THE PERCEPTION OF A FORM IN AN UNDIFFERENTIATED FIELD AS INDICATED BY THE OBSERVER'S USE OF THE TILT-BOARD

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This is to certify that the

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S Howard Bartley
Major professor

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THE PERCEPTION OF A FORM IN AN UNDIFFERENTIATED FIELD AS INDICATED BY THE OBSERVER'S USE OF THE TILT-BOARD

By

Erwin Louis Haan

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DEDICATION

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I. INTRODUCTION

Although they are universally experienced phenomena of visual perception, the peculiar family of psycho-physiological processes referred to as the constancies is yet incompletely understood. While the natures of the various phenomenalogies of the several kinds of constancy are qualitatively different, the grosser psycho-physical aspects of their separate origins and, in a more restricted sense, the psycho-physiology of their action in terms of the perceiving organism are very much the same.

Despite the kinship of the different kinds of constancy in terms of origin and action, each of them is unique enough, qualitatively, to be considered independently of the others. In the course of development of sense psychology these individual phenomenologies have come to be differentiated into four main kinds: constancy of lightness, of color, of size, and of shape. Whereas it is the last of these, shape constancy, which is the chief concern here, a few things must be said concerning constancy in general to best introduce this particular research.

"The perception of things, or objects, involves certain operations on the part of the perceiver. Among them are the maintenance of thing-identity, thing-continuity, and thing-stability. The tendency to maintain stability or uniformity is commonly spoken of as constancy." Thus Bartley (1) defines the general phenomenon of constancy. Implicit in this definition is the basic premise that the perceiving organism is an active participant in all situations where constancy results. To what extent this participation is active, to what extent the contributions of the organism will be explicit, is dependent, among other things, upon the visual field involved in a given visual perception. In general it might be stated (hereinafter referred to as Case I) that the greater the perceiving organism's familiarity with the perceived object, the greater the relatedness of that object to its surrounds, and the more optimal the general conditions for visual perception, the greater the extent to which these variables of visual perception approach the ultimate, the less will the perceiving organism be involved, consciously, in the solution of the particular visual problem involved.

For essentially, visual perception is a problem-solving process, a process of making meaningful the bare essentials of visual perception, that is, the geometrical stimulus pattern on the retina superimposed upon that portion of past experience which is drawn upon to lend significance to the retinal pattern. The implicit judgments of a visual perception at this level tend to become reflexive in nature.

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(1) Bartley, S. Howard, "Beginning Experimental Psychology", 1950, McGraw-Hill Book Company, Inc., New York, p. 157.

While this statement is creditable, it would be erroneous to assume the converse of it (to be referred to as Case II). That is, it is not necessarily true that the less familiar the perceiving organism is with the primary features of a visual field and the more ambiguous the stimulus pattern on the retina, the more the perceiver will be involved in a problem solving way at the conscious, conceptual and/or rational level.

One unique feature of visual perception rests in the fact that for certain types of situations in the visual field, the givens, operative in the field, do not demand any one response to the exclusion of all others. In such cases as those represented by the first statement above (Case I) the consistancy with which that type of visual field will be resolved in the same way time after time approaches certainty. If, however, the component variables comprising the visual field are of the nature of those illustrated in Case II (i.e., ambiguous, unidentifiable, etc.) the variations in type and degree of resolution will be so diverse as to deny any systematic appraisal of responses. That is to say, the final resolution of the problem presented by any visual field may take any one of as many forms as combinations of past experience, learning, and operating givens in the visual field allow. Under conditions of this sort the judgment of the organism is rendered less positive as the degree of impoverishment or ambiguity increases. The less the stimulus value and cue value in the environment, the less precise will be any evaluation of that environment and consequently any judgments arising out of it.

In this connection an explanation of the terminology used here is called for. Traditionally, the terms "cue" and "stimulus" and "stimulus value" have been employed so loosely as to have lost the refinements which at first set them apart one from the other. For purposes of this paper, however, a stimulus will be thought of as a pattern of physical energies impinging upon the sense receptors of the organism at some level at or above threshold for that type of receptor; by stimulus value is meant the property or properties residual in the stimulus itself which are potentially capable of being utilized by the organism in the evaluation or formulation of judgments about the stimulus; a cue, then, is the actual utilization of a stimulus situation.

The point of this differentiation is the fact that a given stimulus situation may abound in stimulus value on a given dimension (i.e., vision) and yet be impossible of resolution or evaluation solely by virtue of the ambiguity of the situation and the impossibility of interpreting and utilizing the stimulus value present. If past learning and/or experience offer no background on which the stimulus values may be cast, they may never achieve cue rank, that is, be meaningful. On the other hand, a stimulus configuration, easily recognizable in surrounds habitually associated with the stimulus in the past, may lose its identity when presented in a strange environment or in any environment bereft of those features traditionally associated with the stimulus. This is one of the fundamental principles underlying the operation of constancy of the sort in which we are interested here.

This very principle denies the implication, found in some literature concerned with constancy, that constancy involving visual mechanisms is a matter of identical retinal image formation from moment to moment. Rather, constancy is, in a large part at least, a function of the incorporating of available stimulus value into the matrix of past experience and learning, and the conceptualizing of the resulting cues into a system of judgment and evaluation adequate to the stimulus situation involved.

The difficulty in dealing with constancy and in attaining any degree of specificity regarding its operation stems from the fact that many researchers put the cart before the horse, as it were. That is, they seek the answer to the question "Why do things look as they do?" in the object world rather than in the visual world (using the terminology employed by Gibson (2)). In terms of the definitions set down here, this course will be unavailing.

(2) Gibson, James J., "The Perception of the Visual World", 1950, Houghton Mifflin Co., Boston.

The object world is no more nor less than a set of givens (physical energy values), and is important only insofar as an organism chooses to attend to certain configurations of this infinite set of physical energies. How the organism will evaluate and conceptualize and respond to this configuration is a truer statement of the problem to be faced in dealing with this phenomenon of constancy. As Miller (3) points out, "Each different set of visual conditions results in a different shape and/or intensity pattern on the retina, and it is these retinal images rather than 'objects' that form the stimulus material for perception." Perhaps a more precise statement of the problem facing experimenters in this area is a necessity for quantification of the degree to which constancy will be maintained throughout any series of retinal image formations produced by any one object presented in a number of different orientations.

Several experimenters have attempted measurement of this sort and also investigation of various manipulations in the visual field which act in quantifiable ways to determine the degree of stability or maintenance of constancy. Thouless (4), in order to quantify constancy introduced the

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(3) Miller, James Woodell, "The Effect of Magnification on the Perception of Elipses", unpublished Masters thesis, Michigan State College, East Lansing, Mich., 1949.

(4) Thouless, R. H., Brit. J. of Psy., 1931, vol. 21, 339-359.

concepts of the real object (R), the stimulus object (S), and the phenomenal object (P). R is the object in the visual world, S is the retinal image of R in a given orientation with respect to the observer, and P is the experience of the physical object in any specific instance. As a result of his experimentation Thouless discovered that the P value, the experience of the object represented by the subject, corresponded to neither the geometric value of the real object nor to its stimulus value projected on the retina. Rather, the P value fell somewhere between the R value and the S value. This discrepancy between what there is for the observer to perceive and his actual perception of the target Thouless termed regression. Definitively stated, regression (Rg) is the degree of which the value of the phenomenal object differs from the stimulus value in the direction of the real object. This relationship Thouless verbalized in this way:

> "When a stimulus which by itself would give rise to a certain phenomenal character is presented together with perceptual cues which indicate a real character of the object, the resulting phenomenal character is neither that indicated by the stimulus alone nor that indicated by these perceptual cues, but is a compromise between them."

This relationship he called the "Law of Phenomenal Regression", and devised an index of regression which is expressed as P-S/R-S.

Later, Stavrianos (5) investigated the relationships which were thought to exist between judgments of inclination and shape perception. As an indication that such relationships did exist, she cited a corollary of Thouless which indicates that any decrease in perceptual cues regarding the nature of the real object reduces the regression of the phenomenal object in the direction of the real object.

The work of Eissler and Klimpfinger (6) also lent itself in support of a hypothesis of this sort. They concluded on the basis of their experimentation that shape and perception of object orientation were related. Stavrianos also mentions that Koffka (7) states in his theoretical treatment of this subject matter that "a certain combination of shape and orientation is invarient for a given retinal image".

With these studies as background Stavrianos executed three experiments using circles and rectangles as targets. Although her hypothesis was unconfirmed, the experimentation did show that 1) while shape judgments of tilted figures were accurate and showed little variation as a function of presented angle or other environmental con-

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(5) Stavrianos, B. K., "The Relation of Shape Perception to Explicit Judgments of Inclination", Arch. Psychol., N.Y., 1945, No. 296.

(6) Klimpfinger, S., "Uber den Einfluss von intentionaler Einstellung und Ubung auf die Gestaltkonstanz", Arch. ges. Psychol., 1933, 88, 551-598.

(7) Koffka, K., Principles of Gestalt Psychology, New York: Harcourt, Brace, 1935.

ditions, the values for tilt varied greatly under different types of experimental conditions: 2) accuracy of tilt judgment decreased as a result of cue reduction (by means of monocular vision and/or reduction tube) even though there was no decrease in accuracy of shape judgment (no loss of constancy): and 3) correlation of paired shape and tilt judgment revealed no relation.

It is to be remembered that Stavrianos in the course of these three experiments presented her targets under a whole gamut of conditions and situations and combinations of them. And of the number of conditions and situations which have direct bearing on the degree of constancy which will be maintained in a given visual field, such as level of illumination, interposition, collateral cues of various kinds, observer acquaintance with the nature of the perceived object, etc., we single out in the present investigation still another factor, instrumental magnification.

Instrumental magnification will alter a visual perception in either one of two ways, either by increasing the size of the perceived object in accordance with the optics of the instrumentation (i.e., twice as large in the case of two power opera glasses) or by decreasing the perceived distance from the object to the observer by a like amount (one-half the distance under two power magnification). Whether an object will be affected by instrumental magnification in terms of size or of distance depends in turn upon the degree of constancy maintained in the situation. Generally, it may be said that the greater the degree of constancy, the greater the tendency for instrumental magnification to alter the visual field in terms of distance.

