record. The GT score[2] is a general indication of intellectual ability and correlates significantly with verbal intelligence test scores. As a group, the subjects in Experiment I had a mean GT score of 105 with a standard deviation of 12.

The visual acuity and depth perception of each subject were tested on the Armed Forces Vision Tester. The stimuli used in the visual acuity test were similar to that on the Snellen chart. The depth perception test stimuli consisted of several small circular outlines embedded in a block of clear plastic (see Appendix A). The subject was requested to identify the circles that appeared to "stand out" from the other circles. Task difficulty increased as the difference in depth of the rings became smaller in

---

[2] The Army Standard Score system, used for GT scores, is defined for a mobilization population for which the distribution would be approximately normal with a mean of 100 and a standard deviation of 20.

different stimulus presentations. If subject did not perceive the largest separation in depth between rings, he was not used in the experiment. Of the total number of subjects tested (22), only two did not meet the depth perception requirement.

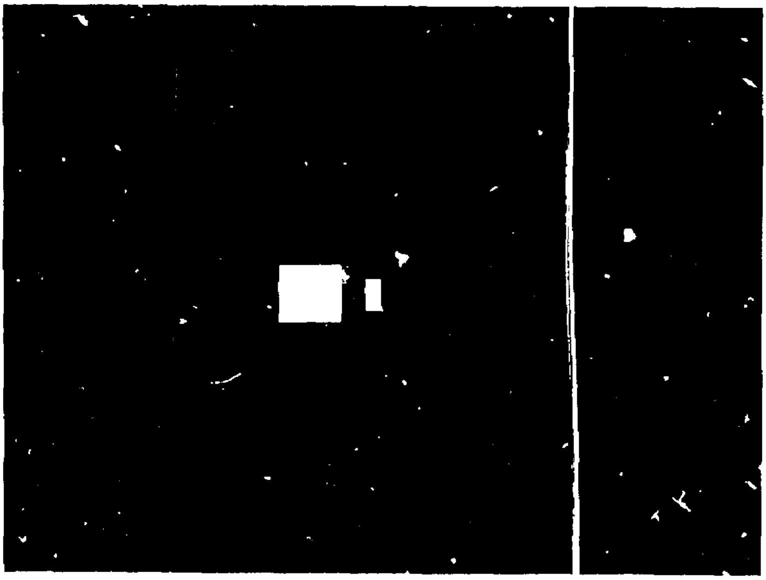
Each enlisted man was assigned a subject number as he arrived at the testing laboratory. Each subject number had been randomly assigned an order in which treatment effects were to be administered. The order of appearance of the subject in the testing situation was also randomized. Such randomization procedures are encouraged by Edgington (59) and by Kirk (60) when random selection of subjects from a population is not possible. Kirk says that to minimize possible confounding of experimental conditions everything that can be randomized should be. All randomizations carried out in both experiments used tables of random numbers.

Perceptual Task and Apparatus

In Experiment I the subjects were asked to match the shape of the comparison stimulus to the shape of the standard stimulus. The stimulus display consisted of a two-dimensional presentation of two rectangular figures. A two-dimensional stimuli display (Figure 2) was used in Experiment I in order that the stimulus shape could be continuously varied.

A continuously variable shape stimulus was required so that shape judgment error could be more accurately measured. This display appeared at the back of a stimulus presentation apparatus (Figure 3) in which the stimulus environment—such as the amount and color of illumination, background color, and surface reflectivity—could be controlled.

Stimulus Display for Experiment I



NOTE: Standard stimulus on the left, comparison stimulus on the right.

Figure 2

Stimulus Presentation Apparatus for Experiment I

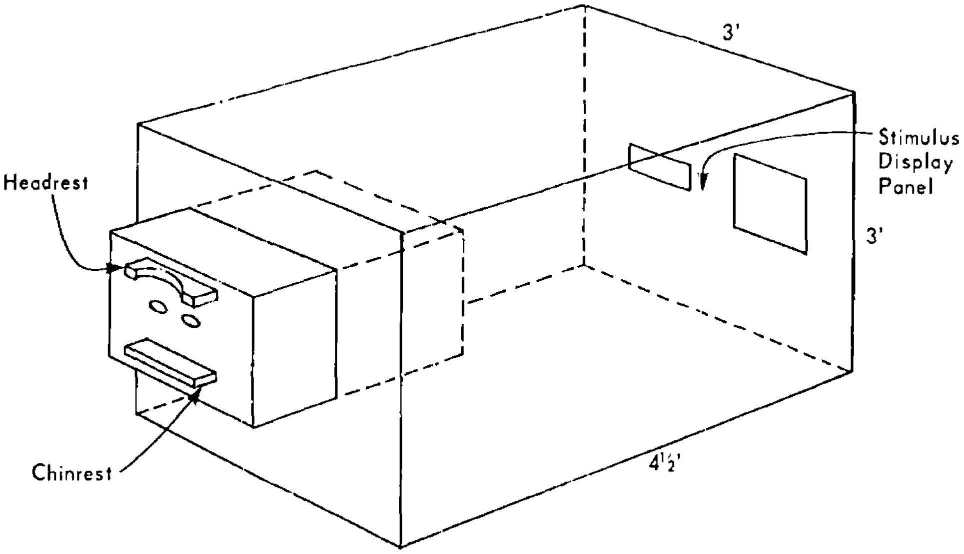


Figure 3

The inside of the stimulus presentation system was a flat black to minimize light reflection and to provide a homogeneous surrounding.

The apparatus was a box 4½ x 3 x 3 feet with a head and chin rest at the front to hold the subject's head at a fixed eye level. The subject looked inside the apparatus through a pair of nonoptical apertures. The apertures were large enough to allow for different interpupilary distances. The center of the apertures lined up with the center of the stimulus display. The front section of the apparatus, where the head and chin rests and visual apertures were located, was constructed so that viewing distance could be adjusted (adjustment was necessary in order to hold retinal area constant across the four standard stimuli that were presented).

The shape testing booth was lighted at approximately the same light level (10 footcandles) as were the test stimuli. As a result, no change in light adaptation was required of the subject when looking inside or outside the apparatus.

Stimuli

The standard and comparison stimuli consisted of rectangular openings cut in the display panel. The rectangular openings were lighted from the rear by a diffuse 10-footcandle light source. (A 10-footcandle light source was chosen because this light was not bright enough to interfere with the subject's vision and yet provided enough light to see the stimuli easily.) The widths of both rectangles were adjustable in order to alter the shape of the stimuli. The widths of the openings were changed by moving black plexiglass cover plates at the rear of the display panel (see Figure 4).

The plates were connected to motors that moved them horizontally in either direction. The speed of the motors was regulated so that the rectangular openings could

Rear of Stimulus Display Panel for Experiment I

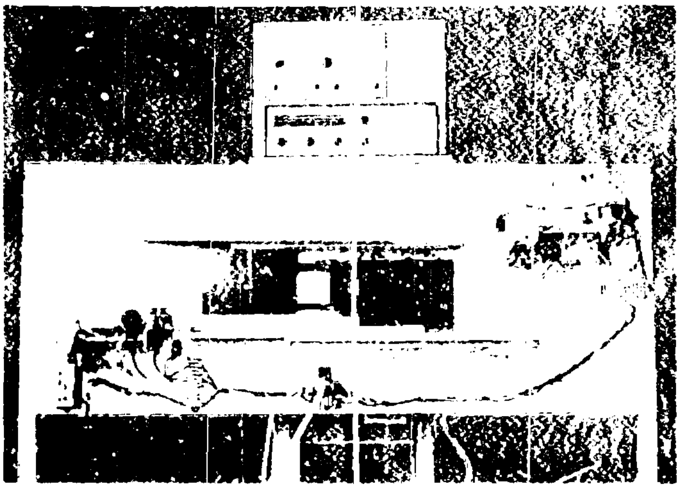


Figure 4

be widened or narrowed at the rate of .02 inch per second. The rate of movement of the variable stimuli was fast enough for the subject to determine whether the shape was changing, but not so fast that reaction time error would result in a large response error. In order to ensure that response error would not mask any perceptual bias, the direction of width change of the stimuli was randomized.

The size of the standard stimulus opening was 3 x 8 inches. This provided for a standard stimulus with a constant height of three inches and any width up to eight inches. The height of the comparison stimulus was half the height of the standard stimulus. This forced the subjects to match the two stimuli in shape, as defined by the width-to-height ratio, rather than along the linear dimension of width or retinal area, which would have been possible if the two stimuli had been the same size.

Four standard stimuli were used during the experiment. On any one trial, the standard stimulus opening was set at one of the following widths: 3.0, 3.3, 3.6, or 3.9 inches. This provided stimuli with the following width-to-height ratios: 1.0, 1.1, 1.2, or 1.3. A constant visual angle for the stimuli (3°31') was created by varying the viewing distances for each stimulus respectively to 48, 52.8, 57.6, and 62.4 inches. If the subject looked at the center of the presented standard stimulus, the resulting retinal image was located within approximately 1¾° of the fovea, placing it in an area of relatively high visual acuity. The number of standard stimuli chosen was a function of the experimental design and of the administrative aspects of data collection. It was felt that the subject should not be kept in the experimental situation more than approximately 45 minutes because of the possible decrease in some subjects' attention to the task. The subject would have been in the total testing situation, including the paper-pencil and vision tests, for 1½ hours.

The comparison stimulus shape on any one trial was continuously changed in width, either increasing or decreasing. The motor drive for the cover plate was started by experimenter. When the subject judged that the shape of the comparison stimulus was the same as the shape of the standard stimulus, he so indicated by pushing a switch, stopping the motor, and thus the cover plate, of the comparison stimulus. The exact positions of both cover plates were measured by using a digital volt ratio meter. The differences in voltage settings for the two cover plates were printed out by means of a digital printer. These differences in voltages were used to determine the errors in matching the shape of the comparison stimulus to the shape of the standard stimulus.

Experimental Design

A repeated measures randomized block experimental design was used to provide the format for data collection in Experiment I. The repeated measures factor was stimulus shape having four levels. The four levels were defined by the width-to-height ratios of the standard stimuli: 1.0, 1.1, 1.2, and 1.3. The blocks were composed of the individual subjects who received all four levels of the treatment variable of stimulus shape. To minimize the possible influence of reaction time error, each standard stimulus shape was presented four times—twice while the comparison stimulus was increasing in width and twice while it was decreasing. A mean error from these four trials was used as the subject's score for each standard shape. The order of presentation of the 16 trials for each of the 20 subjects was randomized.

Procedure

As the subjects arrived at the testing laboratory they were immediately assigned a subject number. A general explanation was then presented to include an introduction of the test personnel, a description of the kind of work being conducted concerning visual perception, and a general outline of what the testing procedures would be.

The GT scores for the subjects were recorded from their aptitude record forms. Next, the visual tests were administered to each subject.

Subjects were tested individually. Specific instructions were given to each subject just prior to beginning the shape judgment task (see Appendix B).

Before each trial, the viewing distance was adjusted so that the different standard stimuli would present the same visual angle. This adjustment was necessary to maintain the visual angle constant for all standard stimuli.

The trial began when experimenter set the standard stimulus to one of the four specific shapes, and then started the comparison stimulus moving. The subject placed his head in the headrest and looked into the eyepieces and continually compared the shape of the comparison stimulus to the standard stimulus. As soon as the subject believed that the shapes of the two stimuli were the same, he so indicated by pushing a switch, which stopped the movement of the cover plate of the comparison stimuli. The subject had no control over the direction of movement of the cover plate so he could not make changes in his judgment. Experimenter pushed the printer button to obtain a record of the subject's response. The print-out recorded, in addition to the response, the subject and trial numbers. As soon as the subject had indicated his response, he moved his head away from the apparatus and waited approximately two minutes for the next trial. This process continued until the subject had observed each of the four standard stimulus shapes four times.

Statistical Procedures

A randomized block analysis of variance design was used to statistically evaluate the influence of the shapes of the standard stimuli and of the individual differences in performance on judgments of shape. The performance measure was the mean error of the width-to-height ratios of the subjects' responses to each standard stimulus shape. This error was defined as the mean algebraic difference in the width-to-height ratios of the comparison and standard stimuli at the time the subject had made his shape matching response. A negative error indicated that the comparison stimulus had a narrower width than the standard stimulus.

It was anticipated that the distribution of scores obtained would meet the requirements of normality and homegeneity of variance, at least within the limits described by Edwards (61). If these assumptions were not met, appropriate transformation of the data would have been made. Tukey's HSD test was used to test the significance of differences among means for significant main and simple effects.

EXPERIMENT II

Experiment II was the primary experiment of this research, and was designed to produce data for testing the shape-slant invariance hypothesis. This hypothesis was tested using three-dimensional solids rotated around the vertical axis. The influence of stimulus shape, orientation, and background on the judgment of shape and rotation was tested. It was assumed that if the shape-slant invariance hypothesis held, the influence of these factors would lead to the same categorical conclusions in the interpretations of the results of the analysis of both the shape and rotation data.

F tests from two different analyses of variance cannot be directly compared since the error terms differ from one study to the next, but it is felt that a qualitative comparison of the results of the analysis could provide logical evidence supporting or rejecting the shape-slant invariance hypothesis. This line of thought follows from the assumption based upon the invariance hypothesis that the same variables should influence both shape judgment and rotation judgment performances.

Experiment II was also designed to test the postulate that perceptual style, as defined by Dees' embedded figures test,[3] was a significant source of variance in shape and rotation perception judgments (see Appendix C).

Previous research had indicated that intellectual ability influenced shape constancy. An estimate of general intelligence was obtained and correlated with both shape and rotation judgments. If the relationship had been found to be significant, a statistical control would have been used for this factor.

Subjects

The subjects were obtained for Experiment II in the same manner as in Experiment I. Because of an apparatus problem in the rotation judgment task (described later), the second experiment was run twice with two different groups of 31 subjects each. The two groups differed significantly on the variable of intellectual ability. The subjects came from two different training units, one of which was a specialty unit for training Army personnel of low intellectual abilities.

The first group had a mean GT score of 109 with a standard deviation of 13. This group was referred to as the High Group. The second group had a mean GT score of 61 with a standard deviation of 9. This latter group was called the Low Group. The occurrence of this group difference in intellectual level was advantageous in that it provided an opportunity for testing the hypothesis that intelligence significantly influences shape judgment performance.

