# THE APPARENT ORIENTATION OF ONE FORM IN THE PRESENCE OF ANOTHER AS INDICATED BY THE OBSERVERS' DRAWINGS

Thesis for the Degree of M. A.

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Joseph Charles Stevens

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THESIS

This is to certify that the

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**The Apparent Orientation of One Form in the Pressure of Another as Indicated by the Observer's Drawings**

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Major professor

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THE APPARENT ORIENTATION OF ONE FORM IN THE PRESENCE OF ANOTHER AS INDICATED BY THE OBSERVERS' DRAWINGS

By

Joseph Charles Stevens

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
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Nelson has set up experimental conditions under which shape constancy fails and there is no normal regression toward a real object.[1] This was achieved by presenting ellipses painted with fluorescent material and lighted by an ultra-violet spot in an otherwise dark, undifferentiated field. The shapes of observers' drawings of such ellipses follow closely the shape of the stimulus object, i.e. the shape of the pattern which is formed on the retina according to the laws of geometrical projection. Theoretically geometric equivalence provides for seeing such ellipses either as tilted circles or as upright ellipses.

The present study was an attempt to discover some of the factors accounting for phenomenal regression toward a real object. It was hypothesized that by slightly structuring the visual field surrounding the ellipses but otherwise employing Nelson's experimental conditions, some regression would be found. This slight structuring consisted simply in the addition of another ellipse, placed directly below the original. Three types of perception involving regression as a consequence were hypothesized: 1, the experience of the objects as tilted; 2, the perceptual formation of cylinder-like objects; and 3, the perception of the ellipses as extended in a plane away from the observer.

Thirty-two observers - 16 men and 16 women - drew their perceptions of the top ellipse of five target combinations which

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1. Nelson, T.M., The perception of a form in a dark field as indicated by the observers' drawings. Unpublished master's thesis, Michigan State College, 1953.

consisted of ellipses of equal major axes and varying minor axes. Half of the subjects had previously indicated their perceptions of the targets by the use of a tiltboard. At the completion of the experimental session observers were asked for introspective reports of their perceptions.

In general observers either saw all the targets as tilted circles or as upright ellipses. Analysis of their drawings and their reports showed that the visual field had been structured to some extent, more regression having been derived than in Nelson's experiment. A large amount of "negative regression" was uncovered (also found by Nelson) which probably concealed the full amount of normal regression.

There were significant sex differences, men indicating the experience of tilt more frequently, and tending to show higher regression scores. The experimental order tilt-drawing also favored higher regression scores. Regression was seen to be high in some individual subjects. In general most regression was found when the real ratio of the minor to the major axis of the top ellipse was .6. Inter-subject variance was also high at this point. Regression was also highest in those subjects who reported seeing the objects as tilted, indicating that the introspective reports had some validity. It can be concluded that some of the ambiguity was removed from Nelson's experimental conditions just by the addition of another ellipse, and that this addition tends to increase phenomenal regression toward a real object.

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The author wishes to express his sincere thanks to Dr. S. Howard Bartley, under whose direction and inspiration this investigation was undertaken, and to whom whatever accomplishment herein contained is dedicated.

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TABLE OF CONTENTS


I. INTRODUCTION AND STATEMENT OF THE PROBLEM . . . Page 1

II. SUBJECTS . . . . . . . . . . . . . . . . . . . . Page 23

III. APPARATUS . . . . . . . . . . . . . . . . . . . Page 24

IV. PROCEDURE . . . . . . . . . . . . . . . . . . . Page 28

V. RESULTS . . . . . . . . . . . . . . . . . . . . Page 32

VI. SUMMARY . . . . . . . . . . . . . . . . . . . . Page 47

VII. BIBLIOGRAPHY . . . . . . . . . . . . . . . . . Page 48

## I. INTRODUCTION AND STATEMENT OF THE PROBLEM

The concept of constancy refers to the fact that "perceptual objects retain to a greater or lesser degree normal appearance in relative (though not in absolute) independence of the local stimulus conditions."[1] From one point of view the phenomenon of constancy is to be differentiated from an illusion. In the case of the latter the organism is responding to its environment as if certain conditions were extant in it which are in reality not there at all; in the case of constancy the organism is responding to conditions actually present in the environment as measured by methods more objective. In the case of the horizontal-vertical illusion, the organism responds as if the vertical axis were actually longer than the horizontal axis, whereas in the case of shape constancy the organism acts as if the perceived object is of a certain form and that object is of approximately that form when measured with ruler and compass.

The "normality" of behavior based upon the constancy principle should not deter one from seeking an honest explanation for it, or from seeing the problems involved in its operation. For, in the first place, it must be kept in mind that the pattern of sensory

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1. Warren, H.C. Dictionary of Psychology, Houghton Mifflin Co., Cambridge, 1934

stimulation, supplied on the retina in the case of visual perception, varies to a far greater extent for a particular object in different circumstances than does the experienced or phenomenological object. That is to say that the perceived shape or form of an object persists when from the point of view of geometric optics a change might be expected. Before proceeding with a further explanation of the mechanisms involved in constancy it might be advisable to set the scope of the concept, define its limits of operation, and formulate a framework within which the entire problem can be discussed.

As to its scope, then, there are primarily four types of constancy. Thus the persistence of normal hue and brightness under different illuminations is <u>color constancy</u>; the perceptual preservation of shape is <u>form constancy</u>; of magnitude, <u>size constancy</u>; and of weight, <u>weight constancy</u>. This thesis will treat only of <u>form constancy</u>, and will not assume that constancy is a feature of all perception nor that all types of constancy are of basically the same character.

Second, it must be said that there is a limit of range within which the constancy principle is seen to operate. There are conditions, not often found in the everyday environment of the organism, which do not lead to a constant perceptual product. Paradoxically, it may be that the study of the extra-constancy ranges, or the periphery of those ranges, may contribute materially to the explanation of the principle of constancy itself; the reader should keep in mind that it is this assumption that has underlain the entire undertaking of this present study.

Third, we must define a framework within which to discuss the phenomenon of constancy. This includes a general method and the exclusion of certain philosophical and extraneous psychological questions which almost always arise in the treatment of constancy. The question at hand is not the epistemological problem of the validity of the relationship between an object and a perceiving mind. That is, we are not here concerned with whether or not the "images" of perception reflect the "true" nature of things. Rather we are seeking operationally to compare perceptual objects as indicated by the perceiver's behavior with more objective measurements of the external object perceived.

Nor are we primarily concerned with the dispute between those who regard primary modes of perceptual response as native to the individual, or learned through empirical experience. It will be necessary, however, to distinguish between what is given, in a particular perceptual situation, from within the organism and from outside the organism. That is to say, purely visual perception of an object is a function of the relationship between organism-contributed factors and an environmentally given pattern of retinal stimulation. The organism-contributed factors are of two types: the native structure of the organism and past empirical experience, which in a sense has become part of the organismic structure. The present problem precludes argument concerning the extent of the native or of the empirical factors in the perceptual formation.

The distinction can be made concrete through the use of an experimental illustration cited by Bartley.[1] An observer is situated in a light-proof room and presented with playing cards illuminated by a spot light. When the distance of the playing card is varied from the observer, the latter nevertheless judges the size of the card as constant throughout. All that is given on the retina is a pattern of light; the identity of the size throughout is almost purely organism-contributed, for if, now, an enlarged playing card is presented, the organism does not perceive it as of greater size but rather as closer to him in distance as measured by a yardstick. In such a case, therefore, "constancy" is probably in the main a function of the past learning of the individual organism, though this is not to say that <u>all</u> cases of constancy are directly dependent upon past experience. The important thing to note is that a given perception involves more than merely the stimulation of retinal cells.