Instrumental magnification, regardless of the physical dimension altered, does cause some change in the relation of the seen object to the stimulus pattern. One such change occurs in the angular values of surfaces with respect to each other, or a reduction in the third dimension. This decrease of depth value of three dimensional objects is referred to as flattening effect.

Referring to the diagrams in Figures Ia, Ib, and Ic, this flattening effect can perhaps be explained in terms of the geometry involved. Figure Ia represents the stimulus pattern on the retina produced by the two-dimensional object XY, tilted on its axis at 45° away from the observer. The extension of this top edge away, into depth, introduces the third dimension, producing a three-dimensional object. Figure Ic demonstrates what occurs with the introduction of a two-power lens into the situation. Assuming that in this case magnification serves to increase size rather than to decrease distance, we see XY double its size, X^1Y^1. However, instrumental magnification can operate in only two dimensions, height and width. Thus, whereas the height (h) of XY has doubled, its depth (third dimension), d_1, has remained constant. In order that the doubled

Figure I. Geometry involved in unaided and aided perception of a tilted plane surface.

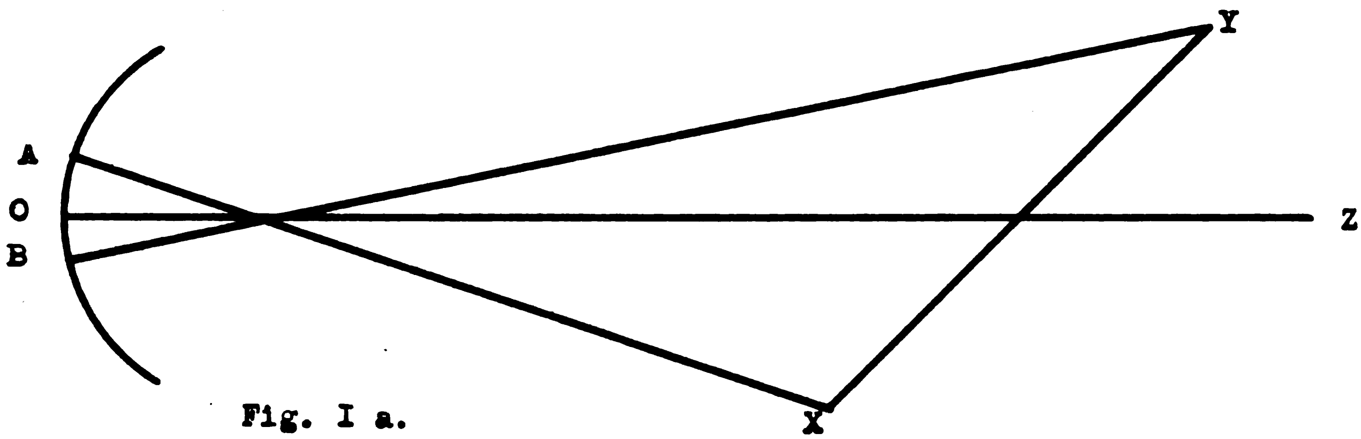

Fig. I a.

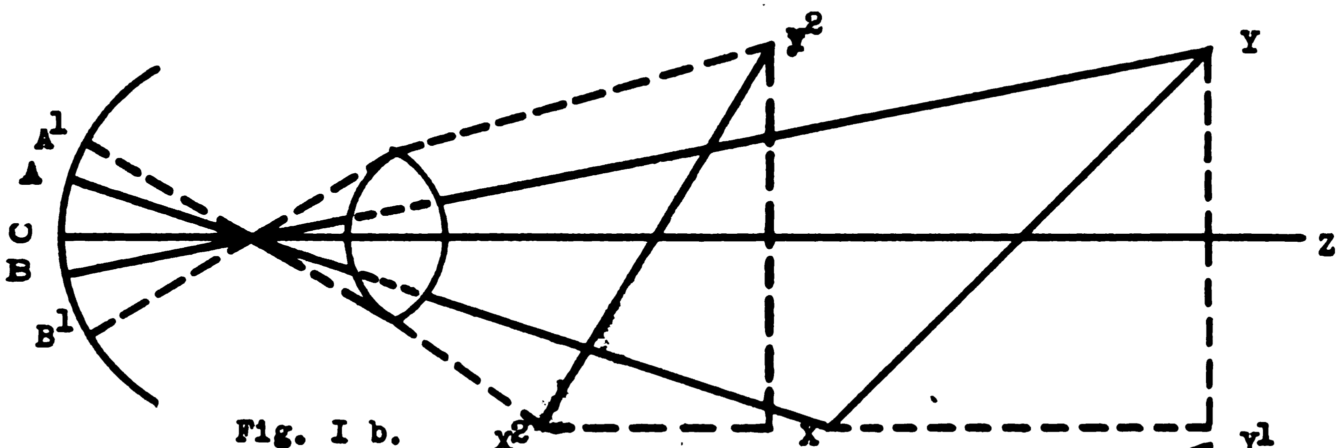

Fig. I b.

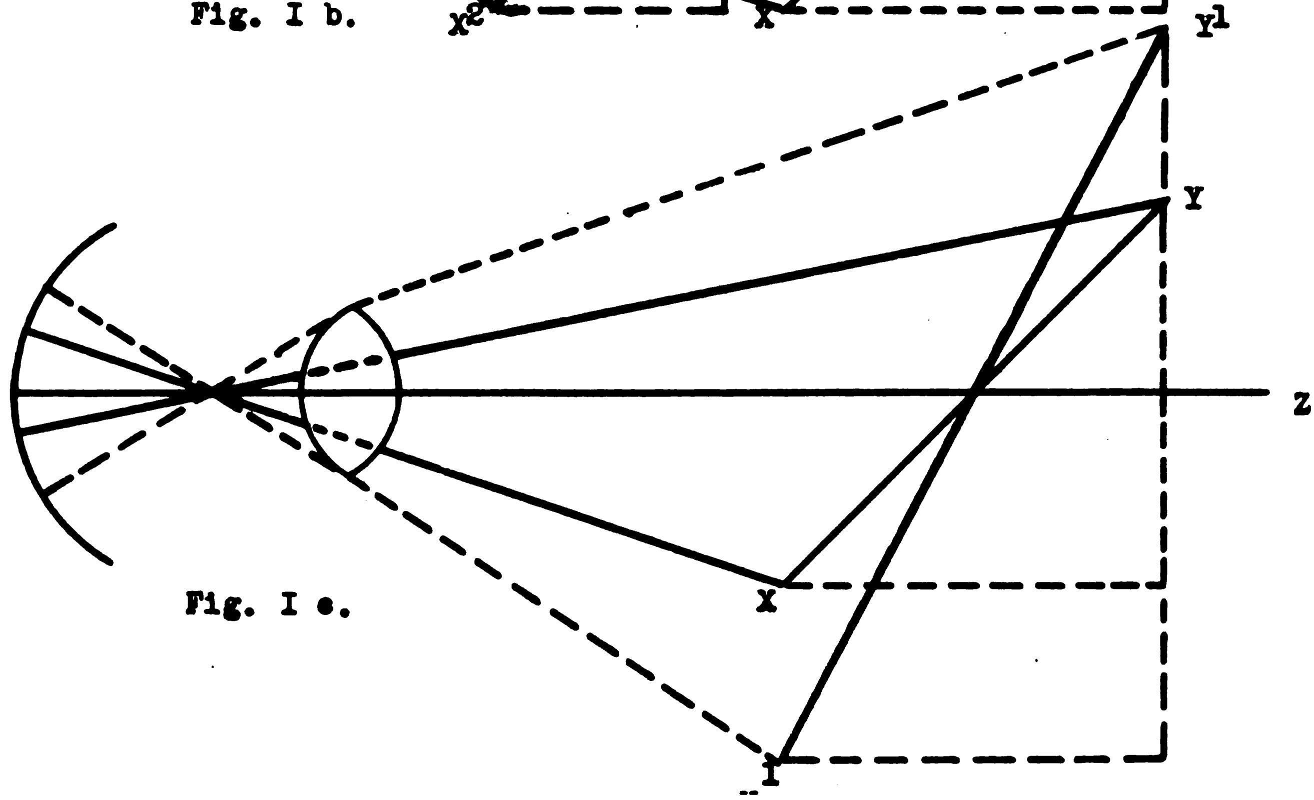

Fig. I c.

image be accommodated in the depth dimension d_1, it must change its angular orientation from its original position at 45° from the line of regard to something significantly less. There has been a reduction of the third dimension.

Perhaps, however, the situation is such that the degree of constancy is sufficient to cause perception of the object XY not as X^1Y^1, twice as large as XY, but as X^2Y^2, twice as near as XY. The geometry of this situation is demonstrated in Figure Ib. In this case the manner in which X^2Y^2 is perceived is geometrically determined by X^1Y^1 as regards the third dimension. That is, whether the perceived object resulting from instrumental magnification is seen as an object twice as large or as one twice as near, the original object, XY, and its object-properties have been lost to the situation. Therefore, if the original object, XY, is perceived as X^2Y^2, it will suffer the same loss of third dimension as did X^1Y^1.

II. STATEMENT OF THE PROBLEM

It has been pointed out that one of a number of factors which creates conditions either in the visual world or in the visual field which may introduce changes in the shape and even the identity, and consequently the degree of constancy, of an object is instrumental magnification. Instrumental magnification alters the perceived shape of an object. Yet, under conditions of magnification all objects are not altered in the same way. Cubical objects containing little or no detail are distorted and flattened in a manner characteristically referred to as Chinese perspective. Cubical objects such as steeples, bell towers, buildings of classical Greek design, etc., do not suffer this type of distortion but shift in shape in a way which gives rise to Chinese perspective, due primarily to the wealth of detail inherent in the perception of them. Two dimensional figures, on the other hand, are much more liable to the distortions occurring under conditions of instrumental magnification.

As was pointed out previously, Thouless, Koffka, Stavrianos, and Miller all dealt with two dimensional objects with plane surfaces, and found what Thouless called regression in the direction of the real object when the two dimensional targets were tilted in respect to the observer's line of regard. Phenomenologically, this tilting produces a third-dimensional character in an object actually possessing but two dimensions and lying in a single plane. The very act of displacing on its axis any portion of an object, a circle or elipse in this case, away from the observer, "awayness" being a correlative of depth, provides a third dimension. With the addition of the third dimension we might, all other conditions being the same, as, for example, those found in Thouless' experimental situation, expect to find a decrease in this third dimension with the introduction of instrumental magnification.