The procedures for the shape judgment visual acuity and depth perception testing was the same for both the High and Low Groups, but due to the difference in apparatus

---

[3] An embedded figures test, consisting of test booklet and instructions, developed by J.W. Dees, K.J. O'Reilley, and D.R. Sennett, at HumRRO Divison No. 1, Fort Benning, Ga.

the procedure for testing rotation judgment differed. As in the first experiment, the subjects were assigned a subject number as soon as they arrived at the laboratory. The order of presentation of treatment conditions was randomized for each subject number.

Perceptual Task and Apparatus

Experimental procedures were adopted in Experiment II designed to obtain two types of perceptual responses in the same test from one standard stimulus. The two types of responses were shape judgments and rotation judgments. The experiment was designed so that the comparison stimuli for both types of responses were presented under the same treatment conditions at the same time.

The first task of the subjects required a judgment of stimulus shape. The subjects were asked to select one of 11 comparison stimuli that they judged had a shape (width-to-height ratio) that matched the shape of the standard stimulus. The psychophysical procedure used to obtain these data was a modification of the method of constant stimuli. The standard stimuli used in Experiment II were three-dimensional solids so that adequate information would be provided allowing shape constancy to occur. The size of the stimulus field used was 15 x 30 inches which was a function of the size of the apparatus used in Experiment I.

Eleven shape comparison stimuli were used which provided for the equal positioning of the standard stimuli within the series of comparison stimuli; that is, the comparison stimulus No. 3 had the same shape as the 1.0 standard stimulus, comparison stimulus No. 6 had the same shape as the 1.1 standard stimulus, and comparison stimulus No. 9 had the same shape as the 1.2 standard stimulus. This provided for two comparison stimuli to be placed to each side of each standard stimulus. The comparison stimuli were placed below the stimulus field so that the position of the stimuli could be easily randomized between subjects (Figure 5). This was necessary because of the requirement for randomizing the position of the shape comparison stimuli for each subject so that influence of the position of the stimuli upon performance would be minimized.

The second task for the subjects required the matching of the rotational settings of the comparison and standard stimuli. The subjects were asked to rotate the single

Stimulus Display for Experiment II

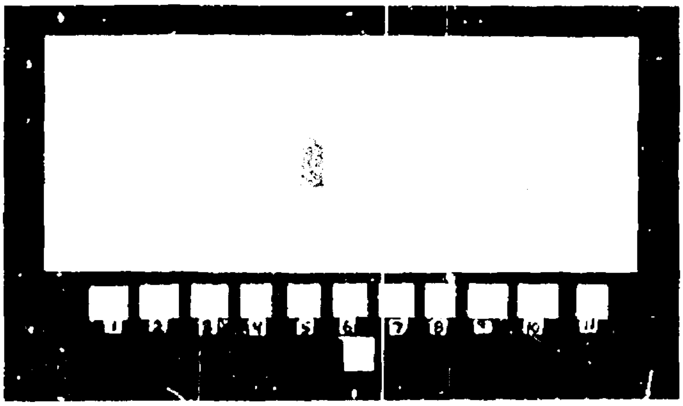


Figure 5

rotational comparison stimulus until they judged that it was the same as the rotational orientation of the standard stimulus.

As mentioned earlier, a problem arose with the response apparatus in the rotation judgment task. During the initial conduct of Experiment II (with the High Group), experimenter noticed that almost all subjects had considerable difficulty using the rotation judgment apparatus. The comparison stimulus used by the High Group was located at the front of and outside of the stimulus presentation apparatus. Subjects were required to shift their viewing from the inside to the outside of the apparatus in order to make comparisons of the rotation of the stimuli. Because of this obvious difficulty and the differences in the stimuli surrounds, the response apparatus was redesigned and the experiment was rerun with the second (Low) group.

Light Box Used in Experiment II

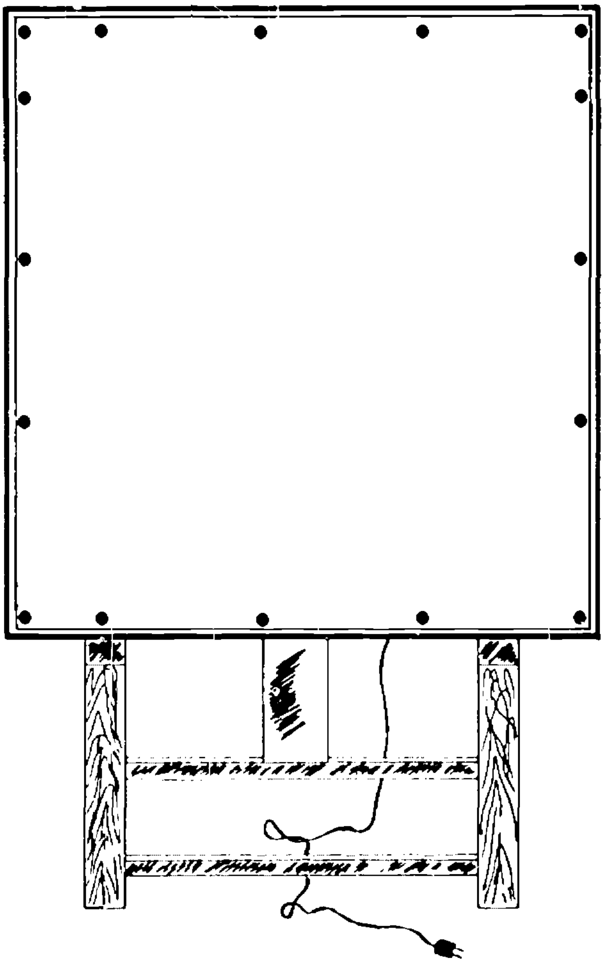


Figure 6

The rotation response apparatus used by the Low Group consisted of a rectangular solid, similar to the shape comparison stimuli, and three servomotors. The rotation comparison stimulus was located below the shape comparison stimuli so that it would not obstruct the view of the shape comparison stimuli, but was still within the same visual field containing the standard stimulus.

The rotation comparison stimulus was mounted on a shaft that was attached to a receiver servomotor. The position of the comparison block was controlled by a transmitter servomotor located near the subject. The transmitter servomotor had a control knob that the subject turned when he was matching the rotational setting of the comparison stimulus to the rotational setting of the standard stimulus. Another receiver servomotor was located near experimenter to provide an indication of the position of the comparison stimulus after the subject had made his rotational match.

The standard stimulus backgrounds were provided in different manners. The unstructured background (Figure 6) was formed by the plain surface of the light box. The structured background (Figure 7) was formed by using flat black artist tape on a clear cellulose sheet. The sheet was attached to a wooden rod so that it could easily be hung onto the light box behind the visual display field.

Structured Background for Experiment II

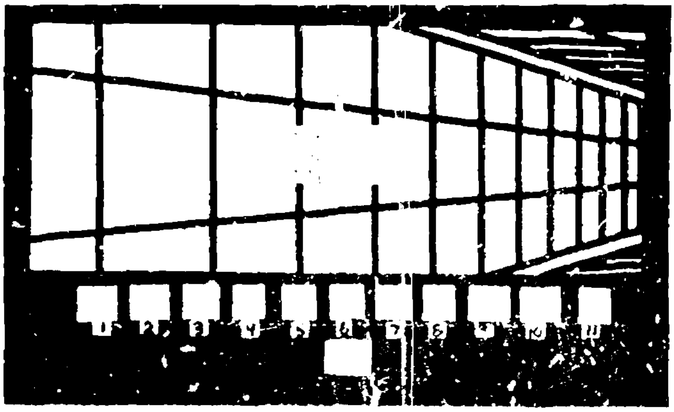


Figure 7

Stimuli

The stimuli for Experiment II were three-dimensional rectangular wooden blocks. The height and depth of the standard stimuli were a constant 3.0 inches. The widths of the standard stimuli were 3.0, 3.3, and 3.6 inches. These dimensions resulted in width-to-height ratios of 1.0, 1.1, and 1.2. The measurements of the three dimensions were accurate to within ±.015 inch.

The 11 shape comparison stimuli were constructed one-half the size of the standard stimuli to prevent the subjects matching either the widths or the retinal areas, rather than the desired match of shape as defined by the width-to-height ratio at the front of the block. The width of the comparison stimuli varied in increments of .05 inch from 1.4 to 1.9 inches. The increment of .05 inch was arrived at using descriptive data from Experiment I. The rotation comparison stimulus was a cube of 1.5 inches to a side.

All stimuli were painted a flat gray to minimize light glare, but they still provided an adequate stimulus-background contrast ratio. The target background contrast ratios were such that the stimuli did not visually fuse with any part of the background.

The standard stimulus, located 53 inches from the center of the eye pieces, was suspended from the top of the display panel by a clear plexiglas rod. The rod was hung from a block to which a protractor was attached. A pointer was affixed to the plexiglas rod above the protractor so that an exact rotational setting of the standard stimulus, with reference to the protractor, could be made by experimenter.

The shape comparison stimuli were placed so that the front of the blocks were perpendicular to the subject's line of sight. The shape comparison stimuli were placed perpendicular to the subject's line of view so that the same information was available for each block. The positions of the comparison blocks were numbered from left to right, 1 through 11.

The stimulus display was lighted from both the front and the back in order to provide constant illumination of the stimuli and eliminate many of the shadows. Inside the presentation system and above the eye apertures, a light bulb was placed to illuminate the front of the display. A light box with a translucent cover illuminated the display from the back. Using a spot photometer the illumination level from the light box was set near 10 footcandles.

Experimental Design

A four-factor split-plot, repeated measures design was used as the data collection format for Experiment II. The repeated measures factors were stimulus shape, rotational setting, and background. The fourth factor, *perceptual style*, was a nonrepeated measures factor because it was an organismic variable. Two levels of perceptual style were used: a field-independent style and a field-dependent style. For this experiment, field-independent subjects were defined as those subjects who had the scores above the 50th percentile on the embedded figures test (EFT), and field-dependent subjects were those who had the scores at and below the 50th percentile.

The shape factor had three levels, defined as the width-to-height ratios of the standard stimuli. These ratios were 1.0, 1.1, and 1.2.

The rotation factor had four levels, defined as the degrees rotated around the vertical axis. These levels were selected in order to be able to relate the results of this study with previous studies. The standard stimuli were rotated only counterclockwise (the right side of the block rotated away from the subject out of the frontal-parallel plane) from 0° to 22°, 44°, and 66°.

The third factor was stimulus background which had two levels. The two levels of the background variables were selected because they provided extreme differences in structure and it was assumed that if background structure was a significant variable, it should show up under these conditions.

The order in which the 24 treatment combinations were presented was randomized for each of the subjects. This randomization procedure was accomplished to minimize possible order effects on performance.

Procedure

The subjects were assigned a subject number as soon as they arrived at the laboratory. Following the general introduction (same as Experiment I), the GT scores for each subject were recorded. The visual acuity and depth perception tests were administered next, with the same procedures and visual requirements as those in Experiment I being observed.

Before beginning the experimental tasks, the subjects were given the EFT (Appendix C). After finishing the EFT, the subjects were individually escorted to the test booth. Specific instructions for the shape and rotation matching tasks were given just prior to beginning the experimental task (Appendix A).

The first trial began after experimenter had set one of the three standard stimuli to one of the four rotational positions and had selected one of the stimulus backgrounds. Experimenter randomized the positions of the 11 comparison stimuli before each subject began the test session. The rotation comparison stimulus was set at 0° rotation before each trial.

After the test stimuli had been installed for a trial, the student placed his head in the head-chin rest, looked through the eyepieces, and selected the comparison stimulus that he judged matched the shape of the standard stimulus. As soon as he made his selection, which was recorded by an assistant experimenter sitting in the test booth, the student then adjusted the rotation comparison stimulus until he judged that it matched the rotational setting of the standard stimulus. The assistant experimenter recorded the rotational setting of the comparison stimulus while experimenter was preparing for the next trial. This procedure continued until each subject had made one shape and one rotation match for each of the three standard stimulus shapes at each of the four rotational settings against both backgrounds—a total of 24 shape and 24 rotation matches.

Performance Measures

The performance measure that was used in the statistical analyses of the shape judgment data was the same as that used in the first experiment—the error in the width-to-height ratios for each response. The performance measure used in the analyses of the rotation judgment data was the error in the rotational setting of the comparison stimulus relative to the setting of the standard stimulus. A negative error indicated that the subject had not rotated the comparison stimulus as far counterclockwise out of the frontal-parallel as the standard stimulus had been rotated. A positive error indicated that the subject had rotated the comparison too far. The negative error was termed an underestimation of the rotation of the standard stimulus and a positive error was termed an overestimation.

Chapter 3

RESULTS AND ANALYSES

EXPERIMENT I

Although Experiment I was designed primarily as a pilot study, the data are presented here to emphasize a behavioral fact: that individual differences are a significant source of performance variance. The data collected in Experiment I were approximately normally distributed about a mean shape judgment error of 0.033. The range of errors was from an underestimation of 0.177 of the width-to-height ratios to an overestimation of 0.241. The standard deviation was 0.102. Measurements were made with an accuracy of 0.001. The reliabilities of the measurements were evaluated by correlating across the subjects the two scores obtained under the same conditions. For the eight conditions (the two directions of movement of the cover plates and the four shapes of the standard stimuli), these reliability coefficients ranged from 0.85 to 0.98.

The summary for the analysis of variance conducted on the data is shown in Table 1. The results of the analysis indicated that the individual perceivers were a significant source of performance variance. As indicated from the analysis of variance, the shape of the standard stimulus was not a significant factor in shape judgment performance. This result is clearly evident when the mean subjective shape responses were compared with the objective shapes (width-to-height ratios of the standard stimuli) in Figure 8.

The results of the first experiment were used to ensure that the shape comparison stimuli used in Experiment II would be sensitive to the measurement of shape judgments. The results of Experiment I indicated the shape could be judged with a mean error (in width-to-height ratio) of 0.033, and this was approximately the interval size between shape comparison stimuli used in Experiment II. An error of this size would indicate that, for example, when the shape of a standard stimulus with a width-to-height ratio of 1.0 was judged, the student would select a comparison stimulus that had a width-to-height ratio of 1.033.

The results of the statistical evaluations from Experiment I supported the hypothesis that individual differences in shape judgment performance were a significant source of variance. This empirical evidence of the importance of individual differences provided a rationale for selecting statistical procedures for Experiment II that take into account this source of variance.

