



145
371
THS

A STUDY OF THE EFFECT OF OPTICAL
MAGNIFICATION ON THE PERCEPTION
OF ELLIPSES

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

James Woodell Miller

1950

This is to certify that the
thesis entitled
A STUDY OF THE EFFECT OF OPTICAL MAGNIFICATION ON
THE PERCEPTION OF ELLIPSES

presented by

James Woodell Miller

has been accepted towards fulfillment
of the requirements for

M. A. degree in Psychology

Howard Bentley
Major professor

Date May 24, 1950

**A STUDY OF THE EFFECT OF OPTICAL MAGNIFICATION ON THE
PERCEPTION OF ELLIPSES**

By

James Woodell Miller

A THESIS

**Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of**

MASTER OF ARTS

Department of Psychology

1950

THESIS

ACKNOWLEDGMENT

Grateful acknowledgment is made to
Doctor S. Howard Bartley for his advice
and assistance throughout the course of
this research.

**
*

TABLE OF CONTENTS

	Page
I. INTRODUCTION.....	1
II. STATEMENT OF THE PROBLEM.....	7
III. EXPERIMENTAL PROCEDURE.....	9
A. Subjects.....	9
B. Apparatus.....	9
C. Instructions to Subjects.....	12
D. Method.....	12
IV. RESULTS.....	14
V. INTERPRETATION OF RESULTS.....	26
VI. SUMMARY.....	32
VII. BIBLIOGRAPHY.....	34

LIST OF TABLES

TABLE	PAGE
I. <u>t</u> VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUB- JECTS COMBINED.....	15
II. INDICES OF PHENOMENAL REGRESSION FOR ALL SUBJECTS COMBINED.....	21

LIST OF FIGURES

FIGURE	PAGE
1. THE EFFECTS OF OPTICAL MAGNIFICATION ON THE PERCEPTION OF A SOLID.....	4
2. A SCHEMATIC REPRESENTATION OF THE EXPERIMEN- TAL SITUATION.....	10
3. THE EFFECTS OF OPTICAL MAGNIFICATION ON A TILTED PLANE FIGURE.....	27

I. INTRODUCTION

In visual perception the visual (stimulus) field is seen as being segregated into components which behave as units. These we call things or objects. The study of the conditions for this segregation is basic. Nevertheless in most perceptual studies, segregation is tacitly assumed, and questions regarding the identity and properties of segregation units or objects become the foci of interest.

Objects tend to retain their identity for an observer in spite of various shifts in the conditions under which they are encountered. Identity is expressed, among other things, in terms of shape, size, color, and lightness of surface. No general statement can be made regarding the roles that each play. Conditions which manipulate the properties just mentioned include, distance from observer, orientation, illumination, optical magnification, and the number and kinds of collateral cues involved. 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.

The tendency for object properties to remain stable under conditions which might be expected to change them has been called "constancy." Constancy actually refers merely to a tendency to remain stable, and the measurement of the extent to which stability is actually maintained is a current problem.

One of the terms used by some investigators is "regression to the real object" (1). This is a concept most useful in dealing with shape constancy. In shape-constancy, for example, one may deal with three concepts regarding objects. The one object is the so-called real object (R). Let us say it is a circular disk. This disk as a real object is considered as a concrete entity retaining circularity without regard to its position or orientation. Circularity actually becomes a concept as well as something perceived. This real object, however forms a different image on the retina, depending upon a number of factors including its distance and orientation with respect to the observer.

The retinal image is called the stimulus object (S). What the observer actually experiences in any specific instance is called the phenomenal object (P). Regression (Rg) is the degree to which the shape of the phenomenal object differs from the stimulus object toward resembling the real object. This relationship was stated by Thouless (2) as:

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.

He has called this the "Law of Phenomenal Regression." The index of phenomenal regression may be expressed as $P-S/R-S$.*

* The index of regression as originally expressed by Thouless (1) was $(\log P - \log S / \log R - \log S)$. It was found unnecessary in the present experiment to include the logarithms in the formula. The logarithms were originally used by Thouless to eliminate certain anomalies which were found to occur when dealing with brightness or size regressions.

As already stated, one of the conditions introducing a change in the experience or identity of objects is optical magnification such as is involved in the use of field glasses or binoculars. When objects are viewed through binoculars, their perceived shapes tend to be altered in one way or another. This is not due to optical imperfections of the instruments, but rather to the way optical principles are involved and to the way the organism uses the stimulus material provided it.