It is to be remembered that the experimental situations of Thouless, Stavrianos, and Miller provided a large amount of collateral cues in addition to those inherent in the target themselves. What the organism would do in a situation affording no collateral cues at all, how his perception of a two-dimensional object given three-dimensional properties by virtue of orientation (tilting) would be altered given only the object and the stimulus values native to its geometry, was the problem posed for this experiment.

By way of comparing Miller's experimental environment, for instance, with the one presented here, it might be said that the degree of active participation on the part of the two different sets of subjects was quite different. Whereas for Miller's subjects a certain degree of internal manipulation (conceptualization) of the retinal image was possible, this same sort of juggling necessarily was limited in scope if not in degree by the total absence of collateral cue in the present experimental situation. The retinal images of Miller's (and Thouless', and Stavrianos') subjects were composed of the target circumscribed by a given amount of collateral cues. Subtle as those cues might have been, one can be sure that in a visual field lacking the normal amount of cue property, the organism will certainly seize hold of whatever cue value remains. It would seem, therefore, quite difficult to attribute to target or environment their respective roles in producing the conceptual outcome in terms of an ambiguous situation.

Removing all cues from the field, except those residing in the target itself, can be expected to introduce a great deal more ambiguity into the situation than any reported in the literature to date. Without the possibility of environmental reference, the observer is left to make judgments on the basis of object (target) properties alone. Whether or not, or to what extent the organism could do this, and to what extent his judgments would correspond in any way, such as by phenomenal regression, with those indicated by the results of Thouless and Miller, is the real nature of this problem.

III. EXPERIMENTAL PROCEDURE

Subjects

Twenty-one subjects were used in the experiment, twelve of which were female, and all were undergraduates at Michigan State College. All twenty-one subjects participated in the complete experiment, under both aided and unaided conditions. All subjects reported 20/20 vision uncorrected. No subject evidenced, either verbally, or in terms of performance, any awareness of the nature or purpose of the experiment, and all were naive regarding the experimental variables and their manipulation.

Apparatus

The experiment was performed in two adjoining light proof rooms. An aperture fourteen by twenty-eight inches was cut into the wall between the two rooms and located at eye-level to the subjects who were seated at a table thirteen feet six inches from this aperture. Attached to the center wall and immediately around the aperture was a large plywood box referred to as the stage and which measured forty-six inches long, thirty inches wide, and thirty-five inches high. The rear panel of the stage contained an opening seven inches square into which the targets were placed for presentation. Thus the distance from target to observer became seventeen feet four inches. Located above the front aperture and inside the stage was the light source, a General Electric CH-4 ultraviolet lamp and its accessory parts, which included its screw base socket, transformer and special filter which eliminated the small component of white light emitted by the source. The lamp was of spotlight construction and was beamed directly on the target area. All surfaces except those of the target proper were painted flat black to absorb not only the small amounts of white light which might still have been present in the emission from the source but also to absorb the traces of white light reflection caused by any foreign matter present in the commercial fluorescent paint used to coat the targets themselves. Between presentations, all target changing activity was hidden from the observer by means of a pair of monk's cloth curtains suspended from a traverse rod which was operated from the rear of the stage by the experimenter. The curtains provided complete occlusion of the stage interior during target changing.

There were twelve targets fabricated from twelve gauge wire. The targets are described in terms of the size of their major-minor axis ratios. Three different sized targets were used: a) 5x5 (a minor axis of five inches and a major axis of five inches), b) 4x5, and c) 3x5. Four of each size target were constructed, one each for the four different degrees at which they were mounted for presentation, 0^{o} (upright), 22.5^{o} (away from the observer), 45^{o}, and 67.5^{o}. These twelve figures were mounted on seven inch squares, constructed to afford a light-tight fit when placed in the opening at the rear of the stage for presentation.

A reduction screen with an aperture two and one-quarter inches high and three and one-quarter inches wide was placed thirty inches from the subject to restrict the field of vision during the part of the experiment in which the binoculars did not serve this purpose. The aperture in the reduction screen was, of course, moveable to compensate for variations in sitting height of the twenty-one subjects.

To enable the subjects to represent the plane in which they perceived the targets to lie (phenomenal tilt), a tilt-board, ten and one-half by seven inches covered with white matte material, was affixed coaxially with the shaft of a one hundred and twenty vòlt Variac. Changing the position of the tilt-board thus changed readings on a volt-meter connected in series with the Variac. These voltage readings, having previously been calibrated in terms of angular degrees of tilt, were transposed into the angle at which the subject had positioned the tilt-board for any one presentation.

Instructions to Subjects

A literal transcription of instructions given the subjects follows: "You are to be presented visually a series of forms or figures some of which are mounted in positions other than upright. Your task is to duplicate the plane in which the various figures lie by manipulating the tilt-board in front of you until the plane at which you set the tilt-board best approximates the plane in which you perceive the object to be oriented."

Method

The subjects were introduced into the experimental situation under normal illumination and allowed to look about while the experimenter made preliminary preparations. The only things visible to the subject were the tilt-board arrangement, the reduction screen, the table and chair he was to use, the dimensions of the room, and the aperture through the wall.

After the subject had seated himself, normal illumination was removed and replaced by illumination afforded by a red bulb of twenty-five watts. The subject was partially dark adapted in this environment for three minutes, during which time he was given his instructions, allowed to manipulate the tilt-board, and operate the buzzer system which informed the experimenter in the other room of completion of evaluation of one target and readiness for the next. After the three minute period of dark adaptation the experimenter indicated to the subject that the experiment was about to begin.

After placing in position the first of the twelve targets of the series (the order of appearance of which had been determined by reference to tables of random order), the experimenter drew open the curtains, exposing the target to the view of the observer who evaluated the target. When the subject had satisfied himself as to the orientation of the target he positioned the tilt-board to represent the plane of the target's orientation. Having done this he pressed the buzzer to indicate his completion of the task, and the experimenter recorded the judgment as represented on the voltmeter, closed the curtains and replaced the target with the next. This cycle was repeated through the series of twelve targets. The complete series was repeated ten times without pause under these conditions.

The second half of the experiment consisted of the same task performed under the same conditions except for the introduction of instrumental magnification into the situation. The twenty-one subjects all performed in the unaided situation, but were divided into two groups as regards the aided situation, twelve using two power (2X) opera glasses, and nine using seven power (7X) military glasses. In both the aided and unaided situations, techniques of presentation by experimenter and representation by the subject were the same. This half of the experiment was performed two days after the first part.

After the complete set of readings was taken, the

voltage readings were transposed into degrees of tilt, the means for the ten trials per target were derived and an analysis of variance applied to the compiled data. The analysis of variance technique was chosen in preference to t-score methods because the data was of a continuous rather than a discontinuous nature.

IV. RESULTS AND INTERPRETATION

Figure II represents a graphical representation of the gross trend of the experimental results yielded by subjects using two-power glasses while Figure III represents the trend of results for subjects using seven-power glasses. Inspection of Figure II shows the type of response curve which seems to be typical for behavior in problems and environments of the type found in this experiment. Nelson (8), for instance, established a nearly identical curve attained from the plotting of minor-major axis ratios of the drawings by his subjects of the same targets used here. The curve of best fit, in the case of both Figure II and Figure III is an approximation and is not mathematically refined. However, it appears as obvious that in the case of judgments of tilt of targets having stimulus values in the middle ranges (between .35 and .65) where no instrumental magnification is employed, these judgments are consistently and significantly overestimations of actual tilt values. In the situation utilizing instrumental magnification of two power, however, a more nearly straight-line function results, one which indicates an increasingly great underestimation of actual angular orientation as stimulus values

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(8) Nelson, Thomas M., "The Perception of a Form in an Undifferentiated Field as Indicated by the Observer's Drawings", unpublished Masters thesis, Michigan State College, 1953.

decrease from 1.0 (a circle to .00 (a straight line).

Although this response curve seems to indicate regression, as do those of Thouless and Miller, the results obtained with the seven-power glasses, as represented in Figure III, differ. For in this case, where instrumental magnification was considerably greater, the type of responses were not at all as one might expect. Whereas the response curves for the unaided eye are very similar in both Figure II and Figure III, the response pattern of the aided observations is quite dissimilar. It is quite probable that mathematically derived curves established for the data of each of the two conditions in Figure III would very nearly coincide. This is in contrast to the obvious and significant difference of the two curves in Figure II. It will be noted, also, that for the range of stimulus values used, the populations of the data for the two viewing conditions intermingle. Since the function of instrumental magnification is of primary importance in this experiment, the explanation of this phenomenon becomes crucial and will be attempted later.

The analysis of variance technique, which was employed in the treatment of these data, indicates some of the relationships which exist between the several variables operating in this experimentation. The number of variables actually dealt with here was kept to a minimum by the experimental design. Nelson's similar and concurrent study found