Table 1

Shape Judgment Analysis of Variance
(Experiment I)

Source of Variance	*df*	*MS*	*F* ratio
Between Shapes	3	.002	<1
Between Subjects	19	.043	3.91[a]
Residual	57	.011	

[a] $p < .05$

Experiment I: Mean Width-to-Height Ratios of Perceptual Shape Compared to Objective Shape

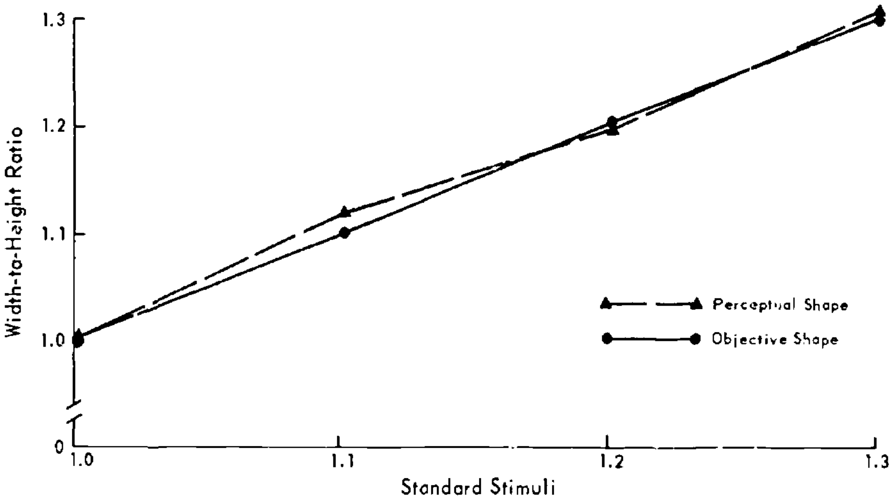


Figure 8

EXPERIMENT II

The establishment of conditions under which shape constancy would occur was a prerequisite for the conduct of Experiment II. Figures 9, 10, and 11 indicate graphically that shape constancy was obtained. It can be seen that both groups (High and Low) judged shape with considerable accuracy. For the High group, the perceptual error for each of the three standard stimuli did not differ significantly from zero error at any of the four rotational settings. For the Low group, eight out of the 12 mean errors did not differ significantly from zero error. It was concluded that the conditions for occurrence of shape constancy had been created.

Because of the differences in intellectual functioning between the High and Low groups, the data for the two groups were analyzed separately for both the shape and the rotation judgment tasks. Although the two groups differed significantly on GT level, there was no significant difference between the mean shape judgment scores. Both groups judged stimulus shape with equal accuracy. The mean judgment errors are presented in Table 2.

The analysis of variance summaries for the shape data are shown in Table 3 for the High group and Table 4 for the Low group. The main effects for orientation and shape were significant for both groups, as were the interactions of shape x style, and orientation x shape. In addition, a significant second-order interaction, orientation x background x shape, was found significant for the High group. These results are shown graphically in Figures 12, 13, and 14. It is of interest to note that despite the fact that the two groups of subjects were quite different in terms of mental abilities, their perceptual performances for the shape judgment task were quite similar.

Comparison of Perceived Shape With Objective and Retinal Shapes *(1.0 Standard Stimulus)*

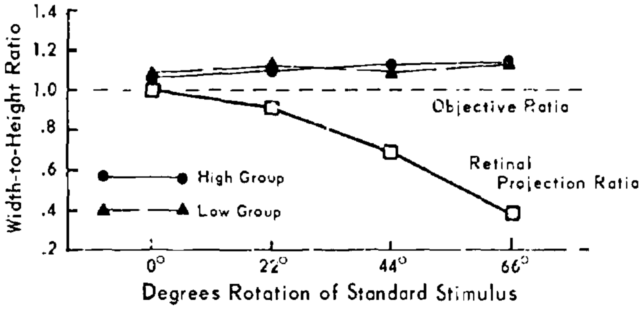


Figure 9

Comparison of Perceived Shape With Objective and Retinal Shapes *(1.1 Standard Stimulus)*

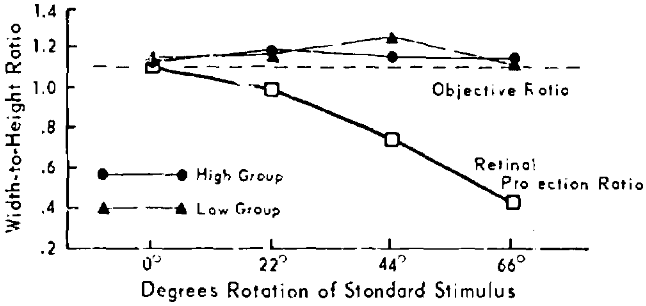


Figure 10

Comparison of Perceived Shape With Objective and Retinal Shapes *(1.2 Standard Stimulus)*

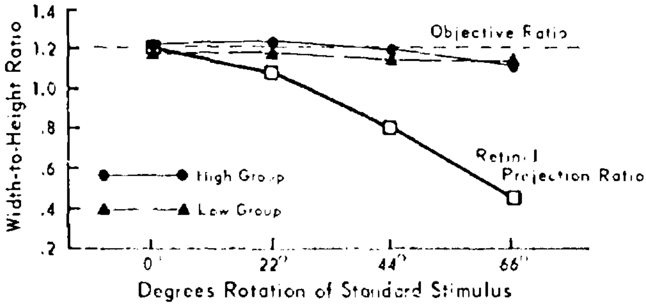


Figure 11

Table 2

Shape Judgment Errors (Width/Height) (Experiment II)

	High Group	Low Group
Mean	.053	.033
Standard Deviation	.069	.035

The Tukey tests for simple effects that were run following the F tests, revealed that shape was judged with greater ($p<.05$) error at a rotational setting of 22° than at 66° for both groups. Further, the High group judged shape with greater ($p<.05$) error at a rotation of 44° than at 66°; the Low group judged shape with less ($p<.05$) error at 41° than at 22°.

Table 3

Analysis of Variance: Shape Judgment for High Group

Source of Variance	*df*	*MS*	*F*
Between Subjects			
Between Styles (A)	1	222	<1
Error A	32	1,271.8	
Within Subjects	782		
Between Orientations (B)	3	841	3.6^a
A x B	3	385	1.7
Error B	96	231.5	
Between Backgrounds (C)	1	93	1.2
A x C	1	62	<1
Error C	32	79.4	
Between Shapes (D)	2	18,849.0	114.1^b
A x D	2	667.0	4.0^a
Error D	64	165.2	
B x C	3	84.3	<1
A x B x C	3	70.3	<1
Error BC	96	108.8	
B x D	6	1,404.2	11.5^b
A x B x D	6	55.8	<1
Error BD	192	122.4	
C x D	2	2.5	<1
A x C x D	2	41	<1
Error CD	64	128.2	
B x C x D	6	256.5	4.3^a
A x B x C x D	6	104.5	1.8
Error BCD	192	58.7	

$^a p < .05$

$^b p < .01$

Table 4

Analysis of Variance: Shape Judgment for Low Group

Source of Variance	*df*	*MS*	*F*
Between Subjects			
Between Styles (A)	1	995	3.3
Error A	32	297.6	
Within Subjects	782		
Between Orientations (B)	3	319	2.9[a]
A x B	3	56.7	
Error B	96	110.4	
Between Backgrounds (C)	1	13	<1
A x C	1	79	<1
Error C	32	97.5	
Between Shapes D	2	12,112.5	81.4[b]
A x D	2	632.5	4.3[a]
Error D	64	148.7	
B x C	3	58.3	1.4
A x B x C	3	63	1.5
Error BC	96	42.9	
B x D	6	278.5	3.2[a]
A x B x D	6	112.5	1.3
Error BD	192	88.3	
C x D	2	40	<1
A x C x D	2	50.5	<1
Error CD	64	62.0	
B x C x D	6	73.3	1.2
A x B x C x D	6	40.8	<1
Error BCD	192	61.6	

[a] $p < .05$
[b] $p < .01$

The standard stimulus having the shape with the 1.0 width-to-height ratio was judged with greater ($p<.05$) error than were the other two standard stimuli by both groups. In addition, both groups underestimated the shape of the most rectangular stimulus; that is, they judged the 1.2 stimulus to be narrower in width than it actually was.

The subjects with a field-dependent perceptual style judged the shapes of the standard stimuli with greater variation between stimuli than did the field-independent subjects.

Subjects in both High and Low groups judged the shape of the 1.0 standard stimulus with greater error as it was rotated out of the frontal-parallel plane. This difficulty was reflected in an increasing overestimation as rotation increased; that is, the width-to-height ratio was judged to be greater than it actually was as the stimulus was turned out of the frontal-parallel plane. Conversely, the most rectangular standard stimulus was increasingly underestimated as rotation increased. These opposite trends produced the orientation x shape interaction.

Shape Judgment Errors: High Group and Low Group *(Width-to-Height Ratios)*

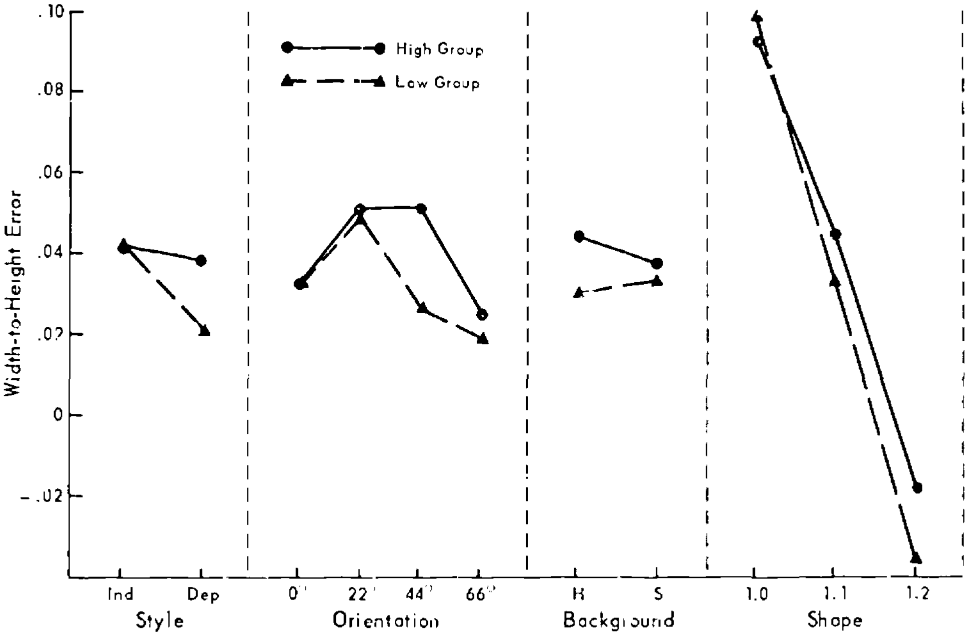


Figure 12

The significant second order interaction of orientation x shape x background (Figure 14) indicated that as the rotational setting of the standard stimuli increased against the structured background, errors of shape judgment became more divergent between the 1.0 and 1.2 standard stimuli.

The significant *F* ratios obtained in the analysis of variance of the data for each group indicated that relationships existed between the dependent variable of shape judgment and the significant treatment levels of the independent variables. The strength of these associations was computed (Kirk, 61) and is presented in Table 5. From this analysis, the independent variable of shape accounted for considerably more variance in shape judgment accuracy than the other treatments combined. The amount of variance attributable to variation between subjects was found to be 22% for the High group and 12% for the Low group. This indicated that the subjects in the Low group were relatively more homogeneous in their performance than the subjects in the High group.

For statistical analysis, the data from the rotation judgment task were separated for the two groups for two reasons: first was the difference in intelligence levels of the High and Low groups of subjects, and second was the difference in the apparatus used to obtain the rotation judgment responses for the two groups. There was a significant difference ($p < .05$) in the mean errors between the two groups (Table 6). This difference could possibly be a function of either the difference in the intelligence variable or in the apparatus.

The apparatus used with the Low group was the more appropriate technique, since with it the comparison stimulus was presented under the same experimental condition as

Significant Interactions Common to Both Groups of Subjects

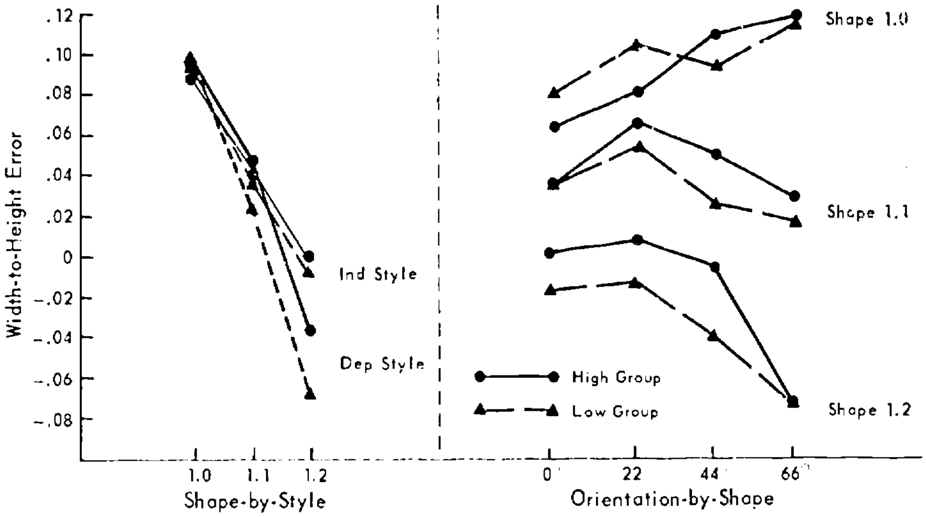


Figure 13

Significant Orientation x Shape x Background Interaction: High Group

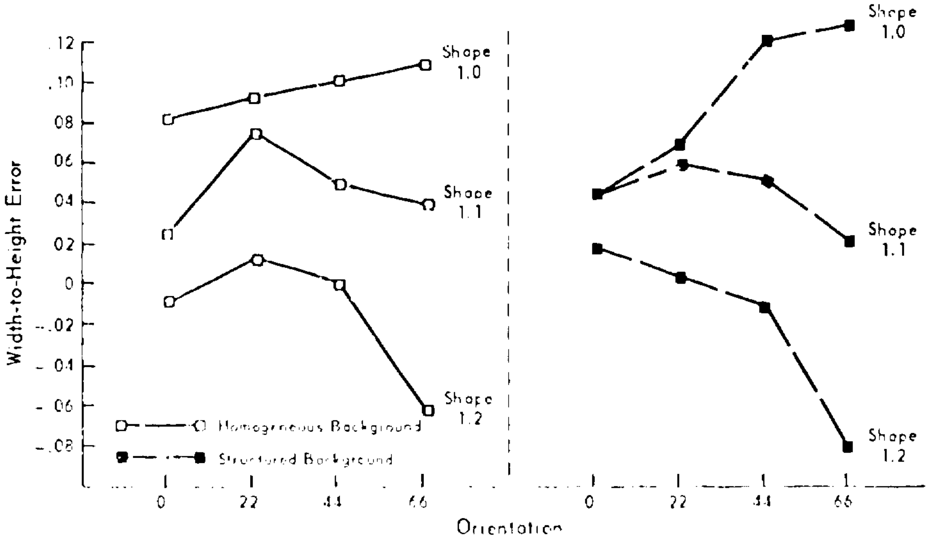


Figure 14

Table 5

Percentage of Variance of Shape Judgments Accounted for by Significant Treatment Effects

Treatment Conditions	High Group	Low Group
Orientation	1	1
Shape	20	25
Orientation x Shape	4	2
Shape x Style	1	0.6
Orientation x Shape x Background	0.5	<1

Table 6

Mean Errors of Rotation Judgment

	High Group	Low Group
Mean	−7.49	1.18
Standard Deviation	5.14	2.02

was the standard stimulus. Therefore, only the rotation judgment data for the Low group were used in the evaluation of the invariance hypothesis.