To illustrate one of the changes produced by optical magnification, we shall take the case of what happens to a cube. Let a solid cube be oriented with one edge toward the observer and viewed from slightly above. With the naked eye, the cube will be seen as a right-angled object with all edge-dimensions equal. We now refer to Figure 1, in which one half of a three dimensional object is shown. The horizontal line is the midline (O-Z) of the object. N is the nodal point of the optical system of the eye. Referring to the upper drawing of the figure, we see that the retinal image is formed by the solid angles subtended at N by the horizontal line (O-Z), and lines from the front and back corners A and B, respectively. When the naked (unaided) eye is used the retinal image is enclosed by the angle formed by the horizontal (O-Z), and (a) and (b). With two-power magnification, all the visual angles involved in the original image are doubled, and the retinal image components are extended to the broken lines, (c) and (d), respectively.

As a retinal image is increased in size, one of two outcomes results. Either the object is perceived to become larger, or else

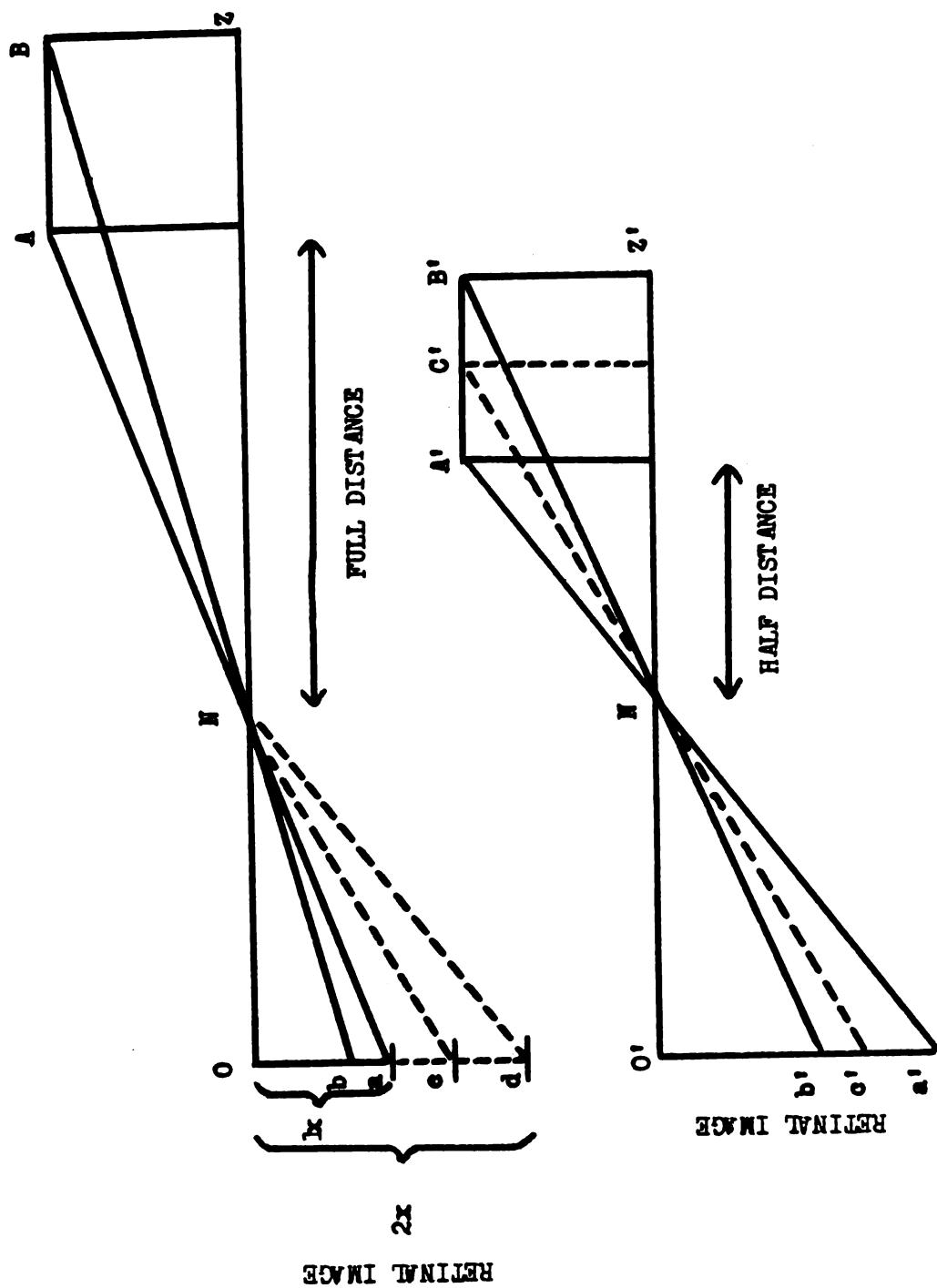


Figure 1. The effects of optical magnification on the perception of a solid.

it is seen to become nearer. As was seen in the upper drawing of Figure 1, we have enlarged the retinal image by optical magnification. The second way to enlarge the image is to move the object nearer. Thus in the lower drawing of Figure 1, we have doubled the overall size of the retinal image by bringing the object twice as close as originally.