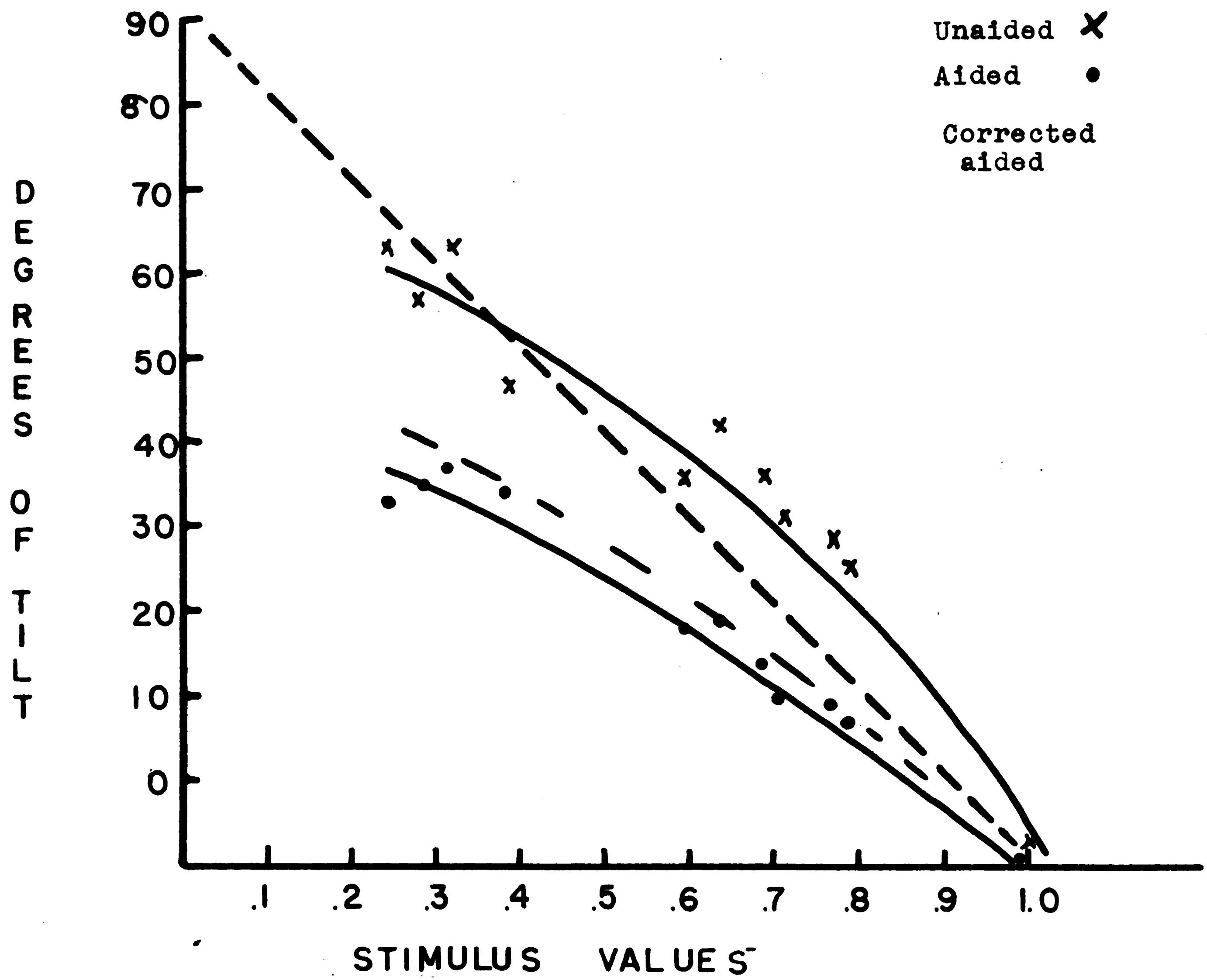

Figure II. Graphical presentation of estimation of tilt under unaided and two-power conditions.

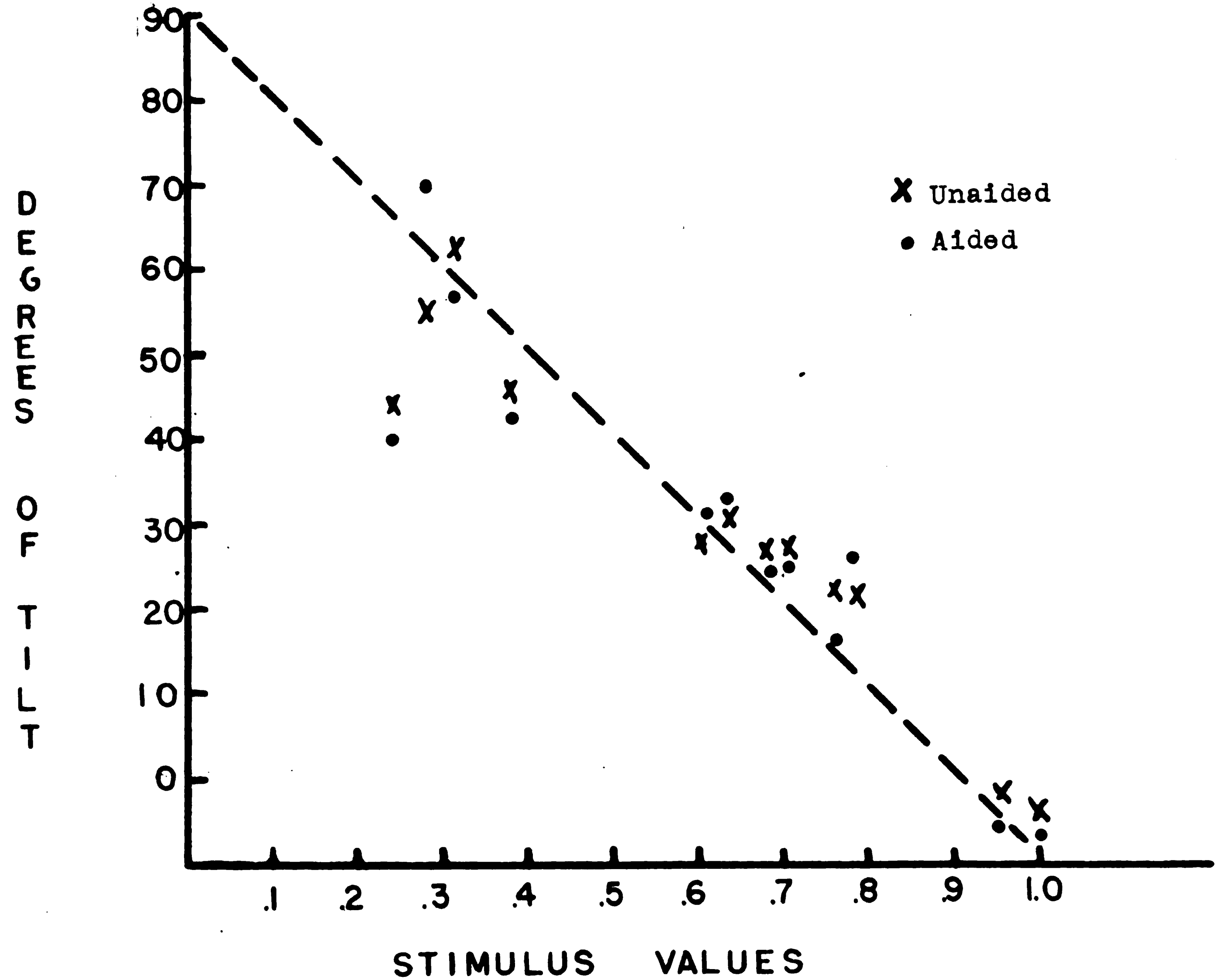

Figure III. Graphical presentation of estimation of tilt under unaided and seven-power conditions.

such variables as age of subjects, time per response, and order of presentation (aided or unaided condition first or last) to operate at levels statistically insignificant. The sex variable, not taken into account here, was found by Nelson to be significant beyond the one percent level of confidence. However, that variable would account for but one degree of freedom and would reduce the error term by 462 units.

The results of the analysis of variance of the means of the trials is presented in Table IV. Bartletts' test of homogeneity was applied to each of the sub-groups and the resulting value of X^2 (chi square) was not significant, indicating homogeneity and insuring the validity of the application of the analysis of variance technique.

Inspection of Table IV will show that the variable dealing with the influence of the various subjects was significant beyond the one percent level of confidence. This, of course, was to be expected in view of the necessity for the subject to contribute to the situation some scheme or conceptualization which would aid him in solving the perceptual problem. In the experimental situation, impoverished as it was with regard to available stimulus value, the observer was compelled to utilize his own system of evaluation and judgment of the targets in lieu of the kind of cues customarily utilized in making judgments of the sort required here. That the various subjects did tend to evaluate each target in much the same way seems to indicate that judgments of tilt were made either in terms of a common scheme, or by employment of individual approaches which resulted in like judgments for any one target.

The introduction of instrumental magnification was a variable which was significant beyond the one percent level of confidence. The significant difference existing between aided and unaided conditions, when analyzed in terms of Figures II and III, must be attributed to the two-power glasses. For it is obvious from inspection of these graphs that the estimations of tilt under seven-power magnifications closely approximated estimations made under unaided conditions. On the other hand, Figure II demonstrates the significant difference between estimations of tilt under unaided and two-power magnification.

The interaction of subjects and aided vs. unaided conditions was significant. The fact of similar evaluations of tilt for a given from observer to observer was mentioned above as being attributable to either one of two possibilities, that the observers responded in terms of a common conceptual system or that the several observers utilized individual schemes. The significant character of the interaction term indicates that the second alternative is, in fact, the valid one. That is, there were significant differences between observers with respect to the influence of aided and unaided conditions. Whereas the introduction of magnification into the environment served to increase the estimate of tilt for one observer, the responses of another observer indicated greater estimates of tilt under unaided conditions. It is to be remembered in this connection that the values plotted in Figures II and III represent aggregate measures and mask the unique behavior of individual observers represented by the raw data.

The figures or targets were broken down in the analysis into their two structural components, the target itself, having physical dimensions and its angular orientation or tilt, both of which factors are also significant at the one percent level. The three targets are each significantly different from each other in terms of their physical dimensions. Figure IVa demonstrates the fact that the three targets tend to order themselves in terms of estimation of magnitude of tilt with the 5x5 figure evidencing the smallest estimations and the 3x5 target showing the largest estimation. This ranking of the estimation of the magnitude of tilt may be a function of similarity or dissimilarity between the target in question and a circle. The experimentation gives no verification of this, however, although this type of evaluating process may well have been the most popular scheme utilized by the various subjects in making their judgments.

The experimental results seem to indicate that estimations of tilt coincided with actual physical orientation.

The analysis tends to support this statement in that it indicates that, while the estimate of the magnitude of tilt at 67.5° is not significantly different than that at 90°, the estimates of magnitude of tilt at 90° and 67.5° are significantly different from those estimates at both 45° and 22.5°, the estimates of which are, in turn, significantly different from each other. This relationship is demonstrated in Figure IVb.

These particular results seem to be explainable in terms of our previous assumption that all targets are judged as being circles at different angular orientations. This assumption, however, allows only for the operation of objective stimulus conditions and ignores any other contribution the individual observer may make. More will be said about this in a succeeding section.

Tables II and III are designed to discover the significant differences in extimates of magnitude of tilt under the three conditions, unaided eye, two-power magnification, and seven-power magnification.