The summary for the analysis of variance for the rotation data for the Low group is presented in Table 7. As in the analysis of the shape judgment data, the main treatment effects of orientation and shape were found to be significant variables influencing rotation judgments. In addition, perceptual style was found to be a significant main effect. The results for all main treatment effects are shown graphically in Figure 15.

Table 7

Analysis of Variance Summary Group: Rotation Judgment for Low Group

Source of Variance	*df*	*MS*	*F*
Between Subjects			
Between Styles (A)	1	389.8	4.18[a]
Error A	32	93.2	
Within Subjects	782		
Between Orientations (B)	3	1,319.5	15.85[b]
A x B	3	31.2	<1
Error B	96	83.3	
Between Backgrounds (C)	1	13.7	<1
A x C	1	0.0	<1
Error C	32	65.6	

(Continued)

Table 7 *(Continued)*

Analysis of Variance Summary Group: Rotation Judgment for Low Group

Source of Variance	*df*	*MS*	*F*
Between Shapes (D)	2	270.8	4.9
A x D	2	19.9	<1
Error D	64	55.0	
B x C	3	12.5	<1
A x B x C	3	36.1	
Error BC	96	61.0	
B x D	6	110.8	1.8
A x B x D	6	69.5	1.1
Error BD	192	61.2	
C x D	2	110.5	1.7
A x C x D	2	63.1	<1
Error CD	64	65.9	
B x C x D	6	97.9	1.8
A x B x C x D	6	25.4	<1
Error BCD	192	54.2	

[a] $p < .05$
[b] $p < .01$

Rotation Judgment Errors: Low Group

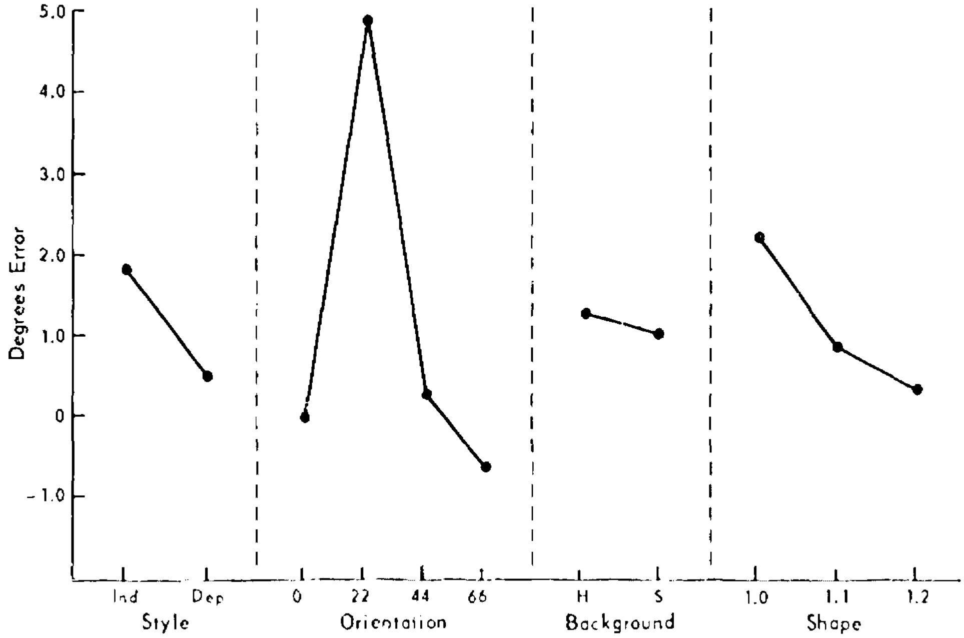


Figure 15

Table 8

Mean Errors for Perceptual Style Grouping of Subjects

	Field-Independent	Field-Dependent
Mean	1.84°	0.46°
Standard Deviation	7.49	9.01

Tukey's tests of differences between means following the *F* tests revealed that rotation was judged with greater ($p<.05$) error when the standard stimuli were at a setting of 22° than at any of the other three settings. The rotation judgments of the standard stimuli at the other settings (0°, 44°, and 66°) did not differ from each other.

Tukey's tests revealed that rotational settings of the standard shape having 1.0 width-to-height ratio were judged with more ($p<.05$) error than were the settings of the other two standard shapes, which did not differ.

Field-independent subjects judged stimulus rotation with greater error than did the field-dependent subjects. However, the field-dependent subjects judged rotation with greater ($p<.01$) variation than the field-independent subjects. The mean errors and standard deviations are shown in Table 8. The strengths of the associations between the independent variables and the dependent variables of rotation judgment are presented in Table 9. The amount of variance attributable to variation in performance between subjects was only 5%. This amount of variance was less than that found for the same subjects in the shape judgment task, thus indicating that the subjects behaved relatively more homogeneously in judging rotation than in judging shape.

Table 9

Percentage of Variance of Rotation Judgments Accounted for by Significant Treatment Effects

Treatment	Percent Variance
Styles	0.5
Orientation	6.6
Shape	0.9

COMPARISON OF SHAPE AND ROTATION PERCEPTION

The shape-slant invariance hypothesis as formulated by Beck and Gibson (4) required that apparent shape be related to apparent slant in a unique way, so that the apparent projected image would be related to the objective projected image (retinal image). The apparent projected image is the image that would be projected into the frontal-parallel plane by a stimulus that would reflect the shape and rotation judgments of the subject.

The objective projected image is the image that would be projected into the frontal-parallel plane by a standard stimulus of a given shape and set at a given rotation. Since the only dimension of the standard stimulus that changed with the shape of the stimulus was the width, the width of both the objective and the apparent projected images was computed. The widths of the apparent projections were then correlated with the widths of the objective projections.

Table 10

Mean Errors of Shape and Rotation Judgments for Each Subject

Subject Number	Shape		Rotation		Correlation of Apparent Projection With Objective Projection[a]
	M	*SD*	*M*	*SD*	
1	.014	.082	1.91	5.17	.99
2	.018	.066	7.79	12.58	.81
3	.007	.115	−.29	2.73	.97
4	.045	.110	2.54	3.84	.98
5	.035	.125	1.21	6.38	.88
6	.006	.119	5.88	6.72	.96
7	.047	.121	.92	4.65	.95
8	−.008	.144	1.88	3.62	.96
9	.003	.127	−1.54	13.78	.86
10	.015	.128	.92	15.66	.94
11	.047	.106	.79	6.26	.99
12	.014	.132	−2.04	9.53	.81
13	.029	.093	−2.33	6.55	.92
14	.067	.095	.67	3.92	.98
15	.078	.108	1.21	10.77	.92
16	.031	.093	1.54	9.72	.90
17	.065	.060	3.67	5.54	.99
18	.043	.113	−1.83	7.90	.90
19	.057	.060	1.54	6.16	.96
20	−.059	.114	1.00	7.32	.92
21	.035	.100	2.46	4.32	.99
22	.085	.121	−1.42	5.38	.93
23	.083	.076	−.13	16.94	.75
24	.081	.078	.92	3.49	.97
25	.054	.092	2.79	5.81	.99
26	.050	.078	1.75	4.29	.98
27	.017	.070	2.38	7.78	.97
28	.055	.105	1.29	14.66	.72
29	.086	.076	1.46	4.44	.98
30	.003	.095	.63	6.67	.98
31	.065	.068	.34	3.43	.98
32	.060	.123	.25	5.55	.91
33	−.015	.134	−.63	8.16	.91
34	.038	.130	2.58	4.84	.93

[a] All correlations $p < .01$, one tail test

The widths (W') of the projected images were obtained using the following general equation:[4]

$$W' = \left(\frac{W}{2}\cos\alpha \quad \frac{D}{2}\sin\alpha\right) + \frac{\left(V - \frac{W}{2}\sin\alpha - \frac{D}{2}\cos\alpha\right)\left(W\cos\alpha + D\sin\alpha\right)}{2V - D\cos\alpha + W\sin\alpha}$$

where W = the actual width of the standard or comparison stimulus, D = the actual depth of the stimulus, V = the viewing distance, and α = the angle of rotation.

The viewing distance and the depth dimension were constant for all computations. The widths and rotational settings of the standard stimuli were used to obtain the objective projected images. The apparent projected images were obtained by using the shape and rotation responses of each subject. Correlation coefficients of the apparent with the objective projections were computed for each subject and are presented in Table 10. All of these coefficients were significant. An overall correlation coefficient was obtained by using Z transformations and averaging across the subjects. The average correlation was 0.95, which was also significant. The coefficients for field-independent subjects were slightly higher (0.97) than for the field-dependent subjects (0.93) but this difference was not significant.

The mean (across all subjects) apparent projected images were compared with the corresponding objective image projections and no significant differences were found. These data are presented in Table 11.

Table 11

Mean Widths of Apparent and Objective Projected Images

Width of Projected Image	Width and Rotation of Standard Stimulus								
	3.0 In.			3.3 In.			3.6 In.		
	22°	44°	66°	22°	44°	66°	22°	44°	66°
Apparent									
M	2.81	2.20	1.09	2.99	2.34	1.31	3.15	2.38	1.38
SD	.35	.36	.30	.24	.24	.45	.34	.36	.40
Objective	2.74	2.09	1.12	3.01	2.27	1.22	3.26	2.48	1.33

The widths of the projected images are compared graphically in Figure 16. The fact that the apparent projected images were correlated with and did not differ from the objective projected images indicated that the subjects selected shape-rotation combinations that represented members of the set of stimuli that would be expected to project the specific images onto the retina. This was probably the most significant finding of this research, since it gives support to the validity of the shape-slant invariance hypothesis.

---

[4] The derivation of this equation appears in "Shape Perception Judgments as a Function of Stimulus Orientation, Stimulus Background and Perceptual Style," by Edward W. Frederickson, PhD. Dissertation, Baylor University, August 1969.

Comparison of Apparent Image With Objective Image *(Width)*

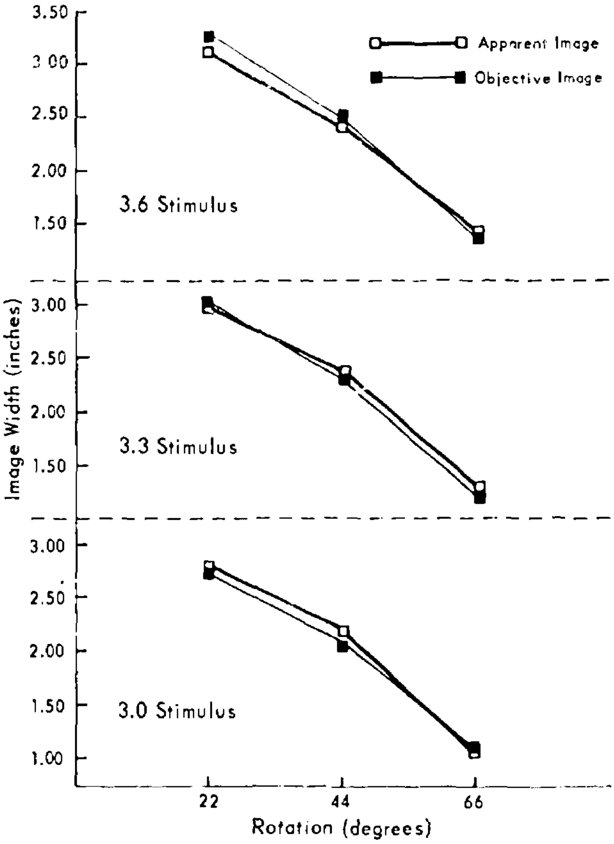


Figure 16

It was proposed that the general shape of the performance curves for both shape and rotation judgments would be similar if the shape-slant invariance hypothesis did describe a valid behavioral relationship. These curves are compared graphically in Figure 17. Note that the mean errors for shape and rotation judgments that are plotted in Figure 17 are rank ordered. A significant ($r = .58$, $p < .05$) Pearson correlation coefficient between the mean errors of shape and rotation judgements was obtained.

Comparison of Shape and Rotation Judgments

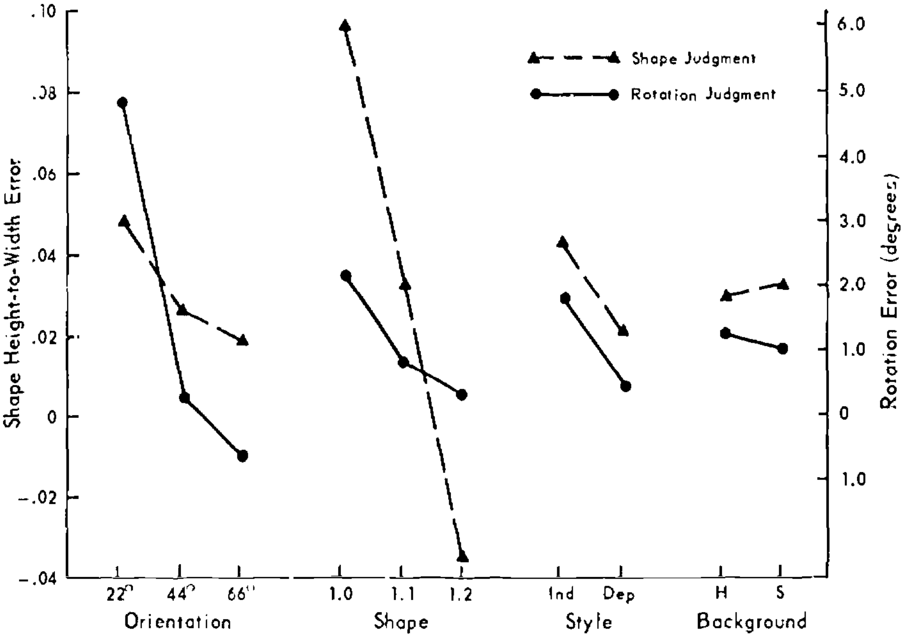


Figure 17

Chapter 4

EVALUATION

DISCUSSION

All three statistical procedures used to evaluate the data in this study led to the conclusion that the apparent shape and apparent rotational orientation of three-dimensional rectangular solids are functionally related.