We must now ask whether the new characteristics of the image, as we bring the object twice as close, are the same as when we magnify the image two times by an optical instrument. All we need to do for example, is to note the difference in the distances from the horizontal line (O-Z) to point (c) in the upper drawing and from line (O'-Z') to point (b') in the lower drawing. It will be found that the distance from (O'-Z') to (b') is less than from (O-Z) to (c). Thus by optical magnification we have distorted the internal relationships of the retinal image. Accordingly we might expect that the phenomenal end-results in the two cases would not be equivalent.

To illustrate further, if we were to place a point on the retinal image of the lower drawing of Figure 1, which corresponds to (c) in the upper drawing, it would fall somewhere between (b') and (a') or at (c'). If we were now to project a line from this point through the nodal point N to line (A'-B') we would find that it would not fall at (B') but at (C'). Therefore (C') would represent the back corner of the phenomenal object. Consequently the object would have less depth in the third dimension and its angles and relative dimensions would be changed. The edge toward the observer is now

obtuse and the angles formed by the lateral corners are acute. In short, what was the original right-angled object has become "flattened."

•

II. STATEMENT OF THE PROBLEM

All objects do not undergo the same changes under optical magnification. Cubical objects such as clock towers, etc. owing to the complexity of detail do not appear flattened. Our problem is the determination of what happens to a two-dimensional figure which is tilted with reference to the observer. Under such conditions, the two-dimensional configuration occupies three dimensions in space, despite the fact that it is a plane figure. If we recall the changes wrought in the solid we might expect a circle to occupy less of the third dimension under optical magnification than with unaided vision. If so, three possibilities would be involved. The angle of tilt would either remain the same, increase, or diminish. In each of these cases, there might be several possible effects on the size and/or shape of the object.

If the angle of tilt with optical magnification were to remain phenomenally the same, one might expect the minor axis of an ellipse to be reduced over what it would be with the unaided eye. This would be a result consistent with the ellipse's occupation of a reduced third dimension. If with the same phenomenal size, the angle of tilt were to shift toward the perpendicular, the same ellipse would naturally occupy a reduced third dimension. If the angle of tilt were to shift toward the horizontal, the opposite end-result would be expected.

We have, however, to consider whether the organism uses the angle of tilt as a basis around which to organize other factors, or

whether the angle of tilt is something that is determined by more basic considerations.

The problem is to determine just what does happen phenomenally when optical magnification is used.

In the present investigation, the objects used were a series of five ellipses and a circle. They were presented both vertically and at a series of tilts. The problem was to determine the perceptual end-results of viewing these objects with the unaided eye and with a two-power field glass. Although we were able to point out the optics involved in viewing a ~~cube~~ (a three dimensional object), we shall not be able, prior to obtaining observational data, to do likewise for the ellipses. Therefore one is unable to state a fixed hypothesis regarding what to expect.

It will be possible to use the optical principles involved in image formation only when the observational data are obtained. This is because the retinal image, even though an optically determined pattern is not of such a character as to provide for only one possibility in perception. The organism is left to "choose" between several alternatives.

It can be said at least, that some sort of internal manipulation of the retinal image involving the third-dimensional component of the targets, is to be expected. This factor may or may not work in the same direction as the factor of regression.

III. EXPERIMENTAL PROCEDURE

A. SUBJECTS

A total of four observers were used in this experiment, all of whom were graduate students in the department of psychology of Michigan State College. Three of the observers were male and one was female. Of the four observers, three had normal 20/20 vision while the fourth had 20/20 vision as corrected by glasses. The same observers were used throughout the entire experiment. All the observers were naive as to the true purpose of the experiment and as far as the experimenter could tell they did not become aware of what was being measured throughout the entire procedure.

B. APPARATUS

The apparatus is presented schematically in Figure 2. It consisted of a long table on which a three-sided boxlike structure was constructed. An adjustable chin rest was built at one end of the table at a height which would allow all observers to maintain a constant eye level of fifteen inches above the table surface. Black curtains were placed on either side of the observer in order to eliminate as many of the extraneous cues as possible. A drawing board was extended from the table to allow the observer to rest his arm in a comfortable position while drawing. An opening, six inches by eight inches was made in the screen directly in front of the observer at a height of thirteen inches above the table surface. A similar opening