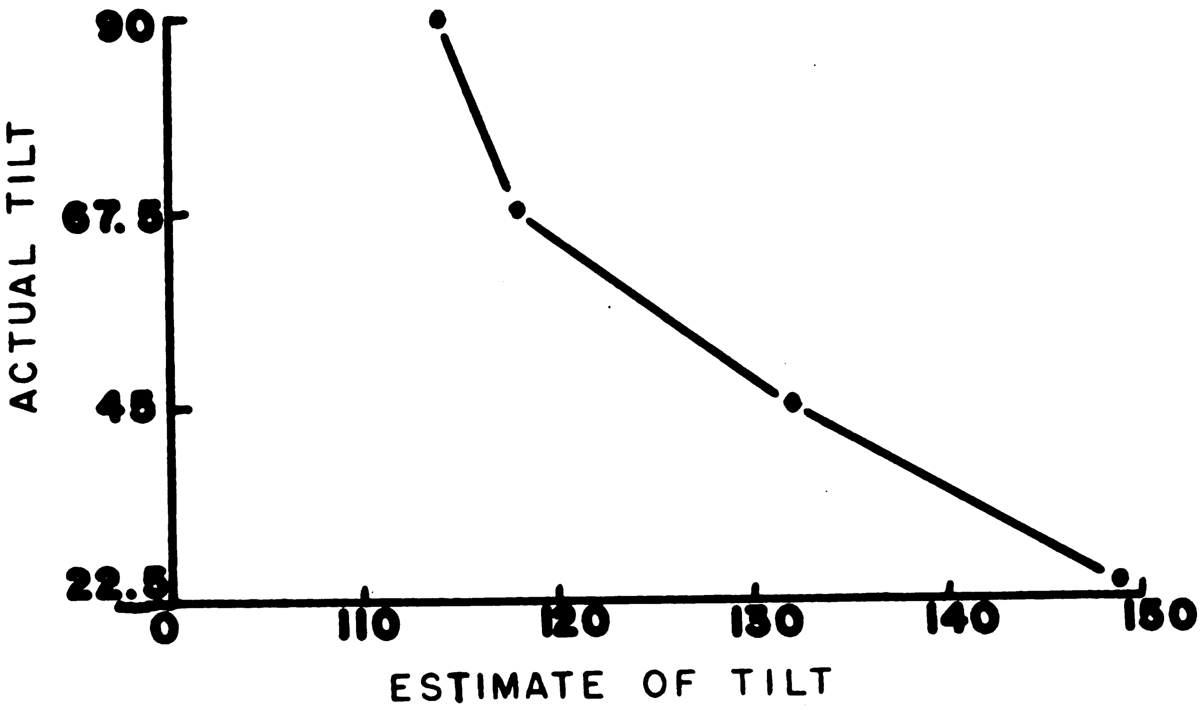

Figure IV a.

Relation of actual tilt of targets to estimation of tilt (phenomenal tilt).

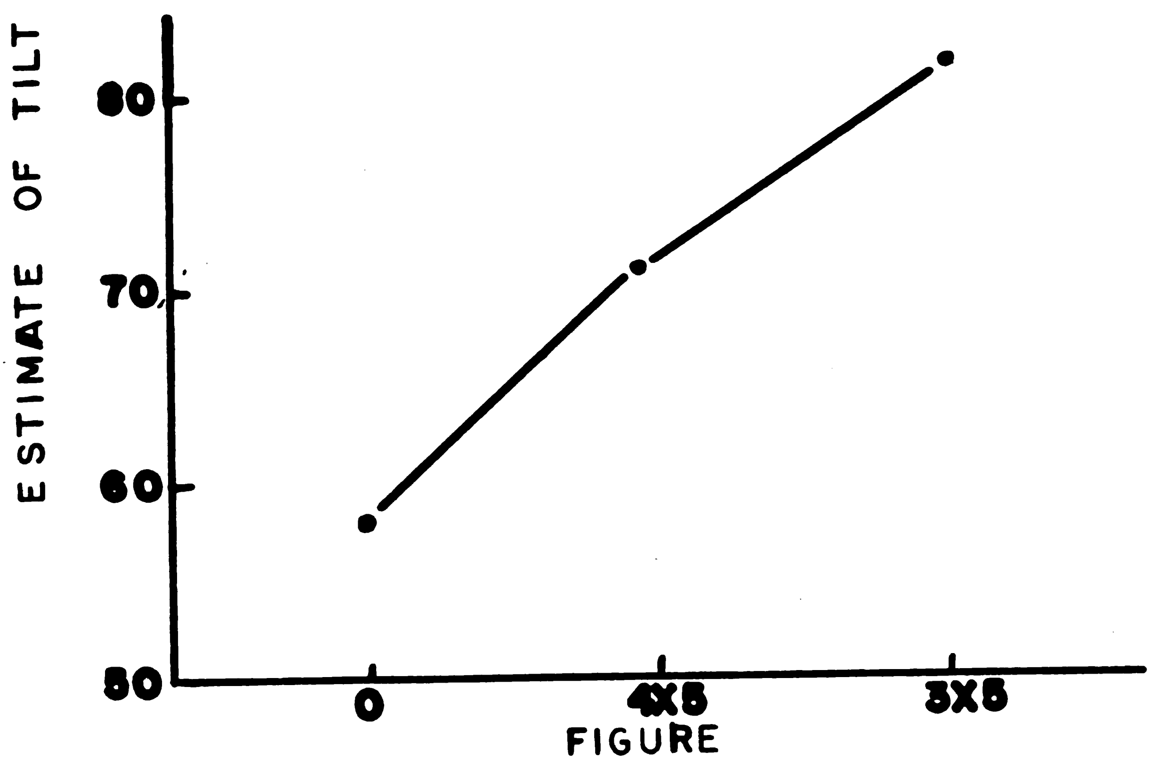

Figure IV b.

Relation of geometric figures to estimation of tilt (phenomenal tilt).

V. DISCUSSION

In the history of sense psychology as well as in other fields, much has been done in attempting to establish the relationships which exist between a real object in a real world, the nature of its associated retinal image, and its sensation or phenomenology. Some generalizations have been made, one of which has to do with geometry, that is, with the relation of size of the real object (its visual angle) to the size of the retinal image. However, such a fixed relationship does not obtain between the shape, size and orientation of a plane figure, and the size and shape of its associated retinal image. Two plane surfaces will function in exactly the same way, visually, given only identical visual angles. The fixed relations existing between a plane surface's shape, size, distance, and orientation, and the size and shape of the retinal image, then, offer nothing with which to differentiate that surface or configuration from any other subtending the identical visual angle. This fact was illustrated by Ames (9) in experiments conducted at the Dartmouth Eye Institute in which he demonstrated the equivalence of three-dimensional objects by presenting to the observer through objectively

(9) See Bartley, S. Howard, "Beginning Experimental Psychology", 1950, McGraw-Hill Book Company, Inc., New York, p. 145.

different physical constellations ("targets") which give rise to identical retinal images and are therefore perceived as the same object in space.

The perception of objects, including plane surfaces, involves not only their known size, perceived size, and shape, but also the orientation of them in regard to the observer and to themselves. For normally, the perception of an object of any kind in space is more than the perception of space relationships to other objects and to the observer. One of the axioms of space perception is that what an object is seen to be and where it is seen to lie are mutually dependent and form a reciprocal relationship.

In this present research, however, not all these necessary elements of space perception were available to the observer in his judgments concerning the nature of the visual field. Not only were there no spatial relations between the target and any other object or surface in the field, but the exact nature of the targets and their geometry were unknown to him. The mere knowledge that he was working with a series of circles and ellipses afforded the observer little with which he could discriminate between an ellipse of a certain major-minor axis ratio and a circle tilted at such a degree as to effect a stimulus value (visual angle) nearly identical to that of the ellipse oriented in a plane perpendicular to the line of regard.

It is significant that the observers were able to discriminate at all in the situation, and indicate the operation of some principle other than those customarily considered as functioning in a visual task involving the types of mechanisms at work here. The principles to which we refer are necessarily a contribution of the observer himself and are not abstracted as such from the visual field. They amount to the observer's conceptualizations about his perceptions. It is just this type of thing which was referred to earlier in this paper.

The diversity of the kinds of conceptual schemes which any group of observer's might utilize are a function of the total visual field depending on the complexity of the retinal image. In this present study, it is relatively safe to assume that the undifferentiated nature of the field and the simplicity of the target configurations limited the scope of conceptual activity. The fact of inter-observer similarity as regards judgments bears out this assumption, since any diversity of conceptual schemes would produce a marked lack of correspondence of judgments from observer to observer.

In this connection, however, it should be pointed out that one subject, whose judgments were made under unaided and seven-power conditions, made responses of a sort which deviated to a degree which invalidated them. While his judgments made during the unaided portion of the experiment deviated no more than one standard deviation from other observers' responses, this subject's responses under seven-power magnification were completely inconsistent in terms of the other observers' judgments. For this subject merely set the tilt-board at the vertical position on the first response for the aided trials and left it in that position for the succeeding 119 trials. Whether this subject was trying to outguess the experimenter, whether he suspected he was being fooled, or whether he gave up any attempt to solve the perceptual problem is not known.

It was suggested earlier that it would be quite possible for an observer to make responses in terms of figures of different major-minor axis ratios all oriented in the vertical plane. However, introspective reports by this particular subject, subsequent to his performance, gave no indication of this type of resolution of the problem. It can only be concluded that his behavior was a function either of his lack of understanding concerning the nature of his task, or of some other factor of which the experimenter is unaware. In either case it was considered advisable to discard the response data of this subject.

Another subject, whose responses were made under unaided and two-power magnification occasionally adjusted the tilt-board to represent the target as lying in the quadrant away from the target. Although there appeared to be no consistent pattern to these responses either in terms of targets or angular orientation, they appeared frequently enough to merit attention. Since no introspective report of the subject was available, it can only be assumed that his estimations in that quadrant were of such a magnitude with respect to the vertical as to preclude the possibility of the responses resulting from a faulty estimation of the vertical.

Keeping in mind the nature of the field and the total absence of collateral cue, it would be impossible to assume that for a retinal pattern produced by a given target there can be any 'right' orientation. That is, with no depth cues or interposition in the visual field, it would be virtually impossible to determine which edge is the nearer one, and consequently to make adequate judgments in terms of orientation with respect to quadrant.

For this reason Figure II bears two curves depicting the responses under two-power magnification. The solid line represents the means of scores including this subject's uncorrected scores. The broken line represents the means of scores which include this subject's corrected scores, that is, his scores corrected by adding to each response a value which results in an equivalent setting in the quadrant used by all other subjects.