The more traditional statistical procedure, correlation of judgment errors, resulted in a significant positive functional relationship between shape judgment errors and rotation judgment errors as was predicted from the invariance hypothesis. This indicated that for a given retinal image, when the subject made an overestimation of shape, he also perceived the rotation as being greater than it actually was. From Gibson's theoretical point of view, this was interpreted to mean that the subject made an error in shape perception because he had not correctly perceived the rotational orientation.

The misperception of rotation could possibly be accounted for by a lack of sufficient information for veridical rotation perception. However, as a group, this sample of subjects actually judged the rotation of the standard stimulus with considerable accuracy. Only when the data for individual subjects were examined was evidence found that would support the insufficient information hypothesis. Here, again, the importance of taking into account individual difference in the evaluation of a hypothesis concerning a behavioral relationship was demonstrated.

The comparison of the categorical decisions, which were arrived at in the analyses of variance, provided further support for the shape-slant invariance hypothesis. The contention was that variables, or combination of variables, that influence shape judgments would also have a similar influence on rotation judgments, and further, any variable that did not influence shape perception would also not influence rotation perception. These contentions were sufficiently confirmed in the analyses of variance. A total of 15 F ratios were obtained in each analysis of variance, and 12 of these resulted in identical categorical decisions for both analyses.

The third statistical evaluation was the comparison of the apparent projected images with the objective projected images. This approach provided an explanation for what appeared to be errors in the judgment of stimulus shape, rotation, or both. What appeared to be errors in judgment of shape and rotation seemed not to be a function of an inability to veridically perceive shape rotation, but actually a function of the apparent perception of the shape-rotation combination of the standard stimulus.

This explanation was arrived at as a result of the observation that the shape of the apparent image did not differ statistically from the retinal image. This conclusion, if it holds across other conditions, will lead to the problem in recognition training brought out in Chapter 2, that object shape, per se, cannot be the sole cue for the recognition of that object.

The mean perceptual judgments obtained in this research were generally in agreement with previous work. Both shape and rotation were overestimated for small values and underestimated for large values, which is the result that has been obtained in a variety of perceptual tasks.

The shape judgments were found to be more accurate than the rotation judgments. That is, when the two distributions were compared, the standard deviation relative to the mean error was less for the shape judgments than for the rotation judgments. This finding supports the work of Smith (13), who reported that phenomenal shape was more stable than phenomenal slant.

Previous research had found that shape judgment errors increased as the rotational orientation increased up to 45°-60°, and then decreased with further rotation. The data for the High Group supported this early work, but the data for the Low Group did not. Errors for the Low Group increased up to 22° but decreased at greater rotations. One explanation that could be offered for this difference in simple effects was the difference in intellectual functioning of the two groups, although it does not seem that an interaction between intelligence and angle of rotation is a reasonable hypothesis.

The expected interaction effect of stimulus background and perceptual style was not obtained, possibly because the amount of contextual information did not differ enough between the homogeneous and structured backgrounds. Although the immediate background of the homogeneous level was unstructured, it was observed that there still existed within the total visual field a sufficient amount of structure to reduce the expected difference of effect on performance.

The shape-slant invariance hypothesis was proposed originally to account for shape constancy. Gibson implicitly had essentially proposed this functional relationship as included in his psychological theory of perceptual behavior. However, whether or not this research could be said to indirectly support Gibson's theory, the psychophysical process underlying the theory can not be specified. The theory, like any complete psychological theory, must specify the series of successive events that produce the observable behavioral relationship.

CONCLUSIONS

The results of this research are too specific to permit other than a conclusion that a relationship between shape perception and rotational orientation was observed under a given set of conditions. These results need to be extended to a more general range of conditions before an attempt can be made to specify the series of events underlying shape-slant invariance.

This research was conceived as being the first in a series of experimental efforts to produce conclusions that could be directed toward an understanding of recognition behavior. This effort was directed toward the delineation of functional behavioral relationships that could aid in this understanding. Before proceeding to the study of other relationships, the shape-slant relationship must be examined under additional treatment conditions which must include different forms, both additional simple and eventually complex forms, various colors, background context, and viewing distances.

The specific conclusions that were reached as a result of this study were:

(1) Shape and rotation judgments of three-dimensional rectangular solids are influenced by the specific shape of the solids.

(2) Shape and rotation judgments of three-dimensional rectangular solids are influenced by the rotational settings of the solids.

(3) The perceptual style of the perceiver influences judgment of the shape and of the rotational settings of three-dimensional rectangular solids.

(4) The individual differences between subjects contribute a significant amount of variance to shape judgment performance.

(5) Shape and rotation judgments are related behaviors in the perception of three-dimensional rectangular solids.

(6) The shape of three-dimensional rectangular solids is judged with relatively more consistency than is the rotational orientation.

(7) The apparent projected image is related to the objective (retinal) image projected from three-dimensional rectangular solids.

(8) The shape-slant invariance hypothesis is a valid description of the relationship between the perception of the shape and rotation of three-dimensional rectangular solids.

(9) The level of intellectual functioning of subjects does not influence the judgment of the shape of three-dimensional rectangular solids.

LITERATURE CITED
AND
APPENDICES

Literature Cited

1. Gibson, J.J. *The Senses Considered as Perceptual Systems,* Houghton-Mifflin Company, Boston, 1966.
2. Koffka, K. *Principles of Gestalt Psychology,* Chap. VI, Harcourt, Brace & Company, New York, 1935.
3. Ittelson, W.H. *Visual Space Perception,* Springer Publishing Company, Inc., New York, 1960.
4. Beck, Jacob and Gibson, James J. "The Relation of Apparent Shape to Apparent Slant in the Perception of Objects," *Journal of Experimental Psychology,* vol. 50, no. 2, 1955, pp. 125-133.
5. Eissler, K. "Die Gestaltkonstanz des Sehdinge," *Archiv fuer Die Gesamete Psychologie,* vol. 88, 1933, p. 487.
6. Klimpfinger, S. "Ueber den Einfluss von Intentionaler Einstellung and Ubung auf die Gestaltkonstanz," *Archiv fuer Die Gesamte Psychologie,* vol. 88, 1933, pp. 551-598.
7. Thouless, R.H. "Phenomenal Regression to the Real Object," Part II, *British Journal of Psychology,* vol. 22, 1931, pp. 1-30.
8. Brown, D.R. and Owen, D.H. "The Metrics of Visual Form: Methodological Dyspepsia," *Psychological Bulletin,* vol. 68, no. 4, 1967, pp. 243-250.
9. Eriksen, Charles W. and Hake, Harold. "Multidimensional Stimulus Differences and Accuracy of Discrimination," *Journal of Experimental Psychology,* vol. 50, no. 3, 1955, pp. 153-160.
10. Koch, S. (Ed.) *Psychology: A Study of a Science,* Vol. 5. McGraw-Hill Book Company, New York, 1963.
11. Arnoult, Malcolm D. "Shape Discrimination as a Function of the Angular Orientation of the Stimuli," *Journal of Experimental Psychology,* vol. 47, no. 5, 1954, pp. 323-328.
12. Smith, A.H. "Perception of Shape as a Function of Order of Angles of Slant," *Perceptual & Motor Skills,* vol. 22, 1966, pp. 971-978.
13. Smith, A.H. "Phenomenal Shape as a Function of Ambiguity of Contour Perspective," *Perceptual & Motor Skills,* vol. 25, 1967, pp. 121-127.
14. Woodworth, R.S. and Schlosberg, H. *Experimental Psychology.* Holt & Company, New York, 1952, pp. 486-491.
15. Cronbach, L.J. *Some Current Studies of Visual Perception,* Office of Naval Research, London, TR ONRL-1-56, 1956.
16. Gibson, J.J. "What is Form?" *Psychological Review,* vol. 58, 1951, pp. 403-412.
17. Lichte, William H. "Shape Constancy: Dependence upon Angle of Rotation; Individual Differences," *Journal of Experimental Psychology,* vol. 43, no. 1, 1952, pp. 49-57.

18. Sheehan, M.R. "A Study of Individual Differences in Phenomenal Constancy," *Archives of Psychology*, No. 222, 1938, pp. 1-95.

19. Moore, W.E. "Experiments on the Constancy of Shape," *British Journal of Psychology*, vol. 29, 1938, pp. 104-116.

20. Winnick, Wilma A. and Rogoff, I. "Role of Apparent Slant in Shape Judgments." *Journal of Experimental Psychology*, vol. 69, no. 6, 1965, pp. 554-563.

21. Nellis, Barbara S.P. "Effects of Object- and Background-Tilt on Perception of Form." University Microfilms, Inc., Ann Arbor, Michigan, 1958.

22. Winnick, Wilma A. and Rosen, E.E. "Shape-Slant Relations under Reduction Conditions," *Perception and Psychophysics*, vol. 1, no. 5, 1966, pp. 157-160

23. Stavrianos, Bertha K. "The Relation of Shape-Perception to Explicit Judgments of Inclination," *Archives of Psychology*, No. 296, 1945.

24. Epstein, William. "Apparent Shape of a Meaningful Representational Form," *Perceptual and Motor Skills*, vol. 15, 1962, pp. 239-240.

25. Epstein, W. and Park, John N. "Shape Constancy: Functional Relationships and Theoretical Formulations," *Psychological Bulletin*, vol. 60, no. 3, 1963, pp. 265-288.

26. Leibowitz, H., Waskow, I., Leoffler, N. and Glaser, F. "Intelligence Level as a Variable in the Perception of Shape," *Quarterly Journal of Psychology*, vol. 11, 1959, pp. 108-113.

27. Kaiser, Peter K. "Investigation of Shape at a Slant," *Proceedings of the 74th Annual Convention of the APA*, 1966, pp. 9-10.

28. Beck, Jacob. "Texture-Gradients and Judgments of Slant and Recession," *American Journal of Psychology*, vol. 73, no. 3, 1960, pp. 411-416.

29. Flock, Howard R. and Moscatelli, Anthony. "Variables of Surface Texture and Accuracy of Space Perception," *Perceptual & Motor Skills*, vol. 19, 1964, pp. 327-334.

30. Leibowitz, H.W. and Meneghini, Kathleen A. "Shape Perception for Round and Elliptically Shaped Test Objects," *Journal of Experimental Psychology*, vol. 72, no. 2, 1966, pp. 244-249.

31. Bevan, William. "The Contextual Basis of Behavior," *American Psychologist*, vol. 23, no 10, 1968. pp. 701-714.

32. Langdon, J. "The Perception of Three-Dimensional Solids," *Quarterly Journal of Experimental Psychology*, vol. 7, 1955, pp. 133-145.

33. Nelson, Thomas M. and Bartley, S. Howard, "The Perception of Form in an Unstructured Field," *Journal of General Psychology*, vol. 54, 1956, pp. 57-63.

34. Bartley, S.H. *Principles of Perception*, Harper & Brothers, New York, 1958.

35. Prentice, W.C.H. "Functionalism in Perception," *Psychological Review*, vol. 63, no. 1, 1956, pp. 29-38.

36. Bruner, Jerome S. and Goodman, Cecile C. "Value and Need as Organizing Factors in Perception," *Journal of Abnormal and Social Psychology*, vol. 42, no. 1, 1947, pp. 33-44.

37. Bruner, Jerome S. and Postman, L. "Perception, Cognition, and Behavior," *Journal of Personality*, vol. 18, 1949, pp. 14-31.

38. Boring, E.G. *Sensation and Perception in the History of Experimental Psychology*, Appleton-Century-Crofts, Inc., New York, 1942.

39. Thouless, R.H. "Individual Differences in Phenomenal Regression," *British Journal of Psychology*, vol. 22, 1932, pp. 216-241.

40. Gottheil, E. and Bitterman, M.E. "The Measurement of Shape Constancy," *American Journal of Psychology*, vol. 64, 1951, pp. 406-408.

41. Epstein, William, Bontrager, Helen, and Park, John. "The Induction of Nonveridical Slant and the Perception of Shape," *Journal of Experimental Psychology*, vol. 63, no. 5, 1962, pp. 472-479.

42. Hake, H.W. *Contributions of Psychology to the Study of Pattern Vision*, Wright Air Development Center, WADC TR 57-621, October 1957.

43. Borreson, C. Robert and Lichte, William H. "Shape Constancy: Dependence Upon Stimulus Familiarity," *Journal of Experimental Psychology*, vol. 63, no. 1, 1962, pp. 91-97.

44. Epstein, W. and Mountford, Damon. "Judgment of Slant in Response to an Isolated Gradient of Stimulation," *Perceptual & Motor Skills*, vol. 16, 1963, pp. 733-737.

45. Witkin, H.A., Lewis, H.B., Hertzman, M., Machover, K., Meissner, P.B. and Wapner, S. *Personality Through Perception: An Experimental and Clinical Study*, Harper, New York, 1954.

46. Witkin, H.A. "Individual Differences in Ease of Perception of Embedded Figures," *Journal of Personality*, vol. 19, 1950, pp. 1-15.

47. Thornton, Carl L., Barrett, Gerald V., and Davis, James A. "Field Dependence and Target Identification," *Human Factors*, vol. 10, no. 5, 1968, pp. 493-496.

48. Kause, R.H. *Interpretations of Complex Images: Literature Survey*, Goodyear Engineering Report 10830, Rev. A., Akron, Ohio 1965.

49. Eriksen, Charles W. "Location of Objects in a Visual Display as a Function of the Number of Dimensions on Which the Objects Differ," *Journal of Experimental Psychology*, vol. 44, no. 1, 1952, pp. 56-60.

50. Fine, R. "On the Nature of Scientific Method in Psychology," *Psychological Reports*, vol. 24, 1969, pp. 519-540.

51. Cox, D.R. "Design of Experiments: The Control of Error," *Journal of the Royal Statistical Society*, Ser. A, vol. 124, 1961, pp. 44-48.