The illustration also demonstrates what Bartley calls the "ambiguity and equivalence of visual stimuli."[2] He has expressed this as follows:

> For example, a given object may be seen as one kind of geometric pattern -- a plane surface at right angles to the line of regard, or another shaped figure at some other angle of orientation to the eye. This lawful possibility of an object being variously perceived -- seen as one or another of several objects -- is based upon the fact that there are degrees of freedom in geometry. Viewed from the observer's standpoint

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1. Bartley, S.H. <u>Beginning Experimental Psychology</u>, McGraw-Hill Book Co., Inc., New York, 1950, pp. 142-143

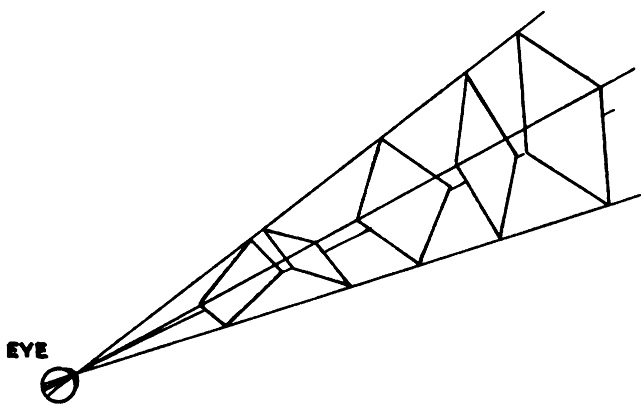
2. <u>Ibid.</u>, p. 140

some stimulation is ambiguous. This is not all. A host of differently shaped objects may be perceived as the same one. This, too, is an outcome of the geometry involved in the situation. That geometry provides for this may be spoken of as its equivalence.[1]

Thus we see that a given geometric pattern of stimulation on the retina can lead to a wide variety of perceptual response. More concretely, an unlimited number of plane objects can subtend the same visual angles at the eye. See figure I.

FIGURE I

THE PRINCIPLE OF GEOMETRIC EQUIVALENCE[2]




The only conclusion to be drawn from this fact is that a perceptual outcome is codetermined by both organism-contributed and extra-organism factors.

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1. Bartley, S.H., Loc. cit.

2. Ibid., p. 142

The primary issues arising out of this theory are how and to what extent perception becomes stable. That is, perception under ordinary circumstances does not exhibit the variety of outcome as geometric equivalence provides in the simple illustration recounted above. As a general rule it may be stated that as the visual field becomes more and more structured the perceptual outcome becomes more and more predictable in terms of this structure. The ways in which the visual field can be structured (and as it was done so in this experiment) will be taken up below, but since the habitus we have chosen excludes all but shape constancy it will first be necessary to review relevant experiments in that area to provide the necessary background and terminology for our specific problem.

Thouless has provided an equation for expressing the degree of shape constancy.[1] He presented subjects with white, inclined circular boards and asked them to draw the shape of these visual targets or to pick out from among a variety of ellipses the one which most closely represented the inclined circle confronting them.[2] It was found that the drawings representing the shape of the circle are not true circles nor ellipses determined by the laws of geometrical projection but rather are compromises between the form of the circle and the projected ellipse.[3] Thouless called the ratio of the minor axis to

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1. Thouless, R.H., Phenomenal regression to the real object, Brit. J. Psychol., 1931a 21, p. 344

2. Ibid., pp. 340-341

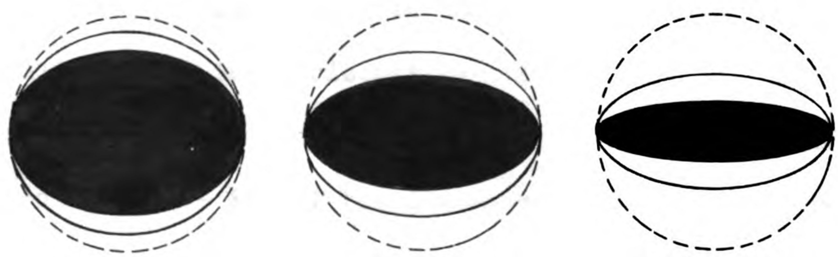
3. Ibid., p.342

the major axis of the object presented a measurement of the "real" or "commonsense" object; the "object" projected on the retina he called the "stimulus" object; and the drawn object or the chosen ellipse he called the "phenomenal" object.[1] These "objects" can be seen diagrammatically in figure II.

FIGURE II

THOULESS'S "OBJECTS"[2]

Broken line indicates physical shape of the object. Solid figure shows its perspective shape or the stimulus object. Continuous line shows reproduced or phenomenal object.



Thouless represented this tendency for the phenomenal object to be a compromise between the real object and the stimulus object as the "index of phenomenal regression."

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1. Thouless, R.H., Ibid., p. 344

2. Ibid., p. 342

Its equation form is:

$$\text{Index of Phenomenal Regression equals } \frac{\text{Log P} - \text{Log S}}{\text{Log R} - \text{Log S}}$$

(where P represents the phenomenal object, S, the stimulus object, and R, the real object, in each case the measurement being the ratio of the minor to the major axis.)[1]

It should be noticed here that Thouless also got some paradoxical results which may be called "negative regression" or "progression." He presented ellipses of various shapes whose angle of tilt with respect to the line of regard was zero. Drawings of these ellipses revealed a slightly smaller minor-major axis ratio than that of the real object.[2] Thouless believed that this phenomenon was in all probability due to the horizontal-vertical illusion. At any rate there is no reason to assume that the effect is not present -- though concealed — in all the instances where positive phenomenal regression is indicated. Thus though the index of phenomenological regression is significantly positive, it might be higher if the factors accounting for "negative regression" were absent. That "negative regression" takes place in the process of indicating responses is probable in view of the fact that the method of choosing ellipses from several prepared ellipses did not lead to

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1. Thouless, R.H., Ibid., p. 344

2. Ibid., p. 343

"negative regression."[1] Table 1 shows the amount of "negative regression" which Thouless's experiment indicated.

TABLE 1

NEGATIVE REGRESSION ACCORDING TO THOULESS[2]

| Minor-major axis ratio of real object | Tilt with respect to line of regard | Minor-major axis ratio of drawn object |
|---|---|---|
| 1.00 | 0 | .975 |
| .95 | 0 | .93 |
| .70 | 0 | .69 |
| .45 | 0 | .45 |
| .25 | 0 | .245 |

It will be seen from Table 1 that "negative regression" was small (though sometimes significant) and greatest at the extremes, i.e. when the stimulus approached a circle or a straight line. The theory that "negative regression" may be concealed by high positive regression is not so surprising when we consider the amount of phenomenal regression Thouless discovered with tilted circles. See Table 2.