This leads to a consideration of general performance under seven-power magnification as demonstrated by Figure III. It was remarked earlier that, whereas the results obtained in the unaided situations and the one employing two-power magnification fell in with expectations, the responses resulting from judgments of the targets under seven-power magnification seem to fall outside any traditional rationale. However, a consideration of events evoked by another situation involving only slightly different primary features may serve to explain the discrepancy between anticipated results and actual responses.

It was explained in a preceding section that the introduction of instrumental magnification incurs a certain degree of distortion in the retinal image, distortion which involves the third dimension. The amount of distortion thus produced is a function of the degree of magnification produced by the optics of the instrumentation employed. A similar type of distortion of the retinal image occurs with the monocular use of size lenses, the amount of distortion in this case depending upon the amount of meridional magnification of the lens. Experiments with size lenses (10) seem to indicate that distortions produced by magnifications of two or three percent are reconcilable by the subject, while distortions produced by greater magnifications act in quite another way. Individuals whose behavior is mediated through size lenses of this latter type appear to suppress the character of the retinal image produced by the size lenses and behave as if monocular,

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(10) Ogle, K. N., "Researches in Visual Perception", 1950, W. B. Saunders Company, Philadelphia and London.

that is, as if the eye whose retinal image was distorted by the size lens was inoperative.

The distortions of the retinal image in both cases is of much the same kind. In this experiment the observers had adequate opportunity to become acquainted with the targets under operationally normal conditions, due in part to what learning theorists refer to as "practice effect" in the unaided portion of the experiment, and in part to their own conceptualizations concerning the nature of the targets.

In view of these factors it can be assumed that the observers, while judging targets under seven-power magnification, responded in the same way as subjects behaving under the influence of retinal images distorted to the degree produced by size lenses ground at five or more degrees away from the vertical axis of the lens. That is, the observer suppressed the character of the retinal image produced by instrumental magnification and responded in terms of the 'known' size, shape, and orientation of the target as these variables were conceived to be during the unaided portion of the experiment. Such an explanation would account for the correspondent nature of the two curves in Figure III.

The major finding of this experiment deals with the role of magnification as it effects the perception of plane surfaces in a field totally undifferentiated. The results of the experimentation indicate that in a situation impoverished with regard to collateral cues, more regression is evidenced in the case of magnification (specifically two-power magnification) than is the case under unaided conditions.

This fact is contrary to the findings of Miller (11) who found that in every case more regression resulted under unaided than aided conditions. This difference, however, can be attributed to differences in the two experimental situations. The visual field for Miller's subjects contained certain amounts of collateral cue which could only be decreased with the introduction of binoculars and the constriction of the visual field incident to their use. In the visual field incorporated in this research, however, with its total lack of cues other than those residual in the targets themselves, the addition of instrumental magnification could delete nothing from the retinal stimulus pattern, but would tend, rather, to enhance those cues which were available, that is, those native to the geometry of the target.

Figures II and III demonstrate still another phenomenon, found but not discussed by either Thouless or Brunswick (12), who established regression ratios of much the same kind as those of Thouless. It will be noted that the

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(11) Miller, J. W., "The Effect of Magnification on the Perception of Elipses", unpublished Masters thesis, Michigan State College, East Lansing, Michigan, 1949.

(12) Koffka, K., "Principles of Gestalt Psychology", Harcourt and Brace, New York, 1935.

curves denoting unaided responses in both Figures II and III show a significant increment in judgments of tilt in the middle stimulus range (.035 - .065). That is, the estimation of magnitude of tilt of figures whose stimulus values (minor-major axis ratios) lie approximately between .035 and .065 was larger than the actual value, while at the lower end actual values and estimated values are nearly equal, and at the upper end the phenomenon of regression is visible.

The question concerning just how to deal with responses of this kind is posed at this juncture. If Thouless' "Law of Phenomenal Regression" deals with underestimations of tilted figures, would it be proper to structure a "Law of Phenomenal Progression"? Actually, the question should be one concerned with the validity of any law of this type. For in Thouless' "Law of Phenomenal Regression" there is the implicit assumption that the organizing factors attributable to the formation of regression to the real object (Rg) are inherent in the target and in the visual field which constitutes its surrounds. This assumption asserts the operation of objective stimulus conditions to the exclusion of the active role of the perceiving organism. Such concepts as this can never hope to adequately explain the traditional query "Why do things look as they do?" However, measures of this sort do fulfill a function which Koffka (13)

(13) Ibid.

accurately verbalizes:

> "These measures were so useful because, by referring each result to a well-defined range (.00-1.00 in the case of Rg), they yielded comparable figures for very diverse constellations, each having its own range defined in some way."

Error does arise, however, when the specified value of these measures are misused and made to answer the whole question.

Although this research did answer the questions asked of it, then, it in turn posed other questions which can be adequately answered only by further research and investigation.

One such question arises with regard to the type of behavior evoked under high powers of magnification (seven-power). The step between the two different powers of magnification was so large as to have passed by what might be the definite point at which the type of response represented in Figure III begins to occur. Therefore, an experiment employing a series of powers of magnification between two-power and ten-power is advised in the hope that this point or range might be established.

Also, this research might well have offered more of an explicit nature about the conceptualizations utilized by the several observers if adequate introspective reports had been required of the subjects.

It is felt that the incorporation of these two techniques in one further experiment would answer the further questions suggested by this research.

VI. SUMMARY

The chief concern of this research was twofold: the determination of the effect of an undifferentiated field upon the perception of certain specified types of objects, and also the determination of the effect of instrumental magnification upon the perception of the same objects in the same type of field.

Twenty-one subjects were used, all undergraduates of Michigan State College, and all of which were naive as to the nature of the experimentation and the experimental variables involved.

The apparatus was constructed in such a manner as to eliminate all extra-retinal cues which the subjects would ordinarily utilize in making the type of judgments demanded here. The target objects, themselves being the only visible feature in the total visual field, were coated with a fluorescent paint and presented under ultra-violet light from which all traces of visible, white light were removed, thus insuring a perfectly undifferentiated field.

The twelve targets, all differing from each other either in physical dimensions or angular orientation, were each presented in random order ten times under unaided conditions, and ten times under aided conditions two days later. Under both conditions the subjects represented their judgments by manipulating a tilt-board which gave electrical readings which in turn were recorded by the experimenter and later transposed into direct angular readings.

The resulting data were subjected to an analysis of variance and the significance of the various factors was determined as well as the significance of the various interactions between them. All these variables and their interaction terms were found to be significant beyond the one percent level of confidence.

In order that any verbalization concerning the experiment might be most explicit, three terms which were primarily involved in the research were operationally defined. They were the terms "cue", "stimulus", and "stimulus value".

In keeping with the purpose of the experimentation, it was determined that, regardless of just how the targets were adjudged to be oriented in the undifferentiated field in which they were exposed, the judgments were made in terms of a conceptual pattern contributed by the observer himself in lieu of any possibility of evaluations based on relationships existing either between the target object and any other objects in the visual field or between the target object and any other feature of the environment which would otherwise have provided collateral stimulus value.

Too, it was shown that, under the influence of instrumental magnification, judgments of angular orientation of plane surfaces in an undifferentiated field evidenced less size constancy, that is, suffered more regression (Thouless' Rg) than did objects of the same kind whose angular orientations were evaluated in an operationally normal manner.

A significant corollary of this fact indicated that with the introduction of a high degree of instrumental magnification the observer evidently suppresses the retinal pattern produced in this way and makes judgments of angular orientation more in keeping with what he knows to be the true physical dimensions of the stimulus object.

The approach used in this research was one which emphasized the active role of the perceiving organism. The point was maintained throughout the execution of this experiment that in perceptual situations of all kinds, the responses made by the observer are a function of more than the bare features of the visual field. And what other than these features are utilized in perception is a contribution of the perceiver.

By way of further clarifying the problems remaining in the area of size and shape constancy (considered here to be invariants of each other), the experimenter suggested further research involving critical introspective reports from observers in an effort to gain insight into the nature of rationalizations and conceptualizations employed by observers in their judgments made of objects in an undifferentiated field.

To further delineate that point at which a conceptual scheme does break down under higher powers of magnification, it was also suggested that experimentation using approximately the same primary features be carried out using successively higher powers of magnification extending from perhaps two-power to ten-power magnification.

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VIII. APPENDIX I

RAW SCORE TABULATIONS OF TARGET OBSERVATIONS UNDER NAKED AND AIDED EYE CONDITIONS

OBJECT NUMBER	DESCRIPTION	SUM OF AIDED	SUM OF UNAIDED	DIFFERENCE
1	3x5 @ 45°	22,777	23,353	576
2	4x5 @ 45°	21,605	22,537	932
3	5x5 @ 67½°	16,401	16,914	513
4	3x5 @ 22½°	24,141	25,232	1091
5	5x5 @ 22½°	24,813	25,347	534
6	5x5 @ 45°	20,392	21,152	760
7	4x5 @ 67½°	19,782	20,216	434
8	5x5 @ 90°	16,196	16,735	539
9	3x5 @ 67½°	21,238	22,397	1159
10	4x5 @ 90°	19,537	20,102	565
11	4x5 @ 22½°	24,166	24,957	791
12	3x5 @ 90°	20,583	21,378	795

	90	67.5	45	22.5	TOTALS
(3x5) -	795	1159	576	1091	3621
(4x5) -	565	434	932	791	2722
(5x5) -	539	513	760	534	2346
TOTALS	1899	2106	2268	2416	8689

TABLE I

ANALYSIS OF VARIANCE OF ROW DEGREES OF FREEDOM FOR DIFFERENCE BETWEEN 2X, 7X, AND UNAIDED VISION

SOURCE	D.F.	SUMS OF SQUARES	MEAN SQUARES	F	p
ROWS	41	26,986,526	-------	---	---
2X x 7X x UNAIDED	2	13,575,699	6,787,850	19.0	.05
WITHIN	39	13,410,827	343,867	---	---

TABLE II

COMPARISON OF PERFORMANCE OF AIDED AND UNAIDED SUBJECTS ON JUDGMENT OF TILT

	MEAN DIFFERENCE	SIGNIFICANCE OF DIFFERENCE	D.F.	t	p
UNAIDED VS. 2X	1033-799	61.22	394	3.83	.01
UNAIDED VS. 7X	1265-1033	67.37	358	3.44	.01
2X VS. 7X	1265-799	74.63	250	6.25	.01

TABLE III

ANALYSIS OF VARIANCE OF THE MEANS OF TEN TRIALS

FOR TILT DATA

SOURCES OF VARIANCE	D.F.	SUMS OF SQUARES	F VALUES	p
TOTAL	503	------	------	------
SUBJECTS	20	23,780,133	142.00	.01
AIDED VS. UNAIDED	1	149,634	17.87	.01
INTERACTION				
SUBJECTS AND AID. VS. UNAID.	20	3,056,759	18.25	.01
FIGURES	11	8,039,817	------	------
OBJECTS	2	1,098,172	65.58	.01
TILTS	3	5,437,043	216.47	.01
INTERACTION				
TILT VS. OBJECTS	6	1,504,602	30.00	.01
ERROR	451	3,775,689	------	------

TABLE IV

IX. APPENDIX II

Figure V. Overall physical features of experimental environment.