52. Owens, William A. "Toward One Discipline of Scientific Psychology," *American Psychologist*, vol. 23, no. 11, 1968, pp. 782-785.

53. Eisenhart, Churchill. "Expression of the Uncertainties of Final Results," *Science*, vol. 160, 14 June 1968, pp. 1201-1204.

54. Levi, I. "On the Seriousness of Mistakes," *Philosophy of Science*, vol. 29, no. 1, 1962, pp. 47-65.

55. Norrie, M.L. "Effect of Practice on True Score and Intra-Individual Variability for Reaction and Movement Times for Simple and Complex Movements," *The Research Quarterly*, vol. 38, no. 3, pp. 457-467.

56. Grose, J.E. "Inter- and Intravariability of Motor Performance," *The Research Quarterly*, vol. 38, no. 4, 1967, pp. 570-575.

57. Jarrett, R.F. and Henry, F.M. "The Relative Influence on Error of Replicating Measurements or Individuals," *The Journal of Psychology*, vol. 31, 1951, pp. 175-180.

58. Henry, F.M. "Reliability, Measurement Error, and Intra-Individual Difference," *The Research Quarterly*, vol. 30, no. 1, 1959, pp. 21-24.

59. Edgington, Eugene W. "Statistical Inference and Nonrandom Samples," *Psychological Bulletin*, vol. 66, no. 6, 1966, pp. 485-487.

60. Kirk, R.E. *Experimental Design: Procedures for the Behavioral Sciences*, Brook/Cole Publishing Company, Belmont, California, 1968.

61. Edwards, A.L. *Experimental Design in Psychological Research*, Holt, Rinehart, and Winston, Inc., New York, 1968.

Appendix A

DEPTH PERCEPTION TEST

The depth perception test that is contained in the Armed Forces Vision Tester (Figure A-1) uses a stereo presentation composed of six groups of circles. The examinee sees the presentation identified as the front view in Figure A-2. Each group has three rows of five circles. The test stimuli are constructed so that one circle in each row should appear to be closer to the examinee than the other four circles. A side view is presented in Figure A-2 to show the difference in depth of the third row in Groups C and F.

Armed Forces Vision Tester

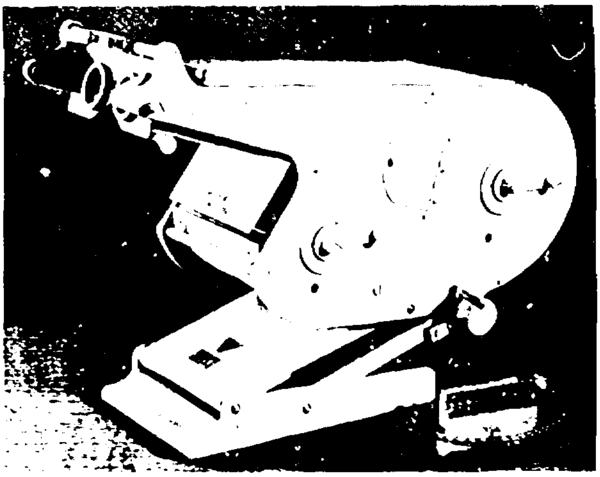
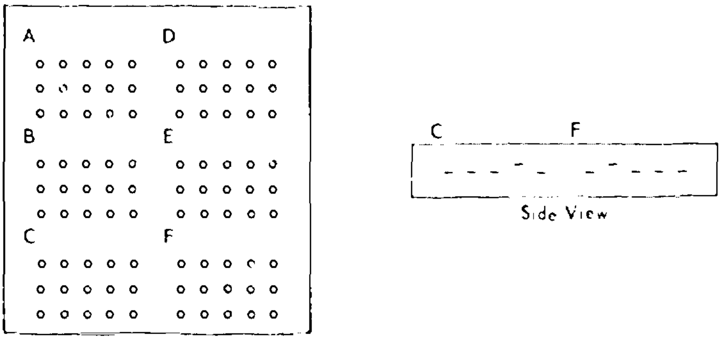


Figure A-1

Stereo Presentation Contained in Armed Forces Vision Tester



Front View

Side View

Figure A-2

The instructions given to the examinee were as follows:

Examiner says to trainee:

"Will you look in this direction? This next test will show groups of circles like this." (Show demonstrator with side having single circle toward examinee.) "Do you see that this circle (point) is closer to you than the others? Look into the instrument again. In Group A, look at the top row of circles. Which circle is closer to you? (Counting across the row from the A.)"

If the examinee does not answer immediately give him clues including the proper answer to this row, and rows two and three of Group A. Be certain he keeps eyes open.

Continue with Groups B through F until one of the three lines in a group is failed. If examinee fails Group B, repeat the training Group A and test a second time in Group B continuing with the remainder of test if Group B is passed.

Appendix B

INSTRUCTIONS

The following general and specific instructions prepared the subjects for testing.

A. General Introductory Instructions

Good morning. I am Mr. Frederickson with the Human Resources Research Office of The George Washington University. Our organization conducts training research for the Department of the Army. Right now we are working on a training program that will be used to teach aircraft recognition. This research requires information concerning how well enlisted personnel can judge the shape and rotation of simple forms. You are going to participate in a test that will give us part of this information.

You will be given three tests, a vision test and two shape judgment tests. You will be tested individually. Specific instructions will be given to you just before you begin the tests. Do you have any questions at this time? If not, just relax until you are called.

SP/4 Robyak and SP/4 Winningham will give you the eye test and one shape test. SP/5 Lohn will assist in the second shape judgment test.

B. Specific Instructions for Experiment I

This is a shape judgment task. You will be shown a two-dimensional rectangular figure. A second, but smaller rectangular figure will be present on the left. The width of the smaller figure will either be increasing or decreasing while you are watching. What I want you to do is compare the shapes of the two rectangles, the width-to-height relationships, and push this switch when you believe the shape of the small rectangle matches the shape of the large rectangle. Do you understand?

O.K., let's try it once. Look into the eyepieces. See the large rectangle on the right? The small rectangle on the left is changing in its width. Push this switch as soon as you believe that the shapes of the two rectangles are the same.

O.K., fine. Now as soon as you have pushed the switch, look away from the eyepieces while we get ready for the next trial. Are there any questions?

C. Specific Instructions for Experiment II

This is a shape and rotation judgment task. We are going to show you several different blocks similar to this one (show example). The blocks will be presented one at a time. All blocks will have the same depth and height (show subject these dimensions), but will vary in width. The blocks will be presented to you at either this position (show example block in frontal-parallel plane) or rotated counter-clockwise like this. The right edge of the block will rotate back like this. The blocks will not move while you are looking at them.

Also, 11 smaller blocks will be present at all times. Look into the eyepieces and you will see what I mean. Do you see the large block suspended in the center of the field, and the 11 smaller blocks below? One of the smaller blocks will have a shape (the relationship of the width to the height of the front or right face of the block) that is the same as the large block. You task is to pick out the small block that you believe has the same shape as the large block, and call out the number in front of that block. Do you understand?

O.K., let's try it once. Pick out the small block that matches the shape of the large block.

O.K., fine. Now you notice that the large block is rotated slightly. By turning this knob (show subject the rotation knob), the small block setting out in front of the others will also turn. Try it. I want you to rotate the small block until you believe that it is at the same rotational setting as the large block. Do you understand? O.K., go ahead and try it once.

Now, once again I'll go over what I want you to do. First, when you are told to start a trial, pick out the small block that you believe has the same shape as the large block hanging in the center of the field. Call out the number of that block. Then rotate the small block to what you believe is the same position as the large block. As soon as you have finished, look away from the eyepieces while we change the large block for the next trial. Do you have any questions?

Appendix C

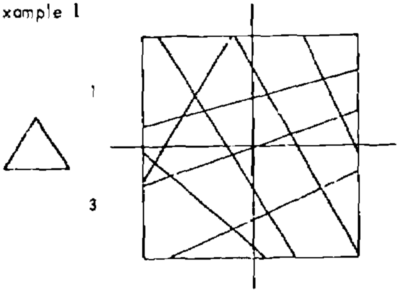
EMBEDDED FIGURES TEST

Presented in this section are examples of the embedded figures test (EFT) developed by Dees, O'Reilly, and Sennett. The test is composed of 60 achromatic items similar to the example presented here. The task is to identify the quadrant or quadrants in which the figure on the left is found. The test is to be completed in 20 minutes. The score that is recorded is the number of correct items.

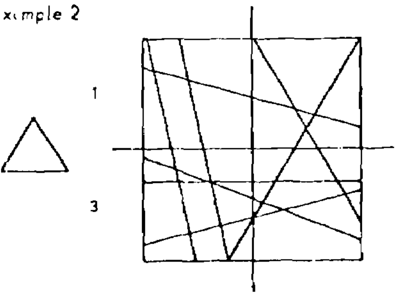
This test correlates .80 with Witkin's EFT. Dees' test is a group form and takes less time to administer than Witkin's test. The split-half reliability is .95 and the repeated reliability is .82.

Examples are presented below.

Example 1



Example 2



Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Human Resources Research Organization (HumRRO)
300 North Washington Street
Alexandria, Virginia 22314

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

SHAPE PERCEPTION JUDGMENTS AS A FUNCTION OF STIMULUS ORIENTATION, STIMULUS BACKGROUND, AND PERCEPTUAL STYLE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Technical Report

5. AUTHOR(S) *(First name, middle initial, last name)*

Edward W. Frederickson

6. REPORT DATE

December 1970

7a. TOTAL NO. OF PAGES

56

7b. NO. OF REFS

62

8a. CONTRACT OR GRANT NO.

DAHC 19-70-C-0012

b. PROJECT NO.

2Q061102B74B

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

Technical Report 70-24

9b. OTHER REPORT NO.(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES

BR-16: Improving Ability to See
Military Targets

12. SPONSORING MILITARY ACTIVITY

Office, Chief of Research and Development
Department of the Army
Washington, D.C. 20310

13. ABSTRACT

Two experiments tested the validity of the shape-slant invariance hypothesis. The first test used two-dimensional rectangular stimuli to obtain shape judgment responses from 20 subjects. Individual differences between subjects were found to significantly influence shape judgment, but stimulus shape did not. In the second experiment, 68 subjects judged the shape and rotational orientation of three-dimensional rectangular solids. A statistical procedure was used to control this source of variance. Shape and Rotation of the stimulus objects were found to influence judgments of shape and rotational orientation. Errors of judging stimulus shape and rotation were significantly correlated, as were the objective and projective stimulus shapes. These later results were interpreted as providing support for the shape-slant invariance hypothesis.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Individual Differences						
Perceptual Style						
Rotation Judgment						
Shape Judgment						
Shape-Slant Invariance						
Visual Perception						