1. Thouless, R. H. Loc. cit.

2. Loc. cit.

TABLE 2

EXAMPLE OF AMOUNT OF REGRESSION FROM REAL OBJECT (A CIRCLE 39.75 CM. IN DIAMETER) AT VARIOUS ANGLES FROM AN OBSERVER[1]

| Index of Phenomenal Regression | Angle A | Angle B | Angle C |
|---|---|---|---|
| | .57 | .465 | .445 |

Thouless also found that there were significant individual differences in connection with the amount of phenomenological regression. For example, women tend to show a lower degree of regression than men, i.e. women's "phenomenal responses" tend to be slightly closer to the stimulus objects. There is little relation between age and amount of regression, and likewise little (though statistically significant) difference between intelligence as measured by I-Q tests and amount of regression. The latter correlation is negative, indicating that those who tend to score lower on the I-Q tests also tend to be more constant in their perception.[2]

Thouless's results show that the retinal image alone is not responsible for all the characteristics of perception. Constancy would not be possible if the perceptual object did not differ from the projected image on the retina, for the same object viewed

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1. Bartley, S.H., Ibid., p. 170

2. Thouless, R.H., Individual differences in phenomenal regression, Brit. J. Psychol., 1932, 22, pp. 234-238

from various positions or at different angles of tilt gives approximately the same perceptual outcome.[1]

Sheehan believes that an important distinction must be drawn in this respect between identifying objects (from various angles) whose shapes are known from past experience and objects whose shapes are not known directly from past experience. For example, a table plate viewed from different angles is identified as of true circular shape, whereas a plain white disc appears elliptical. In the former case identity is complete; in the latter case, partial. Sheehan hypothesized that the perceptual process in the case of the plate goes on at a cortical level, in the case of the disc at a sub-cortical level.[2]

Nelson[3] and Haan[4] attempted to draw up experimental conditions under which the visual field surrounding the real object (always a circular or elliptical object) would be so undifferentiated that constancy would be nil, i.e. the index of phenomenological regression would be equal to or near zero. These conditions were achieved by presenting ellipses of various minor-major axis ratios

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1. Sheehan, M.R., A study of individual consistency in phenomenal constancy. Arch. Psychol., 1938, 222, pp. 7-8

2. Loc. cit.

3. Nelson, T.M., The perception of a form in a dark field as indicated by the observers' drawings. Unpublished master's thesis, Michigan State College, 1953

4. Haan, E.L., The perception of a form in an undifferentiated field as indicated by the observers' use of a tiltboard. Unpublished master's thesis, Michigan State College, 1953

and at various tilts in a light-proof room, where the total source of illumination was an ultraviolet light directed on the ellipses, which were constructed of bent twelve gauge wire coated with fluorescent paint. The exact specifications for these experiments can be found in Haan[1] or Nelson[2] or in part in a later portion of this paper.[3]

The success of this experimental situation in reducing regression to the zero point rested in the elimination of retinal cues which might account for constancy. Thus it was necessary to present targets from a point sufficiently distant from the observers to eliminate binocular and convergence cues. It was found that the distance used was sufficient to prevent any differences between those who were stimulated binocularly and those who were stimulated monocularly.[4] The use of ellipses instead of squares or rectangles eliminated "perspective" cues. The use of an elliptical ring, illuminated by ultraviolet light prevented all textural and shadow cues, *etc*. At any rate stimulation under these conditions led to complete elimination of normal regression when the drawing method was used to represent the phenomenal object. This was true no matter whether or not the object was tilted or upright, nearly circular or highly elliptical. In all cases the results followed a definite pattern: the phenomenological object was very close to the

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1. Haan, E.L., *Ibid*.
2. Nelson, T.M., *Ibid*.
3. See "Apparatus"
4. Nelson, T.M., *Ibid*.

stimulus object in shape.[1] This might well be expected since in view of the unstructured field surrounding the real objects, the real object would be geometrically equivalent to the stimulus object. That is to say, from the point of view of retinal stimulation the real objects could be tilted circles, or ellipses tilted at various angles or upright.

Nelson's work shows more clearly than ever the principle of geometric equivalence and ambiguity. Obviously perception in everyday life depends on the construction of the entire visual field. Even the temporal sequence involved in the presentation of several different shaped ellipses was not sufficient structuring of the visual field to lead to regression. Nelson and Haan's studies can be looked upon as accomplishments in the field of perceptual constancy from another point of view, for they have defined the conditions at which there is no constancy and made it possible for others to work upward from this point, to structure the visual field by degrees in order to discover the exact stimulus factors accounting for constancy. Thus by starting with Nelson and Haan's conditions it should be possible to structure the visual field gradually, hence reducing the direct contributions of the organism to perception and increasing the stimulus contribution. The experiment subsequently described is such an attempt to reduce ambiguity very slightly according to a set of hypotheses as to the nature of the effect of structuring of the visual field.

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1. Nelson, T.M., Ibid

It should not be overlooked that Nelson found the same phenomenon of "negative regression" that Thouless did, the amount of this anomalous regression being high in comparison with Thouless's figures. It may be that a highly undifferentiated visual field enhances this effect. See table 3.

TABLE 3

"NEGATIVE REGRESSION" USING THREE UNTILTED ELLIPSES[1]

| Ratio of minor to major axis of real object | Phenomenal object (Group A) (Means) | Phenomenal object (Group B) (Means) |
|---|---|---|
| 1.00 | 1.01 | .97 |
| .80 | .68 | .69 |
| .60 | .56 | .58 |

Nelson presented many more ellipses than indicated by Table 3. All the other ellipses were tilted; however, as already seen they may be considered equivalent to untilted ellipses, and using their projected dimensions as properties of the real object, it is found that there is a general pattern of "negative regression".

The results of Thouless's and Nelson's studies in regression using the drawing method of response and as they relate to the present inquiry may be summarized as follows:

1. Perceptual shape constancy reveals itself when ellipses are presented in a highly structured visual field, and this constancy, which is almost always partial, is best expressed in terms of the <u>index of phenomenal regression</u>.

2. The amount of this regression is a function of many factors, including distance from target; angle of tilt; sex, age, and intelligence of the observers.

3. There is a type of "negative regression" which may be present at all times and is probably a function of the drawing method of response.

4. Shape constancy fails in a highly unstructured visual field, in which case the phenomenal object follows the stimulus object closely.

5. Negative regression appears higher in an unstructured field than under normal circumstances of stimulation.

* * * *

It has already been stated that one mode of discovering the nature of constancy might be to examine the ranges at which constancy approaches zero, and by gradually differentiating the visual field uncover the stimulus factors associated with constancy. Paradoxically, a more complex field structure leads both to stabilization of the perceptual end product and at the same time to further ambiguity. In ordinary circumstances of everyday life, however, the field is generally so structured that either by way of learning or the native structure of the organism ambiguity is low and constancy high. It is only at the border lines between structure and amorphousness that one is likely to find the perceptual outcome varying greatly from observer to observer for the same target. The ways in which stability and ambiguity might be produced when the field is structured slightly are outlined below for a specific situation using Nelson and Haan's basic experimental conditions.

It may be hypothesized, first of all, that there are two primary types of structuring: 1. temporal structuring and 2. spatial structuring. The first type refers to the effect of the sequence in time of the presentation of objects possessing a common factor of similarity toward viewing them as identical with respect to that factor, there being a kind of generalization of similarity. In Nelson's experiment, for example, it might have been anticipated that the varying targets, all possessing the quality of ellipticity, might be identified through time in terms of circularity or near circularity by phenomenally varying their angles of tilt. This, however, was not the case, as was seen. A further type of temporal structuring is to have the observer operate a tiltboard (described below under apparatus[1]) before drawing ellipses. It was hypothesized that this type of structuring would provide for more regression.

Spatial structuring is more complicated. It was hypothesized that by adding another ellipse (located directly below the original, and having a major axis equal to that of the original, and a minor axis of equal or unequal size) to the experimental conditions produced by Nelson and Haan, three types of perceptual process might raise the regression scores for the original ellipse above zero. The three types of perceptual process would result in or follow from seeing the original ellipses as tilted circles, and would be caused by the addition of the bottom ellipse. It was stated above that slightly structuring an ambiguous field leads to both further ambiguity and further stability. This can now be better explained, for in terms of phenomenal regression all three types of perceptual end result would be expected to be the same — namely an increase in

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1. page 27

regression and the seeing of all tilted circles -- while in terms of the process mediating between the stimulus conditions and the drawn object -- there would be a high variety. The three types of spatial factors hypothesized, then, are: 1. simple generalization of similarity, 2. "object formation", and 3. texture effects. These hypotheses will be discussed seriatum as they bear upon the experiment described below.