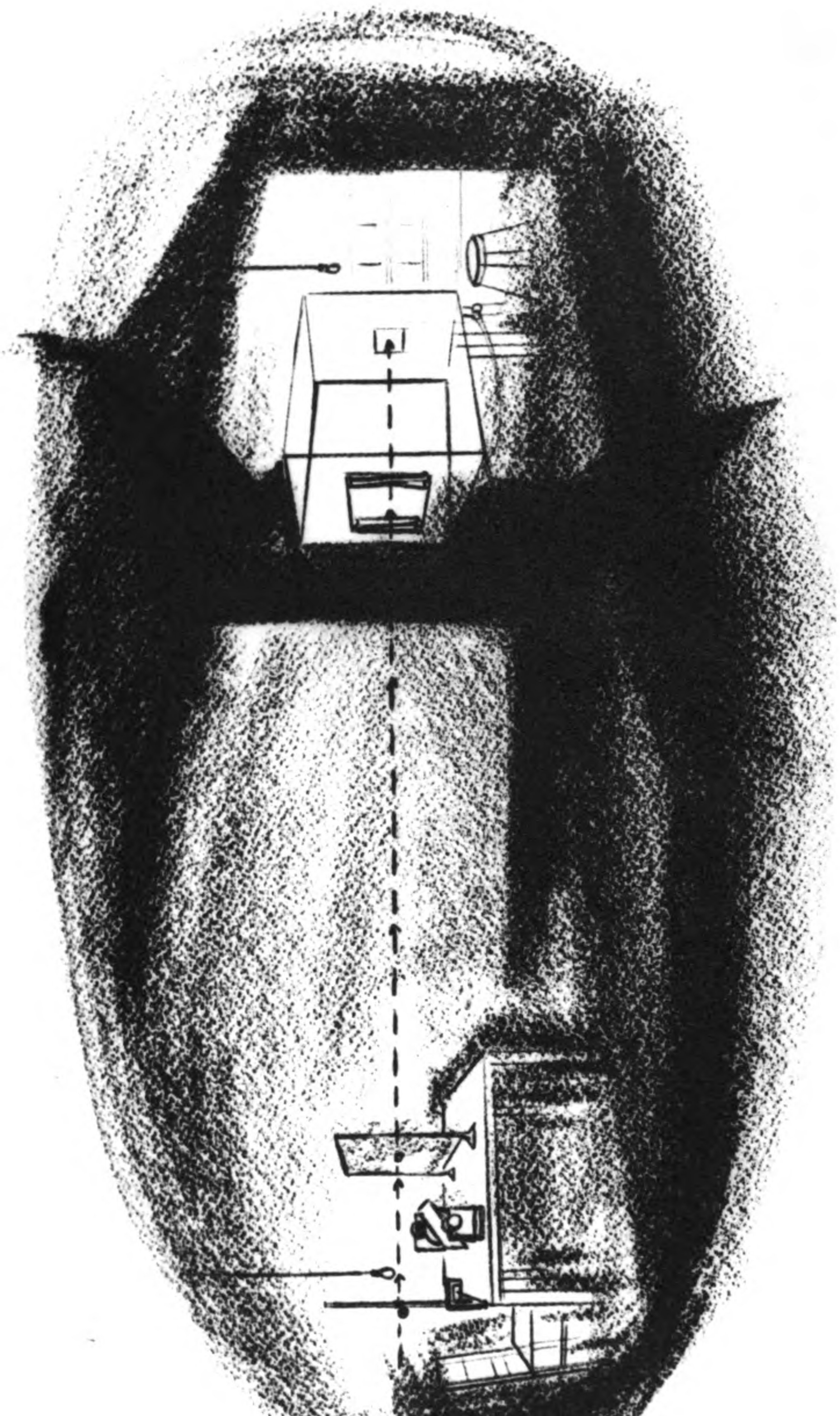


Figure VI. Physical features of observer's position.

A -- Holder for magnification equipment

B -- Reduction screen

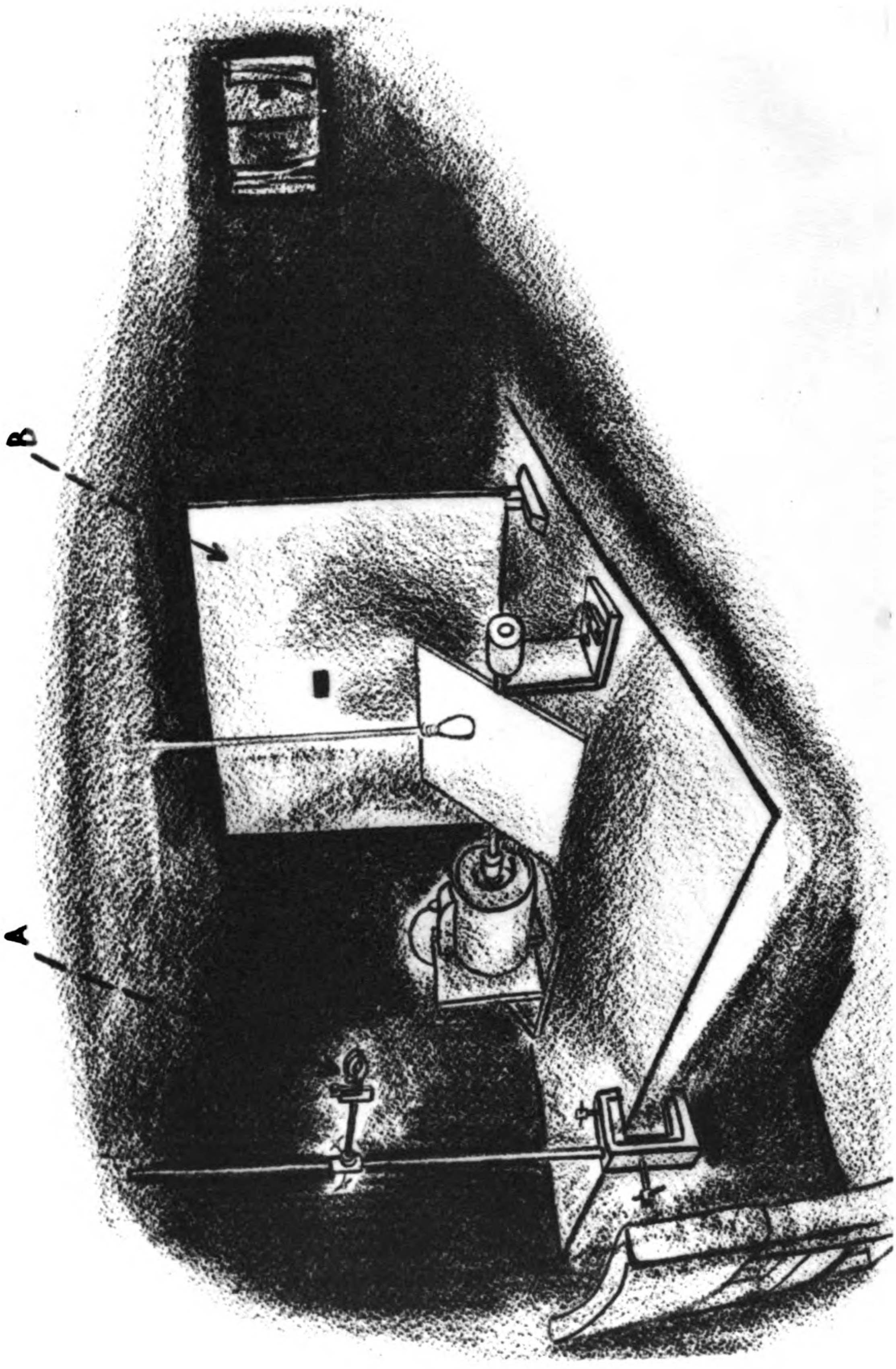

B
A

Figure VII. Close-up of tilt-board arrangement.