Unclassified

Security Classification

Distribution List

2	DIR OASD MANPOWER (PPEGRP)
1	CHF DASA ATTN DOC LIB BR
1	DIR WSEG WASH D.C. 20305
1	DIR OASD MANPOWER & RESERVE AFFAIRS
1	OFC OF THE ASST SEC OF DEF [illegible] ATTN SPEC ASST POLICY STUDIES
2	COMDR FLD COMD DEF ATOMIC SPT AGY SANDIA BASE ATTN FCTG7
2	NASA SCI & TECH INFO FACILITY COLLEGE PARK MD
1	CINC US EUROPEAN COMD ATTN SUPPORT PLANS BR J3
1	CINC USA PACIFIC ATTN G3 OTC APO SAN FRAN 96610
2	CG SOUTHERN EUROPEAN TASK FORCE APO 09168 NY
1	CG US ARMY JAPAN APO 96343 SAN FRAN ATTN G3
10	CG USA FORCES SOUTHERN COMD ATTN SCARCG FT AMADOR CZ
1	CG US ARMY ALASKA ATTN ARACD APO 98749
2	CG US ARMY EUROPE APO 09403 NY ATTN OPNS DIV
1	CO ARMY TRANS RES COMD FT EUSTIS ATTN TECH LIB
1	CG US ARMY AD COMD ENT AFB ATTN ADGPA
5	CG 1ST ARMY ATTN DCSOT FT MEADE MD
1	CG 3RD ARMY ATTN DCSOT FT MCPHERSON
2	CG 4TH ARMY ATTN AKADC-PTUTR FT SAM HOUSTON
1	CG FOURTH ARMY FT SAM HOUSTON ATTN G3
3	CG FIFTH ARMY FT SHERIDAN ATTN ALFGC TNG
1	CG EUSA ATTN AG-AC APO 96301 SAN FRAN
2	CG EUSA ATTN CHD APO 96301 SAN FRAN
1	DIR HEL APG MD
1	CG USA CDC EXPERIMENTATION COMD FT ORD
2	ENGNR PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
1	TECH LIB ARMY NATICK LABS NATICK MASS
3	CO DEF DEVEL ENGNR LAB EDGEWOOD ARSENAL
2	INST OF LAND CBT ATTN TECH LIB FT BELVOIR VA
1	CO USA CDC [illegible] ALA
1	REDSTONE SCIENTIFIC INFO CTR US ARMY MSL COMD ATTN CHF DOC SEC ALA
1	CO USAPA MRELM DET TOBYHANNA ARMY DEPOT
1	CO FT HUACHUCA SPT COMD USA ATTN TECH REF LIB
12	CO 1ST AIR DEF GUIDED MSL BRIG TNG FT BLISS
2	CO US ARMY CDC EXPERIMENTATION COMD FT ORD
1	SIXTH USA LIB DEPOT BLDG M 13 14 PRES OF SAN FRAN
1	CHF DEPT OF CLIN & SOC PSYCH WALTER REED ARMY INST OF RES WASH D C
1	PLANS OFFICER PSYCH [illegible] USACDCEC FORT ORD
5	CO FT ORD ATTN G3 TNG DIV
1	DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
2	DIR [illegible] WALTER REED ARMY MED CTR ATTN NEUROPSYCHIAT DIV
1	CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1	TECH LIB BOX 22 USACDC EXPERIMENTATION COMD FT ORD
1	HUMAN FACTORS TEST DIV (ADHZ) USAF HOSP EGLIN AFB
1	CO USA MOBILITY EQUIP RES CTR ATTN TECH DOC CTR FT BELVOIR
1	CO FRANKFORD ARSNL ATTN SMUFA-N6400/202-4
1	CG 2D RGN ARADCOM RICHARDS-GEBAUR AFB
3	6TH RGN USARADCOM FT BAKER
1	4TH ARMY MSL COMD AIR TRANSPORTABLE SAN FRAN
1	DIR ARMY BD FOR AVN ACCIDENT RES FT RUCKER
2	CO PICATINNY ARSNL DOVER N J ATTN SMUPA VC1
1	DEF SUPPLY AGY CAMERON STATION ATTN LIB
2	CO USA CDC AG AGCY FT BENJ HARRISON IND
1	REF & MS FS NASA FLA
1	CBT OPNS RES GP USACDC SR OPNS ANALYST HUMAN FACTORS ALEX VA
1	CO ARMY CDC INF AGY FT BENNING
1	CO ARMY CDC ARMOR AGY FT KNOX
8	ARMY CDC SPEC WARFARE AGY FT BRAGG
1	EVAL DIV CAD ARMY SIG CTR & SCH FT MONMOUTH
1	CG US ARMY CDC AVN AGCY FT RUCKER
1	CHF CURRICULUM BR RESIDENT INSTR USA LOG MGT CTR FT LEE
3	CO ARMY CBT DEVEL COMD CBT SUPPORT GP
15	CG USA TNG CTR AD ATTN ACOFS G3 FT BLISS
1	CG USA TNG CTR ARMOR ATTN ACOFS G3 FT KNOX
12	CO USA TNG CTR FA ATTN ACOFS G3 FT SILL
1	CG USA TNG CTR & FT LEONARD WOOD ATTN ACOFS G3
1	CG USA TNG CTR INF ATTN ACOFS G3 FT BENNING
1	CG USA TNG CTR INF ATTN ACOFS G3 FT DIX
1	CG USA TNG CTR ATTN ACOFS G3 FT JACKSON
1	CG USA TNG CTR INF ATTN ACOFS G3 FT LEWIS
1	CG USA TNG CTR INF & FT ORD ATTN ACOFS G3
10	CG USA TNG CTR INF ATTN ACOFS G3 FT POLK
4	CO USA MED TNG CTR ATTN DIR OF TNG FT SAM HOUSTON
1	CG USA TNG CTR INF ATTN ACOFS G3 FT [illegible]
1	CG USA TNG CTR INF ATTN ACOFS G3 FT CAMPBELL KY
5	CIVLN PERS OFCR US ARMY SPT CTR ST LOUIS ATTN EMPLOYEE DEVEL BRCH
3	LIB ARMY WAR COLL CARLISLE BKS
1	COMDT USA INTELL SCH ATTN ARBHI-S-AT FT HOLABIRD
1	COMDT CMD & GEN STAFF COLL FT LEAVENWORTH ATTN ARCHIVES
1	DIR OF MILIT PSYCHOL & LDRSHP US MILIT ACAD WEST POINT
1	US MILIT ACAD WEST POINT ATTN LIB
1	COMDT ARMY AVN SCH ATTN DIR OF INSTR FT RUCKER
2	COMDT ARMY SECUR AGY TNG CTR & SCH FT DEVENS ATTN LIB
1	COMDT INDSTR COLL OF THE ARMED FORCES FT MCNAIR
1	MED FLD SERV SCH BROOKE ARMY MED CTR FT SAM HOUSTON ATTN STIMSON LIB
17	DIR OF INSTR ARMOR SCH FT KNOX
1	COMDT ARMY ARMOR SCH FT KNOX ATTN WEAPONS DEPT
1	COMDT USA CHAPLAIN SCH ATTN [illegible] FT HAMILTON
1	COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN EDUC ADV
1	COMDT USA FIN SCH ATTN CHF DOC CTR LIB BEN HAR IND
1	USA FINANCE SCH FT BENJ HARRISON ATTN EDUC ADV
4	COMDT ARMY ADJ GEN SCH FT BENJ HARRISON ATTN EDUC ADV
1	EDUC ADV USAIS ATTN AJIIS-H FT BENNING
1	DIR OF INSTR USAIS ATTN AJIIS-H-[illegible] FT BENNING
1	HQ US ARMY ADJ GEN SCH FT BENJ HARRISON ATT COMDT
1	LIB ARMY QM SCH FT LEE
1	COMDT ARMY QM SCH FT LEE ATTN EDUC ADV
1	COMDT ARMY TRANS SCH FT EUSTIS ATTN EDUC ADV
1	CO USA SEC AGY TNG CTR & SCH ATTN TARCH RSCH ADV FT DEVENS
1	COMDT ARMY MILIT POLICE SCH FT GORDON ATTN DIR OF INSTR
2	COMDT US ARMY SOUTHEASTERN SIG SCH ATTN EDUC ADVISOR FT GORDON
1	COMDT USA AD SCH FT BLISS
1	CO USA ORD CTR & SCH OFC OF OPS ATTN [illegible] APG MD
5	ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
4	CG USA FLD ARTY CTR ATTN AVN [illegible] FT SILL
1	COMDT ARMY [illegible] INTEL SCH ATTN [illegible] DEPT
2	COMDT ARMED FORCES STAFF COLL NORFOLK
1	COMDT USA SIG CTR & SCH ATTN DOI FT MONMOUTH
1	COMDT JUDGE ADVOCATE GENERALS SCH U OF VA
1	DPTY COMDT USA AVN SCH ELEMENT GA
1	DPTY ASST COMDT USA AVN SCH ELEMENT GA
1	USA AVN SCH ELEMENT OFC OF DIR OF INSTR ATTN EDUC ADV GA
1	EDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
6	COMDT USA ENGR SCH ATTN EDUC ADV FT BELVOIR
2	COMDT US ARMY SCH EUR [illegible] ATTN REF LIB APO 09172 NY
1	CHF POLICY & TNG DIV ARMY ARMOR SCH FT KNOX
1	COMDT ARMY AVN SCH FT RUCKER ATTN EDUC ADV
1	COMDT ARMY PRIMARY HEL SCH FT WOLTERS
1	DIR OF INSTR US MIL ACAD WEST POINT NY
1	DIR OF MILIT INSTR US MILIT ACAD WEST POINT NY
1	USA INST FOR MIL ASST ATTN LIB FT BRAGG
4	USA INST FOR MIL ASSIST ATTN COUNTERINSURGENCY DEPT FT BRAGG
1	ARMY SIG CTR & SCH FT MONM USASCS ATTN TNG LIT DIV [illegible]
1	COMDT USA MSL & MUN CTR & SCH ATTN CHF [illegible] RESEARCH [illegible]
2	COMDT US WAC SCH US WAC CTR ATTN AJMCT FT MCCLELLAN
2	HQ ABERDEEN PG ATTN TECH LIB
1	COMDT USA INTELL SCH ATTN DIR OF ACADEMIC OPS FT HOLABIRD
2	COMDT USA INTELL SCH ATTN DIR OF DOC & LIT FT HOLABIRD
1	COMDT USA CGSC OFC OF DIR OF RESIDENT INSTR FT LEAVENWORTH
1	COMDT USA CA SCH ATTN DEPT OF RSCH ANALYSES & DOC FT GORDON
1	COMDT USA CA SCH ATTN DOI FT GORDON
1	COMDT USA CA SCH ATTN EDUC ADV FT GORDON
1	COMDT USA CA SCH ATTN LIB FT GORDON
1	COMDT USA SCH & TNG CTR ATTN ACOFS G3 INT DIV FT MCCLELLAN
1	COMDT USA SCH & TNG CTR ATTN ACOFS G3 PLNG & OPS DIV FT MCCLELLAN
10	COMDT USA INST FOR MIL ASSIST ATTN DOI FT BRAGG
1	COMDT USA CBR WPNS ORIENTATION COURSE ATTN DOI DUGWAY UTAH
1	COMDT USA FLD ARTY SCH ATTN DOI FT SILL
1	COMDT USA ARTY & MSL SCH ATTN EDUC SERVICES DIV FT SILL
1	COMDT USA ARTY & MSL SCH ATTN EDUC ADV FT SILL
1	COMDT USA TRANS SCH ATTN DIR OF DOC & LIT FT EUSTIS
1	COMDT USA TRANS SCH ATTN LIB FT EUSTIS
1	USA INST FOR MIL ASST ATTN EDUC ADV FT BRAGG
1	COMDT ARMY QM SCH OFC DIR OF NONRES ACTVY ATTN TNG MEDIA DIV VA
1	COMDT USA ARTY & MSL SCH ATTN LIB FT SILL
1	CG USA SCH & TNG CTR ATTN ACOFS G3 FT GORDON
1	COMDT USA AD SCH ATTN AKBAAS-DL-EA FT BLISS
2	DIR BRGD & BN OPNS DEPT USAIS FT BENNING
1	DIR COMM ELEC USAIS FT BENNING
1	DIR ARM-AIR MOBILITY DEPT USAIS FT BENNING
2	DIR COMPANY TACTICS DEPT USAIS FT BENNING
1	CG US ARMY SIGNAL CTR & SCH ATTN SIGFT-[illegible]
1	SECY OF ARMY, PENTAGON
1	DCS-PERS DA ATTN CHF C&S DIV
1	DIR OF PERS STUDIES & RSCH OCS-PER DA WASH DC
2	ACSFOR DA ATTN CHF TNG DIV WASH DC
1	CG USA MAT COMD ATTN AMCRD-TF
1	CHF OF ENGNRS DA ATTN ENGTE-T
1	HQ ARMY MAT COMD R&D DRCTE ATTN AMCRD-RC
2	CG ARMY R&D COMD ATTN BEHAV SCI RES BR
1	US ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN CRD-AW
1	OPO PERS MGT DEV OFC ATTN RES SEC INFO EQUIPT GROUP
1	ARMY PROVOST MARSHAL GEN
1	DIR CIVIL AFFAIRS DRCTE ODCSOPS
1	OFC RESERVE COMPON DA
2	CG USA SEC AGCY ARL HALL STA ATTN AC OF S G1 VA
20	ADMIN DDC ATTN TCA (HEALY) CAMERON STA ALEX, VA, 22314
1	CO US ARMY MED RES LAB FT KNOX
1	CG ARMY ELECT COMD FT MONMOUTH ATTN AMSEL CP
1	CHF OF R&D DA ATTN CHF TECH & INDSTR LIAISON OFC
2	CG ARMY MED R&D COMD ATTN MEDDH-SR
1	U S ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN CRD-AIC
1	COMDT USA CBT SURVEIL SCH & TNG CTR ATT ED ADV FT HUACHUCA
1	COMDT USA CBT SURVEIL SCH & TNG CTR ATTN ORG DOC & NEW EQUIP ARIZ
2	TNG & DEVEL DIV ODCS-PERS
1	COMDT USA CBT SURVEIL SCH & TNG CTR ATTN 1ST CBT TNG BDE ARIZ
1	CAREER MGT HR ATTN W [illegible] CAMERON STA ALEX VA
2	PRES ARMY ARMOR BD FT KNOX
1	PRES ARMY INF BD FT BENNING ATTN [illegible] DIV
2	PRES ARMY AIR DEF BD FT BLISS ATTN MGT DIV
1	PRES ARMY MAINT BD FT KNOX
2	PRES ARMY ARTY BD FT SILL
1	DPTY PRES ARMY MAT COMD BD ABERDEEN PG
25	CG USCONARC ATTN ATIT-RD-RD FT MONROE
2	CG USCONARC ATTN LIB FT MONROE
1	CO ARMY CBT DEVEL COMD MILIT POLICE AGY FT GORDON
1	US ARMY ARCTIC TEST CTR APO [illegible] SEATTLE
1	CHF USA AD HRU FT BLISS
1	CHF USA ARMOR HRU FT KNOX
1	CHF USA AVN HRU FT RUCKER
1	CHF USA INF HRU FT BENNING
1	CHF USA TNG CTR HRU PRES OF MONTEREY
40	CG 4TH ARMORED DIV ATTN DCSOT APO NY [illegible]
2	CO 24TH [illegible] FT [illegible]
5	CO 2D ARMD CAV REGT APO [illegible] NY
1	CO 3D ARMORED CAV REGT APO [illegible] NY
4	CO 14TH ARMORED CAV REGT APO 09026 NY
2	CG ARMY ARMOR & ARTY FIRING CTR FT STEWART ATTN AC OF S [illegible]
1	1ST ARMORED DIV HQ & HQ CO FT HOOD ATTN AC OF S G2
12	CO 1ST BN 63RD ARMOR 1ST INF DIV ATTN S3 FT RILEY
4	CO 1ST BN 64TH ARMOR 3RD INF DIV ATTN S3 APO NY [illegible]
2	CO 1ST BN 73RD ARMOR 7TH INF DIV ATTN S3 APO SAN FRAN [illegible]
4	CO 2ND BN 68TH ARMOR 8TH INF DIV ATTN S3 APO NY [illegible]
1	CO [illegible] 3D ARMORED DIV APO NY
1	CO 1ST BN 69TH ARMOR 4TH INF DIV ATTN S3 APO SAN FRAN [illegible]
1	CO 5TH BN 33D ARMOR ATTN S3 FT KNOX
1	CO 1ST BN 66TH ARMOR 4TH INF DIV ATTN S3 APO NY [illegible]
1	CO 1ST BN 37TH ARMOR 4TH ARMORED DIV ATTN S3 APO NY [illegible]
5	CO 2ND BN 34TH ARMOR 25TH INF DIV ATTN S3 APO SAN FRAN [illegible]
1	[illegible] NORTH ARMORED [illegible] ATTN [illegible]
1	[illegible]
1	CG HQ 27TH ARMORED DIV [illegible] SYRACUSE NY
1	TEXAS NG 49TH ARMORED DIV DALLAS
1	CG ARMY ARMOR [illegible] FT KNOX ATTN [illegible]
2	CG 1ST INF DIV ATTN AC OF S G3 APO SAN FRAN [illegible]
1	CG 3RD INF DIV ATTN ACOFS G3 APO NY [illegible]
1	CG 4TH INF DIV ATTN AC OF S G3 APO SAN FRAN [illegible]
1	CG 7TH INF DIV ATTN ACOFS G3 APO SAN FRAN [illegible]
1	CG 8TH INF DIV ATTN ACOFS G3 APO NY [illegible]
1	CG 9TH INF DIV [illegible] ATTN AC OF S G3 [illegible]
2	CG [illegible] USA HAWAII ATTN [illegible] SAN FRAN [illegible]
1	CG 82ND ABN INF DIV ATTN AC OF S G3 FT BRAGG
1	CO 197TH INF [illegible] FT BENNING ATTN S3
1	CO 1ST BN [illegible] ATTN S3 FT [illegible]
1	CO [illegible] BN 6TH INF [illegible] ATTN S3 APO NY [illegible]
1	CO 3RD BN 6TH INF [illegible] ATTN S3 APO NY [illegible]
1	CO 171ST INF [illegible] ATTN S3 [illegible] SEATTLE [illegible]
1	CG 25TH INF DIV [illegible] SAN FRAN
1	CO 4TH BN [illegible] INF ATTN [illegible] FT SILL
1	CO 1ST BN 30TH INF 3RD INF DIV ATTN S3 APO NY [illegible]
1	CO 2ND BN 15TH INF 3RD INF DIV ATTN S3 APO NY [illegible]
5	CG 24TH INF DIV ATTN AC OF S G3 FT RILEY
5	CO 1ST BN [illegible] INF [illegible] INF [illegible] ATTN S3 [illegible] SAN FRAN [illegible]
2	CO 4TH BN [illegible] ATTN [illegible]
1	[illegible]
2	COMDT [illegible]
2	[illegible] STAFF [illegible] ATTN [illegible]
1	CHF MIL PERS [illegible] MILIT ACAD WEST POINT [illegible]
1	CG MILIT DIST OF WASHINGTON
1	[illegible]
1	[illegible] STA [illegible]
1	DIR ARMY LIB PENTAGON