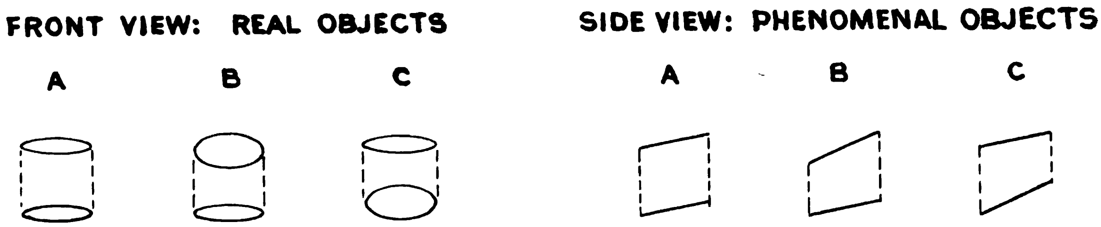
1. Simple generalization of similarity. It might be expected that the presentation of ellipses of different shape in the otherwise unstructured visual field would lead to equating them in terms of shape and seeing them different in terms of angle of tilt. Or to put it another way, similarity of shape and size may in some observers outweigh similarity in angle of tilt, leading to a greater amount of phenomenal regression. The common factor of ellipticity is generalized to such an extent that all objects are seen as tilted circles.

2. "Object formation." One ellipse presented above another can form, phenomenologically speaking, the top and bottom respectively of a cylinder. If the ellipses are of nearly equal size and shape the phenomenal cylinder would be regular and tilted slightly toward or away from the observer. If the ellipses are of unequal minor axes and equal major axes the cylinders would be expected to appear irregular, e.g., as truncated. See figure III.

Whether the object formation would be a function of a native tendency of the organism or of past learning is not here at stake; it is merely a question of whether or not such formation can take place and whether they might lead to increase of the regression scores.

FIGURE III

THEORETICAL OBJECT FORMATION




3. <u>Texture effect.</u> James Gibson has recently proposed a theory of depth perception which appears relevant to the present thesis. Gibson attempts to account for much of the phenomenon of depth perception in terms of the texture of the visual field, to be described below. The problem involved is that human beings experience three dimensions in the visual world while the pattern of light stimulation on the retina is in only two dimensions.[1] Gibson has pointed out that the visual field (i.e., pattern of light stimulation on the retina) in ordinary circumstances is characterized by an increase in density of light stimulation from the top of the retina down to a point corresponding to the horizon, or in the case of a "ceiling" extending away from the observer, an increase of density from the bottom of the retinal image upward toward a point corresponding to the horizon. These gradients of density become the partial basis for

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1. Gibson, J.J., <u>The Perception of the Visual World</u>. <u>The Riverside Press</u>, Cambridge, 1950, pp 77-116

the experience of the dimension extending away from the observer. This may be illustrated diagrammatically as in figures IV and V.

FIGURE IV

DISTANCE PERCEPTION OF THE "FLOOR"[1]
See accompanying text

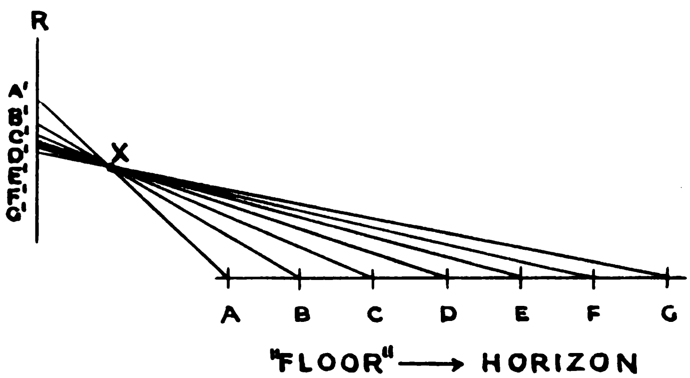
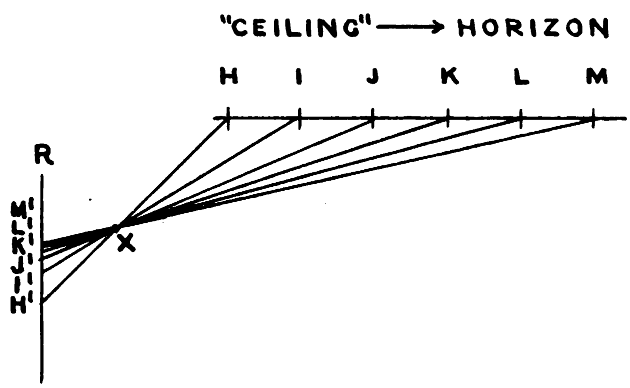



FIGURE V

DISTANCE PERCEPTION OF THE "CEILING"
See accompanying text




1. Gibson, J.J., Ibid., p. 82

The equal or near-equal distances marked off by points A, B, C, _etc._ and by points H, I, J, _etc._ in figures IV and V form a texture gradient on the retina (R) through focal point X. This gradient of density is thought of by Gibson as a possible cue for distance. Phenomenologically speaking, the observer "keeps" the distance between the points (A, B, C, _etc._) constant, the retinal density gradient becoming a distance cue.

The reader will note that the presentation of one ellipse above another in an otherwise unstructured field forms a kind of density gradient on the retina of the most simple type. It can be hypothesized, therefore, that if the major axes are kept equal, and the top ellipse has a smaller minor axis than the bottom one, the top ellipse may be seen as further away from the observer than the bottom; conversely that if the bottom ellipse had a smaller minor axis than the top, it would appear closer, or like a "ceiling" extending toward the observer. When the ellipses are of equal size discrepancy in experienced distances should be minimized. Of course, geometrical equivalence allows for distance discrepancy here, too, for stimulus objects located one above the other can be "interpreted" as one _above_ the other or one _behind_ the other, i.e., the top _further away_ from the observer than the bottom; but the omission of the density cue would be expected to reduce the experience of discrepancies in distances of the two targets.

If the observer would experience this effect and the experience is based in part upon the density cues, the phenomenal objects would have to be tilted circles, for there would be no density gradient if the "real" objects were not of equal or near-equal size, as reference to figures IV and V makes clear. That is to say, the observer "interprets" the density gradient on the retina as meaning similar objects extended away from him in space. Once more, the point at issue is not whether such a relationship between stimulation and perceptual outcome is native or learned, but merely that such a relationship may lead to constancy as indicated by drawings and the index of phenomenal regression. It may be hypothesized, of course, that experience of tilting would cause the texture-distance effect, and not _vice versa_. This may or may not be the case.

It should also be noted that the "distance discrepancy" effect would probably be minimized in any case by the identity of the size of the major axes of the top and bottom targets. If the top actually were further away, for example, its major axis would be "expected" by an observer to be smaller than that of the bottom ellipse, if the ellipses are to be completely equated by the observers for size. But the major axes are the same in the following experiment, a factor which would be expected to outweigh the textural-gradient effect in certain instances and minimize the experience of distance discrepancy.

From the foregoing account a set of definite hypotheses can be formulated:

1. that experience with the tiltboard[1] prior to drawing would increase the experience of seeing the ellipses tilted, even when drawings are used later to indicate shape;

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1. See "Apparatus"

2. that the addition of an ellipse directly below the original ellipse (otherwise using the Nelson-Haan stimulus conditions) might lead to:

   A. the seeing of tilt;
   B. the perceptual formation of three-dimensional objects like cylinders;
   C. the seeing of ellipsis as extended toward or away from the observer in space, i.e., as located at different distances away from the observer, possibly as lying on a plane extending away from the observer;

3. that regression be a result of or concommitant with (1) and (2) and that in view of the high ambiguity of the visual field this regression be small and not ubiquitous, though greater for the top object than in Nelson's experiment where only one ellipse was presented at one time.