A -- Buzzer

B -- Control knob

C -- Tilt-board

D -- Variae

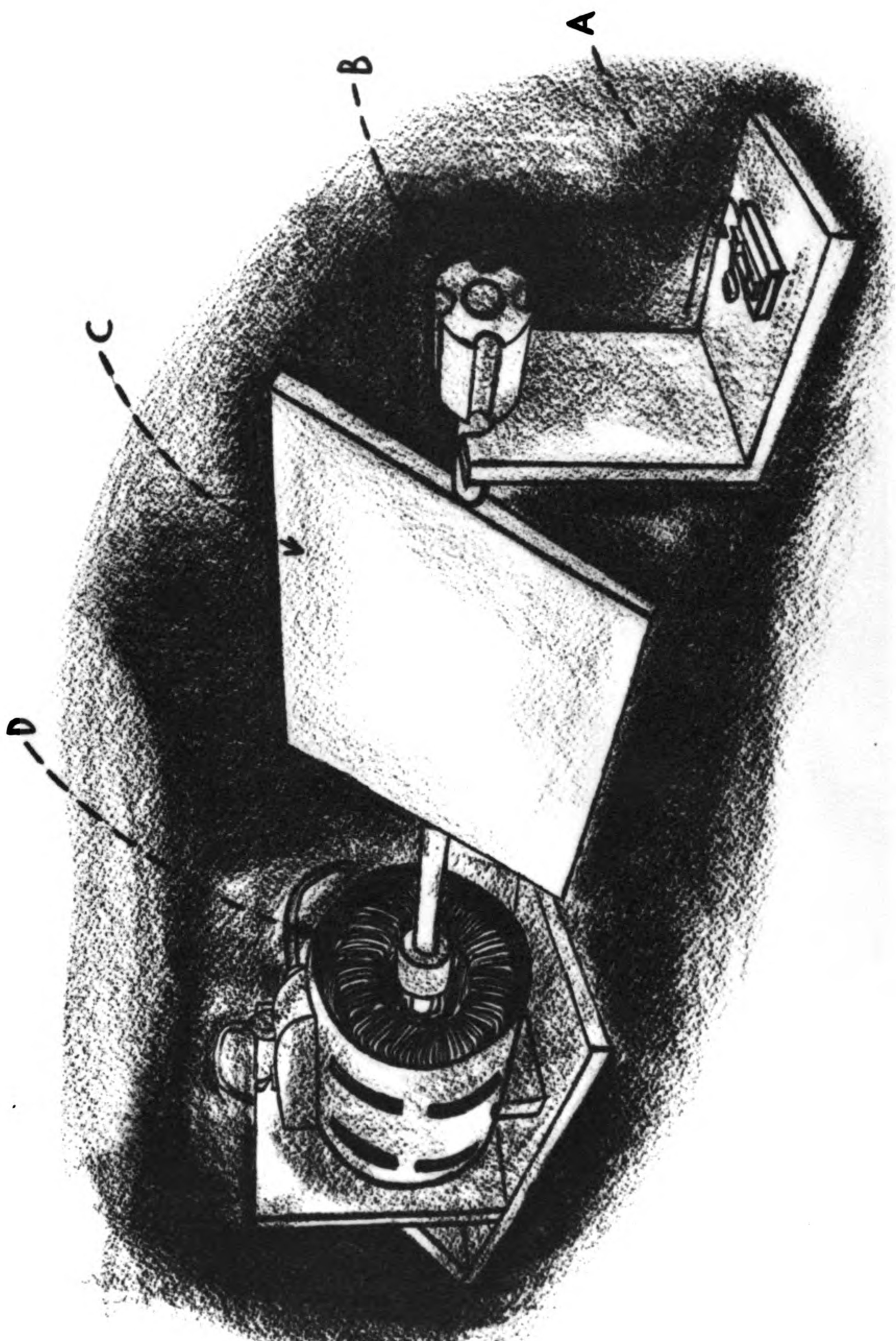

A
B
C
D

Figure VIII. Target construction.

A -- Wire target

B -- Mounting posts (invisible)

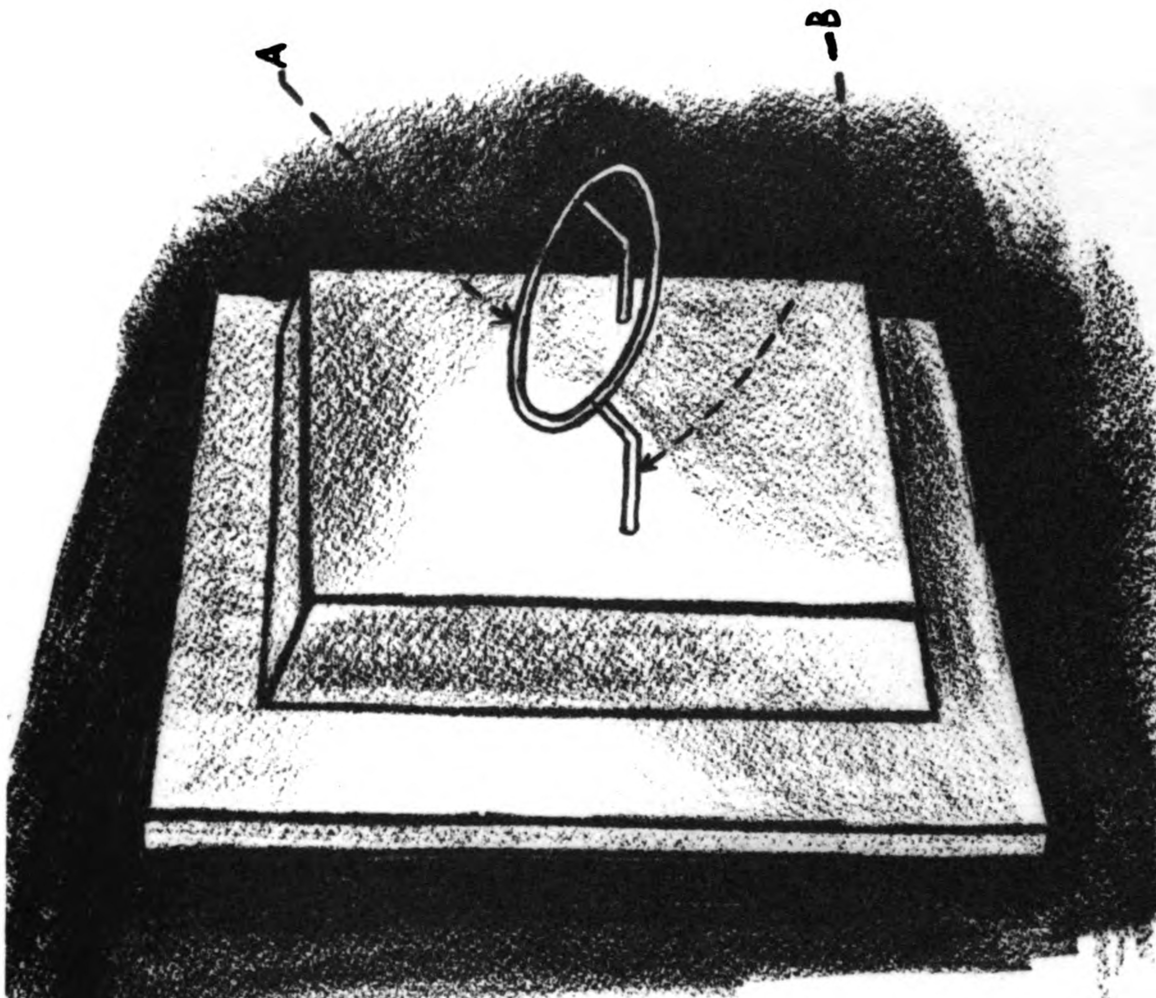
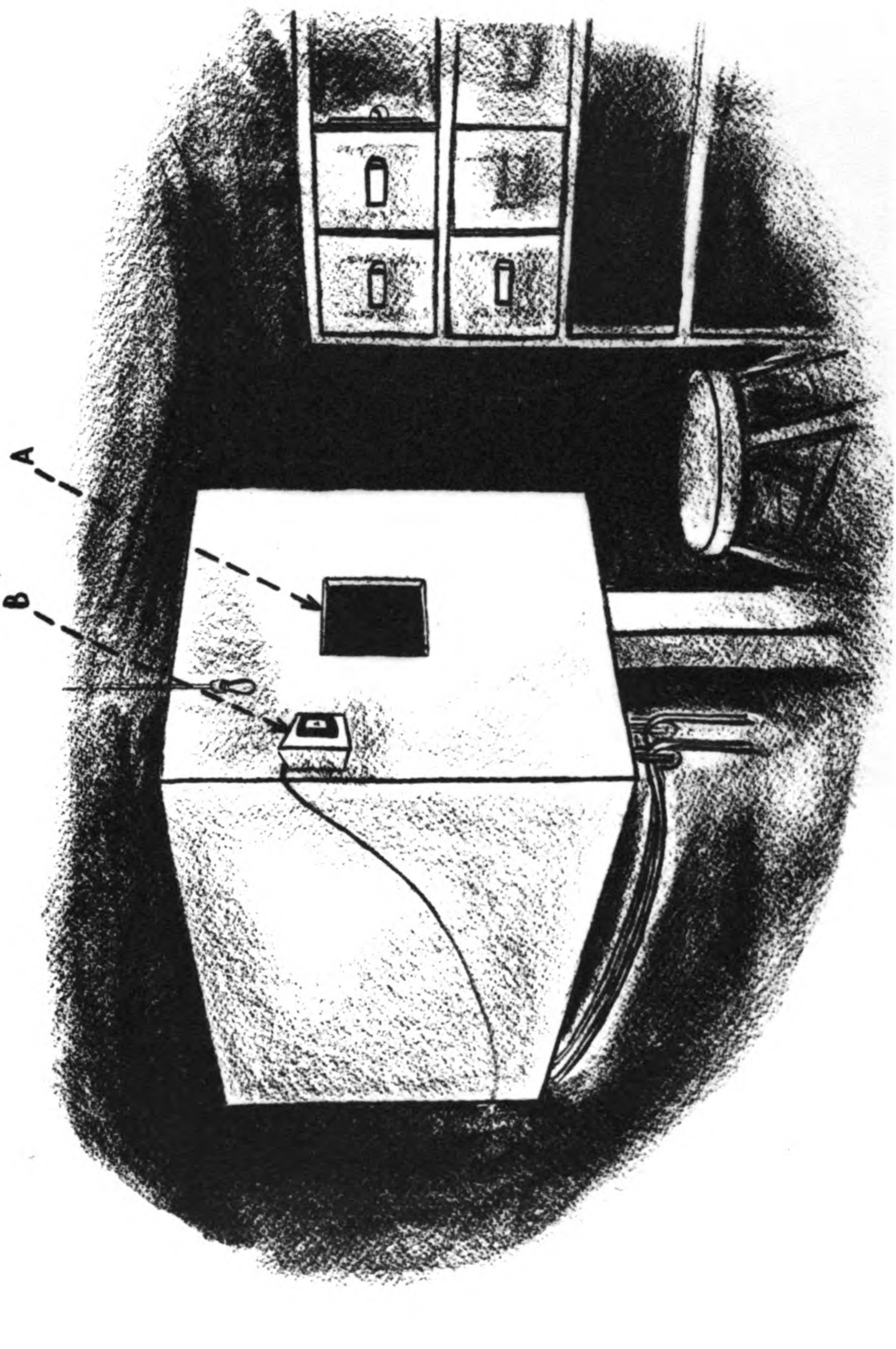

A
B

Figure IX. Experimenter's room and stage.

A -- Opening at rear of stage

B -- Volt-meter


A
B