1 STRATEGIC PLANNING OF [illegible] ARMY WAR COLL
1 CHF OF MILIT HIST DA ATTN [illegible]
1 CO [illegible] 10TH [illegible] FT [illegible]
1 CO 24TH ARTY GP (AD) ATTN S3 [illegible]
1 CO 31ST ARTY [illegible] ATTN S3 [illegible]
1 CO 4TH ARTY GP AD ATTN S3 FT LAWTON
2 HQS 4TH RGN [illegible] ARTY [illegible] ATTN [illegible]
1 CO [illegible] ARTY GP AD ATTN S3 SELFRIDGE AFB
1 CO 52D ARTY BDE AD ATTN S3 FT HANCOCK
1 HQ USA [illegible] ARMY [illegible]
1 HQS 45TH ARTY [illegible] ATTN S3 ARL HTS ILL
1 CO 8TH ARTY [illegible] ATTN S3 FT MEADE MD
1 CG 101ST ABN DIV (AIRMOBILE) ATTN [illegible] APO SAN FRAN [illegible]
1 CG 1ST CAV (AIRMOBILE) ATTN ACOFS [illegible] APO SAN FRAN [illegible]
1 US ARMY GEN EQUIP ATTN TECH LIB FT LEE
1 US ARMY [illegible] TEST CTR [illegible] ATTN [illegible]
1 CO 525TH MIL INTELL GP ATTN S3 APO SAN FRAN [illegible]
4 CG III CORPS & FT HOOD ATTN G3 SEC FT HOOD
10 CG 1ST ARMORED DIV ATTN G3 SEC FT HOOD
30 CG 2D ARM DIV ATTN G3 SEC FT HOOD
25 CO 13TH SUPT BDE ATTN S3 SEC FT HOOD
10 CG USAFAC ATTN G3 SEC FT SILL
20 CG III CORPS ARTY ATTN S3 SEC FT SILL
20 CG USA [illegible] CTR ATTN G3 SEC FT [illegible]
3 CG ATTN G3 SEC FT POLK LA
1 RESD ARMY [illegible] WASH DC
1 CHF OF RES [illegible] ATTN [illegible] WASH DC
2 CINC US PACIFIC FLT FPO SAN FRAN
1 CINC US ATLANTIC FLT [illegible] NORFOLK
1 CINC PACIFIC [illegible] FPO SAN FRAN
1 COM TNG COMMAND US PACIFIC FLT SAN DIEGO
1 CHF RES DIV BUR OF MED & SURGERY
5 TECH LIB PERS LIB BUR OF NAV PERS ARL ANNEX
1 DIR PERS RES DIV BUR OF NAV PERS
1 TECH LIB BUR OF SHIPS CODE 210L NAVY DEPT
2 NAV AIR SYS COMD [illegible] ATLANTIC NAV AIR STA NORFOLK
1 HUMAN FACTORS [illegible] PSYCH [illegible]
1 ENGNR PSYCH [illegible] ATTN [illegible] WASH DC
1 CO & DIR NAV TNG DEVICE CTR ORLANDO ATTN TECH LIB
1 CO FLT ANTI-AIR WARFARE TNG CTR SAN DIEGO
1 CO NUCLEAR WEAPONS TNG CTR PACIFIC U S NAV AIR STA SAN DIEGO
2 FLT ANTI-AIR WARFARE TNG CTR DAM NECK VA BEACH
7 CO FLT TNG CTR NAV BASE NEWPORT
1 CO FLEET TNG CTR U S NAV STA SAN DIEGO
1 CLIN PSYCHOL MENTAL HYGIENE UNIT [illegible]
1 PRES NAV WAR COLL NEWPORT ATTN MAHAN LIB
1 CO NAV GUIDED MSL SCH DAM NECK VA BEACH
2 CO & DIR ATLANTIC FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1 CO NUCLEAR WEAPONS TNG CTR ATLANTIC NAV AIR STA NORFOLK
2 CO FLT SONAR SCH KEY WEST
1 CO FLT ANTI-SUB WARFARE SCH SAN DIEGO
1 CHF OF NAV RES ATTN [illegible]
1 CHF OF NAV RES ATTN HEAD PERS & TNG BR CODE [illegible]
1 CHF OF NAV RES ATTN DIR PSYCHOL SCI DIV CODE [illegible]
1 CHF OF NAV RES ATTN HEAD GP PSYCHOL BR CODE [illegible]
1 DIR US NAV RES LAB ATTN CODE [illegible]
1 DIR NAVAL RSCH ATTN LIB CODE [illegible] WASH DC
1 CHF OF NAV AIR TNG TNG RES DEPT NAV AIR STA PENSACOLA
1 CO MED FLD RES LAB CAMP LEJEUNE
1 CDR NAV MSL CTR POINT MUGU CALIF ATTN [illegible]
1 DIR AEROSPACE CREW EQUIP LAB NAV AIR ENGNR CTR PA
2 CO NAV PERS RES ACTVY SAN DIEGO
1 NAV NEUROPSYCHIATRIC RES UNIT SAN DIEGO
2 NAVAL MSL CTR [illegible] PT MUGU CALIF
1 DIR PERS RES LAB NAV PERS PR [illegible] ACTIVITY WASH NAV YD
1 NAV TNG PERS [illegible] ATTN LIB WASH
1 COMDT MARINE CORPS HQ MARINE CORPS ATTN [illegible]
1 HQ MARINE CORPS ATTN AX
1 DIR MARINE CORPS [illegible] MARINE [illegible] QUANTICO
1 DIR MARINE CORPS INST ATTN [illegible]
1 CHF OF NAV OPNS [illegible]
1 CHF OF NAVAL OPNS [illegible] WASH DC
1 CHF OF NAV OPNS [illegible]
2 COMDT [illegible] NAV DIST ATTN [illegible] NEW ORLEANS
1 CHF OF NAV AIR TECH TNG NAV AIR STA MEMPHIS
1 DIR [illegible] EVAL [illegible] CHF OF NAV [illegible]
2 COMDT [illegible] COAST GUARD HQ
1 CHF [illegible] HQ
1 CO US COAST GUARD TNG CTR GOVERNORS ISLAND NY
1 CO US COAST GUARD TNG CTR CAPE MAY NJ
1 CO US COAST GUARD TNG CTR & SUP CTR ALAMEDA CALIF
1 CO US COAST GUARD INST [illegible] CITY OKLA
1 CO US COAST GUARD RES TNG CTR YORKTOWN VA
1 SUPT US COAST GUARD ACAD NEW LONDON CONN
1 [illegible] AFB
1 CINC [illegible] AFB ATTN [illegible]
1 AIR TNG COMD RANDOLPH AFB ATTN [illegible]
1 TECH DIR TECH TNG [illegible] LOWRY AFB COLO
1 [illegible] ATTN [illegible] WRIGHT-PATTERSON [illegible]
1 CHF SCI DIV [illegible] ARLINGTON
1 CHF OF PERS [illegible]
1 CHF [illegible]
1 HQ [illegible] ANDREWS AFB
1 [illegible] AIR [illegible] AFB
2 [illegible]
2 [illegible] AFB
1 ATC [illegible]
1 HQ [illegible] CALIF
2 MILIT TNG CTR [illegible] LACKLAND AFB
2 AFHRL [illegible] AFB
1 [illegible]
1 [illegible]
4 HQS ATC [illegible] AFB
1 DIR [illegible] ATTN [illegible]
1 DIR AIR [illegible] ATTN [illegible]
1 AIR [illegible] SCH [illegible] ATTN [illegible]
1 DIR [illegible] AFB
1 COMDT [illegible] WRIGHT-PATTERSON AFB
1 COMDT ATTN [illegible] WRIGHT-PATTERSON AFB
1 [illegible]
1 [illegible]
1 TECH TNG CTR [illegible] AFB
2 AF HUMAN RES [illegible] AFB
2 [illegible]
1 [illegible]
1 DIR NATL [illegible] ATTN [illegible]
1 [illegible]
2 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
2 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible] ATTN LIB

2 [illegible] ATTN LIB
2 RAC ATTN LIB MCLEAN VA
1 [illegible] WASHINGTON ATTN LIB
1 DIR RAND CORP SANTA MONICA ATTN LIB
1 [illegible] DEPT OF PSYCHOL
2 [illegible]
1 [illegible] ATTN [illegible]
1 MITRE CORP [illegible] ATTN LIB
2 SIMULATION [illegible] ATTN [illegible] FAIRFAX VA
2 [illegible] ATTN [illegible]
1 HUMAN SCI [illegible] MCLEAN VA
2 TECH INFO [illegible] DATA [illegible]
1 CHRYSLER CORP MSL DIV DETROIT ATTN [illegible]
1 [illegible] ATTN [illegible] WILMINGTON MASS
1 CTR FOR RES IN SOCIAL SYS AMER U ATTN LIBN
1 RAYTHEON SERV CO ATTN LIBN [illegible] MASS
2 [illegible]
1 [illegible] DIV ATTN [illegible] CALIF
2 [illegible] CALIF
2 [illegible]
1 [illegible] SEATTLE
2 CTR FOR RES IN SOCIAL SYS [illegible]
1 [illegible] PSYCH & ENG SUPT DIV ARL VA
1 HUGHES AIRCRAFT COMPANY CULVER CITY CALIF
1 DIR CTR FOR RES ON LEARNING & TEACHING U OF MICH
1 [illegible] NASHVILLE TENN
1 U OF [illegible]
1 CTR FOR RES IN SOCIAL SYS AMER U
5 BRITISH EMBASSY [illegible] STAFF WASHINGTON
4 CANADIAN JOINT STAFF [illegible] WASHINGTON
3 CANADIAN ARMY STAFF WASHINGTON ATTN GSO2 TNG
1 CANADIAN LIAISON OFCR ARMY ARMOR AGCY FT KNOX
3 ACS FOR INTEL [illegible] MILIT ATTACHE
1 ARMY ATTACHE ROYAL SWEDISH EMBASSY WASHINGTON
1 DEF RES [illegible] CANADA
4 AUSTRALIAN ARMY ATTACHE EMBASSY OF AUSTRALIA WASH DC
1 FRENCH LIAISON OFCR [illegible] FT RUCKER
1 [illegible] ATTACHE AUSTRALIAN EMBASSY [illegible] WASH DC
2 AUSTRALIAN EMBASSY [illegible] MILIT ATTACHE WASHINGTON
2 U OF SHEFFIELD DEPT OF PSYCHOL
1 MENNINGER FOUNDATION TOPEKA
1 AMER INST FOR RES SILVER SPRING
1 AMER INST FOR RES PGH ATTN LIBN
1 LIB PRIMATE LAB UNIV OF WIS MADISON
1 COLUMBIA U SCH OF BUS
3 MATRIX CORP ALEXANDRIA ATTN TECH LIBN
1 [illegible]
1 U OF [illegible] DEPT OF PSYCHOL
1 [illegible] DEPT OF PSYCHOL
1 [illegible]
1 [illegible] SANTA BARBARA ATTN LIB
1 [illegible] ATTN LIBN
1 HEAD DEPT OF PSYCHOL UNIV OF SO CAROLINA
1 [illegible] ATTN [illegible]
1 U OF [illegible] DEPT OF PSYCHOL
1 [illegible] WASH DC
1 AMER INST FOR RES [illegible] CALIF
1 MICH STATE U [illegible]
1 [illegible] STATE U ATTN [illegible]
1 [illegible]
1 [illegible] ANAHEIM CALIF
1 OHIO STATE U SCH OF [illegible]
1 [illegible] CHICAGO ILL
2 [illegible]
2 [illegible] ATTN [illegible]
1 [illegible]
1 [illegible] ATTN [illegible]
1 [illegible]
1 [illegible] PSYCHOL
1 [illegible]
1 WASHINGTON [illegible]
1 [illegible] ATTN [illegible]
1 [illegible] CALIF
2 [illegible] STATE COLL [illegible] MINN
1 COLL OF WM & MARY [illegible]
1 [illegible]
2 [illegible] ATLANTA
2 [illegible]
1 [illegible]
1 [illegible] MINN
1 [illegible]
1 [illegible] CALIF [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]
1 [illegible]

HUMAN RESOURCES RESEARCH ORGANIZATION

300 North Washington Street • Alexandria, Virginia 22314

President	Dr. Meredith P. Crawford
Executive Vice President	Dr. William A. McClelland
Director for Business Affairs and Treasurer	Mr. Charles W. Smith
Director for Operations	Mr. Arnold A. Heyl
Director for Program Development	Dr. Robert G. Smith, Jr.
Director for Research Design and Reporting	Dr. Eugene A. Cogan

RESEARCH DIVISIONS

HumRRO Division No. 1 (System Operations) 300 North Washington Street Alexandria, Virginia 22314	Dr. J. Daniel Lyons Director
HumRRO Division No. 2 Fort Knox, Kentucky 40121	Dr. Donald F. Haggard Director
HumRRO Division No. 3 Post Office Box 5787 Presidio of Monterey, California 93940	Dr. Howard H. McFann Director
HumRRO Division No. 4 Post Office Box 2086 Fort Benning, Georgia 31905	Dr. T.O. Jacobs Director
HumRRO Division No. 5 Post Office Box 6057 Fort Bliss, Texas 79916	Dr. Albert L. Kubala Director
HumRRO Division No. 6 (Aviation) Post Office Box 428 Fort Rucker, Alabama 36360	Dr. Wallace W. Prophet Director
HumRRO Division No. 7 (Social Science) 300 North Washington Street Alexandria, Virginia 22314	Dr. Arthur J. Hoehn Director