## II. SUBJECTS

Thirty-two subjects were used in the experiment, one-half of whom were male, and half of whom were female. The writer presented the visual targets to the male subjects, another experimenter presenting them to the female subjects. The subjects varied from the age of 18 to the age of 25. All of the male subjects were undergraduate students at Michigan State College. The female subjects were, in the main, students' wives and undergraduate students. All subjects were considered experimentally naive, both as to the specific nature of this experiment and to the concept of and the methods of investigation in shape constancy.

## III. APPARATUS

The experiment was performed in two adjoining light-proof rooms. The rooms were connected by an aperture fourteen inches by twenty-eight inches located at an eye level to the subjects, who were seated at a table 13 feet, seven inches from this aperture. A plywood box, referred to by Nelson and Haan[1] as the "stage", which measured 46 inches long, 30 inches wide, and 35 inches high, was attached to the wall dividing the rooms, and surrounded the aperture. The rear panel of the stage contained two openings, each seven inches square, the bottom of one exactly one inch above the top of the other. The targets were placed into these openings for presentation. The distance from the observer's eye to the targets was, therefore, 17 feet, five inches, approximately.

A General Electric CH-4 ultraviolet lamp, including its accessory parts (screw base socket, transformer, and a special filter which eliminated the fractional percentage of white light emitted by the source), was mounted above the aperture and inside the stage. This lamp was beamed onto the target area. All surfaces inside of the stage except the targets themselves were painted flat black to absorb any white light from the ultra-violet lamp or reflected white light caused by any foreign matter present in the fluorescent paint

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1. Nelson, T.M., Ibid.

with which the targets were covered. The aperture was covered with a dark cloth curtain which the experimenter was able to part when the targets were presented or to close between presentations.

Five targets were presented to the subjects in five different combination pairs. The targets were formed of twelve gauge wire bent into the shape of ellipses, and described best in terms of the sizes of their major and minor axes. See table 4.

TABLE 4

DESCRIPTION OF TARGETS IN TERMS OF DIMENSIONS

| Target Number | Major axis in inches | Minor axis in inches | Ratio of minor to major axis |
|---|---|---|---|
| 1. | 5 | 2 | .4 |
| 2. | 5 | 2 | .4 |
| 3. | 5 | 4 | .8 |
| 4. | 5 | 1.5 | .3 |
| 5. | 5 | 3 | .6 |

TABLE 5

TARGET COMBINATIONS PRESENTED

| Target Situation | Combination of targets |
|---|---|
| A | $\frac{.4}{.8}$ |
| B | $\frac{.8}{.4}$ |
| C | $\frac{.3}{.6}$ |
| D | $\frac{.6}{.3}$ |
| E | $\frac{.4}{.4}$ |

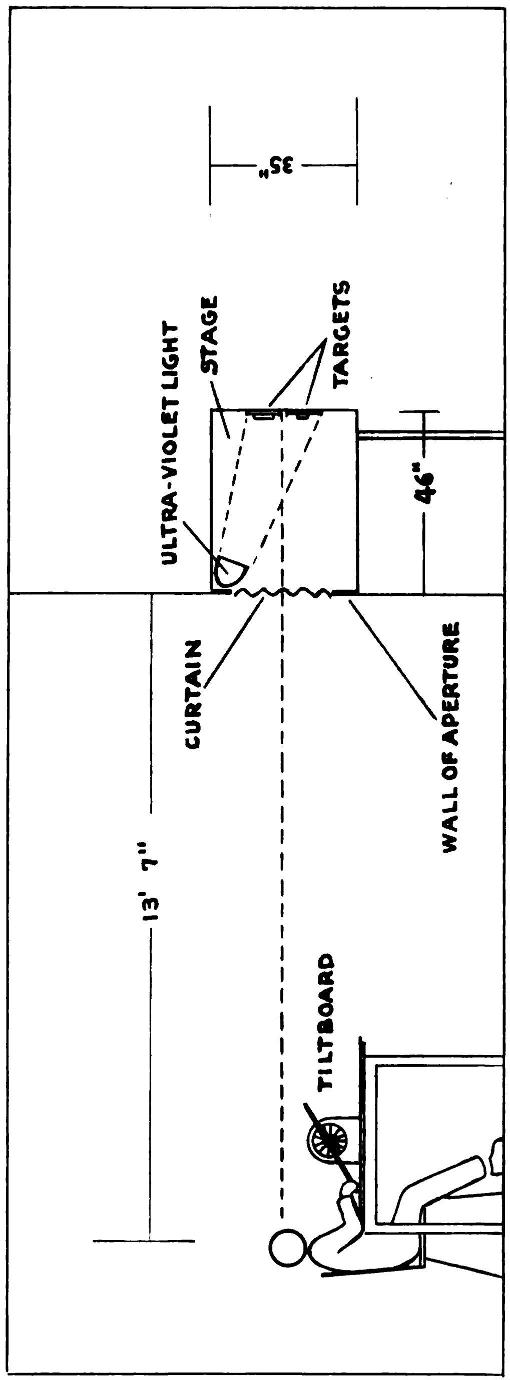


FIGURE FIVE-a DIAGRAM OF EXPERIMENTAL SITUATION

The targets were presented only in the combinations listed in table 5. In subsequent discussion of the experiment these letters alone will be used to represent the target situations.

All targets used were painted with commercial fluorescent paint and were mounted on seven-inch square plywood boards which excluded all light from outside the stage when fitted into the two rear-panel apertures to form the target situations. All the ellipses were mounted so that their major axes lay in a true horizontal plane and their minor axes in a true vertical plane with respect to the observer's line of vision. That is to say that none of the ellipses was actually tilted toward or away from the observers.

To indicate the subjects' representation of the plane at which he perceived the targets to lie, a tiltboard ten and 1/2 by seven inches was connected coaxially with a 120 volt Variac to represent the perceived angle of tilt of the targets. The exact specifications of this apparatus can be found in Haan[1] or Nelson.[2]

Above the observer a 25 watt red photographer's bulb was suspended to give the observer the necessary illumination for drawing and for operation of the tiltboard. A diagrammatic representation of the experimental situation can be seen in figure V-a.

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1. Haan, E.L., Ibid.

2. Nelson, T.M., Ibid.

## IV. PROCEDURE

One half of the male subjects and one half of the female subjects indicated their responses with the tiltboard first and by drawing later; the other subjects followed a reverse order. Table 6 shows the general experimental pattern.

TABLE 6

ORDER OF MODES OF PERCEPTUAL EXPRESSION
FOR THIRTY-TWO OBSERVERS

| Experimenter | Observer's sex | No. of subjects in tilt-drawing order | No. of subjects in drawing-tilt order | |
|---|---|---|---|---|
| I | male | 8 | 8 | |
| II | female | 8 | 8 | |
| | Totals | 16 | 16 | 32 |

When the order was drawing-tilt, the subject was presented at the beginning of the experimental situation with the following instructions, which were read by the experimenter:

> I am going to present to you certain targets which you are to look at. Each time I present a target, as soon as I pull the curtain open, look at the target and draw on this paper the <u>top</u> figure of the target. After making a drawing with which you are satisfied as being representative of the <u>top</u> figure, signal

> on this key that you are through and I'll present the next target.[1] Take one paper at a time. Make one drawing on each paper. Make a pile so that the papers are in the order that you draw the targets. After each drawing put the number of that drawing in the upper right hand corner of the paper. After each five drawings buzz twice. If you make a mistake in a drawing throw that sheet on the floor and start over on a new sheet.

At the completion of the drawing session the experimenter read the following directions to the subject:

> This time there will be no drawings. Adjust this handle in such a way that the attached board will express your sensation about the top figure. Buzz when you are finished with each adjustment. Buzz twice after every fifth adjustment.

When the order of presentation was tilt-drawing the experimenter read the following instructions:

> I am going to present to you certain targets which you are to look at. Each time I present a target, as soon as I pull the curtain open, look at the target and adjust this handle in such a way that the attached board will express your sensation about the top figure of the target. Buzz when you are finished with each adjustment. Buzz twice after every fifth adjustment.

Following the tiltboard session the subjects were given drawing instructions identical to those given to the subjects who followed the drawing-tiltboard sequence. If an observer was confused concerning the instructions, the experimenter attempted to clarify them, but in every case was very cautious not to give any indication of the true nature of the stimulus nor to reveal the actual rationale of the experiment.

After all the target situations had been presented to a subject, he was presented with the following questions and asked to clarify

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1. This key was connected with an electric buzzer which could be heard by the experimenter and the subject

and elaborate upon his answers. The experimenters made every attempt not to bias the observer's answers:

1. How far away did the top target appear to you?
2. How far away did the bottom target appear to you?
3. How far away were both targets when you think of them as composing one target?
4. Did it, or did it not, appear to you that one target, in a given situation, was closer or farther away than the other target?
5. Did you, or did you not, see any difference in the size of the two targets in any given situation?
6. Did you, or did you not, have the experience of both targets in a given presentation forming an object of some kind?

Questions one through four were attempts to ascertain whether or not the subjects saw one target as more distant than another in any of the target situations. Question five was formulated to find out whether or not a subject perceived "object formation," between the two targets presented. Subjects were encouraged to report any sensations or perception they had had during the observational session, and these reports as well as the answers to the questions were recorded.

Each target situation was presented twenty times to each subject, ten times in the drawing phase and ten times in the tiltboard phase. Since there were five target situations, this makes a total of one hundred presentations for each subject. The order of presentation of the targets was exactly the same in the tiltboard session as it was in the drawing board session. The order within each series of five situations was random to prevent anticipation of the target.

During the drawing session the tiltboard was kept out of sight to prevent any suggestion of the stimulus nature from that source.

Sheets of plain white paper 5 and 1/2 inches by 8 and 1/2 inches were accessible to the subjects to record their perceptions during the drawing session.

TABLE 7

ORDER OF TARGET PRESENTATIONS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | E | 6. | D | 11. | B | 16. | E | 21. | D |
| 2. | B | 7. | E | 12. | A | 17. | C | 22. | A |
| 3. | A | 8. | B | 13. | C | 18. | A | 23. | C |
| 4. | C | 9. | C | 14. | E | 19. | B | 24. | E |
| 5. | D | 10. | A | 15. | D | 20. | D | 25. | B |
| 26. | B | 31. | A | 36. | C | 41. | E | 46. | C |
| 27. | A | 32. | E | 37. | A | 42. | A | 47. | E |
| 28. | D | 33. | B | 38. | D | 43. | D | 48. | B |
| 29. | E | 34. | D | 39. | B | 44. | C | 49. | A |
| 30. | C | 35. | C | 40. | E | 45. | B | 50. | D |

After the presentation of a given target situation the curtain covering the aperture was closed while the experimenter changed the target situation. The sound of the buzzer was the experimenter's cue to close the curtain, no time limit being imposed upon the subject.

The major and minor axes of all the drawings were measured by the experimenters and the ratio of the minor axis to the major axis calculated.

## V. RESULTS

Since discovering how an observer perceived a target combination is dependent in part upon his introspective reports at the end of the experimental session, the results based upon those reports cannot be expected to reflect more accuracy and inclusiveness than the observers' memory and honesty allow. Subjects were in the main able to recall the general pattern of their experiences but often failed to give detailed accounts corresponding to the specific target combinations which had been presented to them.

Out of a total of 32 observers only two women reported experiencing the objects as tilted circles (always or frequently) whereas eight men reported the experience always or frequently. This difference is significant, using the Chi Square statistic (and employing Yate's method of correction) above the one per cent level of confidence. The difference is similar to the one Thouless found, the women's perception following the true character of the real object more closely than the men's. It is difficult to assay, however, whether or not this difference may be due, in part at least, to the fact that all the men were college students and part of the women observers not.

In general a subject saw tilt all the way through the experimental session or not at all. There were, however, a few instances in which observers reported seeing only some of the objects tilted or of changing their perception during the course of the experiment from tilt to non-tilt and <u>vice versa</u>. The fact that the majority of the subjects did not see the objects as tilted indicates that the field was not so structured as to remove a great degree of ambiguity.

Out of the 32 subjects four men and six women reported seeing distance discrepancies sometimes or always between the two targets of a given combination as over against those who reported seeing it never or very infrequently. Several subjects reported that they saw the effect only when the top target had a smaller minor axis than the bottom target, the top target appearing as further away than the bottom. Some observers, correspondingly, reported that the top target appeared closer when its minor axis was longer than that of the bottom target. No observer reported that he saw the top target closer when its minor axis was shorter or the bottom target more distant when its minor axis was longer. The distance discrepancy effect seemed to be least when the top and bottom targets were identical. All these facts are in line with the "texture" theory outlined above. Moreover, the effect is small and not ubiquitous as predicted.

Six men and two women always or almost always experienced the formation of cylinder-like objects between the two targets. Using the Chi Square statistic and Yate's correction factor this difference is significant above the one per cent level of confidence and suggests a correlation between sex and experience of object formation. Some of the subjects were able to recall and express the exact appearance of the phenomenal cylinder, e.g., in which direction it was tilted and how it was truncated for a given target combination. In general similarity of size and shape of the two targets favored this kind of phenomenal object formation.

As might be expected, there are significant relationships between the reports of seeing the objects tilted and seeing them forming objects and between experiencing tilt and seeing distance discrepancy. These relationships are significant at the one per cent and two per cent levels of confidence respectively, using Chi Square. This corresponds to the hypothesis that the experience of seeing the targets tilted is related to the seeing of distance discrepancies or the formation of objects. It may also be that in the very rare cases where subjects reported experiencing distance discrepancy or object formation and did not report seeing tilt, they were not explicitly "aware" of tilt but were nevertheless reacting unconsciously as if the targets were tilted.

All the remaining statistical comparisons are in terms of measurements of the drawings of the top targets made by the observers. The minor and major axes of each drawing were measured and the ratio of the former to the latter taken as a measure of the phenomenal object. Since each target combination was presented ten times, the average ratio of each set of ten ratios was taken as the phenomenal object for a given observer and a given target. Table 8 shows the mean reading for each target and each subject.

TABLE 8

MEANS OF TEN READINGS FOR THIRTY-TWO SUBJECTS AND FIVE TARGETS

| Target No. | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratios | .4/.8 | .8/.4 | .3/.6 | .6/.3 | .4/.4 |
| Subject No. | | | | | |
| 1. | .402 | .765 | .329 | .652 | .418 |
| 2. | .336 | .728 | .270 | .610 | .370 |
| 3. | .368 | .996 | .310 | .820 | .385 |
| 4. | .416 | .745 | .358 | .689 | .408 |
| 5. | .276 | .705 | .218 | .646 | .280 |
| 6. | .336 | .681 | .258 | .555 | .357 |
| 7. | .349 | .768 | .294 | .608 | .326 |
| 8. | .355 | .806 | .328 | .739 | .372 |
| 9. | .403 | .717 | .303 | .601 | .360 |
| 10. | .336 | .717 | .315 | .587 | .339 |
| 11. | .300 | .713 | .256 | .720 | .259 |
| 12. | .299 | .727 | .267 | .717 | .307 |
| 13. | .309 | .694 | .267 | .618 | .316 |
| 14. | .336 | .597 | .267 | .496 | .321 |
| 15. | .285 | .659 | .267 | .571 | .303 |
| 16. | .254 | .626 | .236 | .547 | .267 |
| 17. | .319 | .842 | .302 | .733 | .340 |
| 18. | .382 | .749 | .286 | .674 | .309 |
| 19. | .320 | .677 | .280 | .571 | .336 |
| 20. | .317 | .737 | .301 | .646 | .310 |
| 21. | .348 | .744 | .284 | .638 | .335 |
| 22. | .330 | .762 | .271 | .688 | .321 |
| 23. | .310 | .605 | .263 | .495 | .313 |
| 24. | .412 | .812 | .370 | .728 | .417 |
| 25. | .258 | .646 | .249 | .480 | .256 |
| 26. | .382 | .754 | .304 | .630 | .380 |
| 27. | .309 | .628 | .306 | .551 | .338 |
| 28. | .328 | .872 | .260 | .656 | .320 |
| 29. | .347 | .659 | .345 | .564 | .386 |
| 30. | .303 | .768 | .272 | .655 | .309 |
| 31. | .245 | .656 | .227 | .507 | .285 |
| 32. | .340 | .699 | .326 | .614 | .351 |

Table 8 is provided to give the reader a concrete picture of the general patterns of perceptual response. Subjects one through eight were male observers following the experimental order tilt-drawing; subjects nine through sixteen were male observers following the opposite order, while subjects 17 through 32 were female observers, the first half of whom followed the order tilt-drawing.

The mean of the mean ratios in table 8 can be seen below in table 9. This table shows that there is a significant amount of "negative regression" on target combinations A, B, and E at the one per cent level of confidence. This is not surprising in view of the fact that Nelson found a correspondingly high amount of it when one target alone was presented. On target D where the ratio of the minor to the major axis of the top target was .6, there is a tendency toward positive regression. However, this difference is not significant at any high level of confidence. It should be kept in mind that any phenomenal ratio which is significantly higher than a real ratio represents regression. It should also be remembered that all the way through this experiment the real object ratio may be taken as equal to the stimulus object ratio. Regression, then, is marked by any phenomenal ratio greater than the real ratio or the stimulus ratio, and "negative regression" any phenomenal ratio less than the real or stimulus ratio.

When the average of the means for all the targets are taken for the men's drawing ratios as over against the women's scores, approximately the same differences are seen as when all measures are combined. The men's measurements generally show slightly more positive regression on target D and slightly less negative regression than the women on the other targets. This difference is small, however, and not significant. The direction of difference, however, is in line with Thouless's sex differences as well as the differences shown above using the Chi Square statistic.

TABLE 9

AVERAGE OF MEANS OF ALL DRAWING RATIOS FOR 32 SUBJECTS COMPARED WITH REAL RATIOS

| Target No. | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratios of top target | .4 | .8 | .3 | .6 | .4 |
| Average phenomenal ratio | .3319 | .7265 | .2872 | .6250 | .3342 |
| Standard error of the mean | .0079 | .0146 | .0143 | .0143 | .0073 |
| Phenomenal ratio minus real ratio | -.0781 | -.0835 | -.0128 | .0250 | -.0073 |
| t ratio testing null hypothesis | 9.89 | 5.72 | $< 1$ | 1.75 | 9.01 |

TABLE 10

MEN COMPARED WITH WOMEN ON ALL TARGETS

| Targets | A | B | C | D | E |
|---|---|---|---|---|---|
| Male | .3350 | .7274 | .2839 | .6360 | .3368 |
| Female | .3286 | .7256 | .2904 | .6140 | .3316 |
| Difference | .0064 | .0018 | .0065 | .0220 | .0052 |

When the measurements are divided according to the order of the observers in the experimental session, namely those who operated the tiltboard first and drew the objects second and vice versa, some interesting differences appear.

TABLE 11

AVERAGE OF MEANS FOR ALL SUBJECTS WHOSE ORDER WAS TILT-DRAWING. COMPARISON WITH REAL RATIO OF TOP TARGET

| Targets | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratios of top target | .4 | .8 | .3 | .6 | .4 |
| Average phenomenal ratio | .3485 | .7576 | .2912 | .6558 | .3498 |
| Standard error of mean | .0098 | .0214 | .0094 | .0200 | .0104 |
| Phenomenal ratio minus real ratio | -.0615 | -.0424 | -.0088 | .0558 | -.0502 |
| t ratio testing null hypothesis | 6.28 | --- | --- | 2.79 | 4.83 |

TABLE 12

AVERAGE OF MEANS FOR ALL SUBJECTS WHOSE ORDER WAS DRAWING-TILT. COMPARISON WITH REAL RATIO OF TOP TARGET

| Targets | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratios of top target | .4 | .8 | .3 | .6 | .4 |
| Average phenomenal ratio | .3152 | .6954 | .2792 | .5942 | .3186 |
| Standard error of mean | .0130 | .0168 | .0084 | .0180 | .0100 |
| Phenomenal ratio minus real ratio | -.0848 | -.1046 | -.0208 | -.0056 | -.0814 |
| t ratio testing null hypothesis | 6.52 | 6.23 | 2.48 | --- | 8.14 |

TABLE 13

COMPARISON OF TILT-DRAWING ORDER WITH DRAWING-TILT ORDER

| Targets | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratios of top target | .4 | .8 | .3 | .6 | .4 |
| Tilt-Drawing order | .3485 | .7576 | .2912 | .6558 | .3498 |
| Drawing-Tilt order | .3152 | .6954 | .2792 | .5942 | .3186 |
| Difference | .0333 | .0822 | .0120 | .0616 | .0312 |
| Standard error of dif. | .0613 | .0272 | .0126 | .0269 | .0142 |
| t ratio testing null hypothesis | 2.04 | 3.02 | <1 | 2.29 | 2.13 |

Tables 11, 12 and 13 show that the tilt-drawing order favors regression. Table 11 shows that there is a significant amount of regression on Target combination D. Using Thouless's formula for the index of phenomenal regression, the average absolute degree of regression for subjects in the order tilt-drawing is .174. Targets A and E show a significant amount of "negative regression" for that order. Table 12 indicates that the order drawing-tilt does not favor regression, Targets A, B, and E showing "negative regression" at the one per cent level of confidence and Target C "negative regression" at the five per cent level of confidence. Table 13 shows that the order tilt-drawing yields higher phenomenal ratios on all targets except Target C. The difference in the case of Target B is significant at the one per cent level of confidence, while in the case of Targets A, D, and E, the differences are significant at or above the five per cent level of confidence. These data indicate that the visual field is structured to some degree by the use of the tiltboard before drawing. It will be noticed by the reader, however, that no subject was ever told that the objects were tilted. Many subjects who used the tiltboard did not report seeing the objects as tilted. On the contrary several of the subjects reported tilting the board in order to show the <u>size</u> of the top target and not its angle of inclination.

At first glance the differences corresponding to the orders of perceptual expression on Targets A, B, and E may appear anomalous. The question arises, why does the group whose order is tilt-drawing show a significantly higher mean phenomenal ratio for those targets than that of the group following the other order, yet does not show significant regression when compared with the real stimulus ratio? In all probability this is because of the concealed influence of "negative regression" spoken of above. This leads to a serious methodological problem. For the high "negative regression" is very likely concealing some positive regression for Targets A, B, and E, where the order is tilt-drawing. There is, however, no other way of testing this assumption using the data collected. Certainly this points to a need of studying the phenomenon of negative regression. The hypothesis that the horizontal-vertical illusion underlies it is ingenuous at best. This author's opinion is that it is probably due to a motor factor, since it seems easier to <u>draw</u> in a horizontal direction than in a vertical direction.

Because of the differences apparently due to experimental order and the slight differences due to sex, it was deemed necessary to explore the possibility that the combined variables may provide greater differences.

Women in the order tilt-drawing showed no positive regression on any target combinations except a small insignificant amount on Target D. There was significant "negative regression" on target combinations A and E, at the one per cent level of confidence. Men in the order drawing-tilt and women in the order drawing-tilt both showed no positive regression and much "negative regression" on several targets. Men in the order tilt-drawing, however, showed signs of regression (at about the five per cent level of confidence) on Target D. The average amount of regression using Thouless's formula was .201.

There were no significant differences between men in the order tilt-drawing and women in the same order. The slight differences were always in favor of the male observers, however. Nor were there any significant differences between female subjects whose experimental order was drawing-tilt and male subjects whose order was the same, the differences not even taking any particular directionality. Men in the order tilt-drawing showed a significantly (at the five per cent level of confidence) higher average ratio for Targets A and D than did women in the order drawing-tilt. There were no significant differences between men in the order drawing-tilt and women in the order tilt-drawing, but the latter conditions showed a directionality in favor of higher scores for the women. These comparisons suggest that the experimental order is a more important factor than the sex of the observer, though there was a trend for men to show higher regression scores than women. This is doubtless to be expected in line with the above significant Chi Square ratios.

It must be kept in mind that one can be sure of regression only when the ratio of the minor to the major axis of the phenomenal object is greater than that of the real or the stimulus object. This was seen to be the case only with Target D and only then under specific circumstances. However, if the theory that "negative regression" factors can conceal true "positive" regression, the comparisons between sex and order can be taken as indicating regression even when in terms of "absolute" regression from the stimulus object toward a circle none is apparent, or to put it another way, even when the phenomenal ratio is not significantly higher than the stimulus ratio.

In terms of individual observers' phenomenal ratios there are many instances of significant regression at high levels of confidence both in a negative and in a positive direction. Positive regression was especially frequent on Target D, 13 of the subjects having a statistically higher (in most cases at the one per cent level of confidence) phenomenal mean ratio than the stimulus ratio of the top target. The stimulus ratio of the top target of Target combination D was .6. Where the stimulus ratio corresponding to the top target was .4 (Targets A and E) there were <u>no</u> instances of individual positive regression. Where this ratio was .8 (Target combination B), there were only two instances of regression, and when it was .3 (Target C) there were five instances of regression. This data together with that where the measures are combined indicate that regression is greatest when the stimulus ratio is .6 and least at extremes away from it until the ratio is down to .3 where there is slightly more. In view of the fact that Nelson found no instances of regression at all, this indicates that the visual field has been sufficiently structured by the addition of one ellipse to cause it. This regression is probably due mainly to the previous experience with the tiltboard, but not exclusively since seven of the instances of significant individual regression out of a total of twenty instances were those corresponding to the order drawing-tilt.

A direct comparison between phenomenal ratios corresponding to Target combinations A and E, where the stimulus ratios of the top target were identical but of the bottom target different, shows very small differences, all the way through. This is not to be interpreted necessarily as implying that the bottom targets therefore had no influence in the perception of the top targets, for whatever influence they may have exerted was probably in the same direction.

A comparison of inter-subject variance corresponding to the five Target combinations shows that variance was generally highest when the real ratio of the top target was high and lowest when the real ratio of the top target was low. In other words, there was more inter-subject "agreement" when the real or stimulus ratio was lower. These differences are generally significant, even when broken down according to sex and order, using Fischer's F test for the reliability of differences in variance.

When the measures of those who reported experiencing tilt always or almost always are compared with those of the observers who reported never or very infrequently experiencing tilt, some interesting relationships appear. See tables 14 and 15.

TABLE 14

REGRESSION IN SUBJECTS REPORTING EXPERIENCE OF TILT

| Target | A | B | C | D | E |
|---|---|---|---|---|---|
| Real ratio | .4 | .8 | .3 | .6 | .4 |
| Average phenomenal ratio | .3444 | .7745 | .2945 | .6788 | .3494 |
| Standard error | .0129 | .0324 | .0114 | .0239 | .0164 |
| Phenomenal ratio minus real ratio | -.0556 | -.0255 | -.0055 | .0788 | -.0506 |
| t ratio testing null hypothesis | 4.31 | --- | --- | 3.29 | 3.09 |

TABLE 15

REGRESSION IN SUBJECTS REPORTING NO EXPERIENCE OF TILT

| Target | A | B | C | D | E |
|---|---|---|---|---|---|
| Real Ratio | .4 | .8 | .3 | .6 | .4 |
| Average phenomenal ratio | .3263 | .7050 | .2838 | .6008 | .3293 |
| Standard error | .0096 | .0140 | .0075 | .0155 | .0081 |
| Phenomenal ratio minus real ratio | -.0737 | -.0950 | -.0162 | .0008 | -.0727 |
| t ratio testing null hypothesis | 7.68 | 6.79 | 2.16 | --- | 8.98 |

The average of the means of the drawing ratios of those who reported experiencing tilt was in the case of Target combination D significantly higher than the ratio of the stimulus or real object. In terms of Thouless's formula the average amount of regression was, therefore, .242. The means corresponding to Target combinations A and E show significant "negative regression" at the one and five per cent levels of confidence respectively. There was no significant regression in either positive or negative directions corresponding to Target combinations B and C.

The average of the means of the drawing ratios of those who reported no experience of tilt was significantly lower than the stimulus ratio corresponding to Target combinations A, B, C, and E, in the case of Target C at the five per cent level, in the other cases at the one per cent level of confidence. With Target D there was an almost perfect equality between the stimulus ratio and average of the phenomenal means.

When comparisons are made directly between the two groups it is found that the averages of the phenomenal means were higher in each instance in the case of the group who reported experience of tilt. This difference is significant (just below the one per cent level of confidence) only in the case of Target D.

These comparisons indicate that there is at least some positive relationship between seeing tilt and regression scores, and that introspective reports in this experiment had some reliability. They also corroborate the findings above that the stimulus ratio of .6 is most favorable to regression of all the targets used. It is difficult to account for this fact. It may be that "negative regression" is least at this point, or that positive regression is here greatest.

## VI. SUMMARY

Presenting two ellipses, one above the other, in a dark, undifferentiated visual field to 32 subjects, who reported their experiences by drawings, led to the following conclusions:

1. There was a significant relationship between sex and the report of seeing tilted circles, more men reporting the effect than women.
2. A similar relationship was found between sex and the perceptual formation of cylinder-like objects.
3. There was a tendency for those observers who saw tilt also to see distance discrepancy of the targets and object formation.
4. Regression toward a real object as indicated by drawing the top target was far less than Thouless found when the real object was placed in a highly structured field. However, there was some indication of regression, the phenomenal objects tending to be drawn as relatively larger in the vertical direction than those drawn under the Nelson-Haan experimental conditions.
5. This regression was particularly prominent among those observers who reported the experience of tilt. Regression was also most frequent when the real ratio of the minor to the major axis of the top target was .6.

6. The experimental order tilt-drawing was more favorable to regression than the opposite order.
7. Male observers showed more tendency to regression than female observers.
8. A large amount of "negative regression" was found. In all probability this concealed the true amount of regression toward the real object and points to the need of investigation of this phenomenon and of its control in further regression experiments of this type.

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