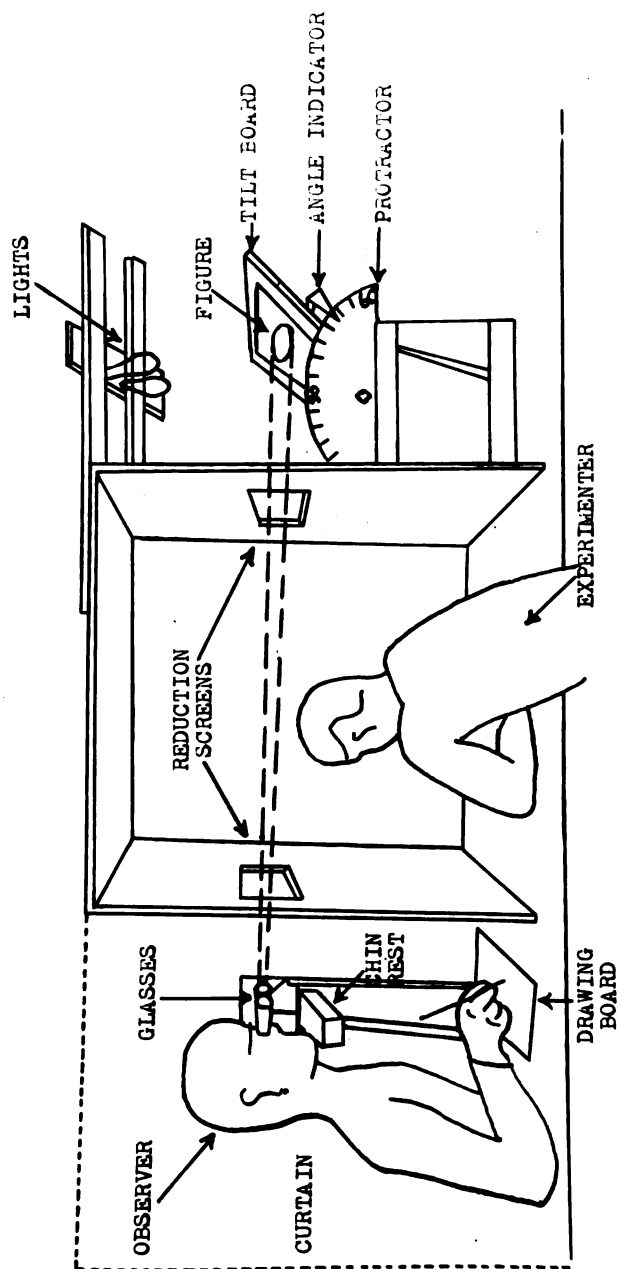


Figure 12
A schematic representation of the
experimental situation.

was made in the screen located immediately in front of the tilt board. These openings served as reduction screens, and the center of each opening was at the eye level of the observer.

A black card was used to cover the first screen while the experimenter was changing the forms on the tilt board. The first screen was located twenty inches from the observer and the second screen forty-eight inches from the observer. The two-power glasses used by the observer were mounted so that they could be easily removed.

An adjustable tilt-board was constructed directly behind the second screen so that the angles of tilt could be easily read from the adjoining protractor by the experimenter. There were no lights in the experimental room other than those placed directly over the figure. These lights consisted of two sixty watt bulbs, which were located twelve inches above the figure regardless of the angle of inclination. This position of the lights also served to eliminate any element of shadow which might otherwise have been present.

There were six figures used in the experiment. All of the figures possessed a major axis of five inches. The minor ^{or vertical} axis of card number one was also five inches, thus forming a perfect circle. Beginning with card number two, the minor axis was decreased one half an inch with each succeeding card so that card number six had a minor axis of two and one half inches. These figures (forms) were mounted on sheets of black cardboard which were placed on the tilt-board by means of thumb tacks that were out of sight of the observer during the period of exposure.

The position of the figures was properly adjusted so that at all times the center of the figure was at the eye level of the observer. The experimenter sat in a position which enabled him to change the cards, manipulate the angles of tilt, and to keep the observer supplied with pencils and paper.

C. INSTRUCTIONS TO SUBJECTS

Each observer was instructed by the experimenter on the following points: That he was to reproduce to the best of his ability the figures which would be presented, that the procedure was not a measure of drawing ability, and that the important thing was to draw what he immediately perceived. He was also told not to hurry, as time was not an important factor in the experiment. Throughout the entire experiment the observer was reminded that he was to draw only what he perceived and that he was not to attempt to devise systems whereby he could draw what he "thought" the figures might be.

D. METHOD

The procedure followed was the same for all observers. The observer was seated and five or ten minutes were allowed for partial dark adaptation. When the observer indicated that he was ready to begin, the experimenter removed the black card covering the opening of the screen, and the observer proceeded to draw the figure. When the observer finished the drawing, the card was replaced over the opening. After replacing the card, the experimenter changed the

figure, adjusted the angle of tilt, and removed the black card in preparation for the next trial.

The experiment was conducted throughout a period of five weeks. Two sessions were held each week for every observer, with each period lasting for approximately two hours. During an experimental period all six figures were presented at four angles; ninety degrees, sixty-seven and one half degrees, forty-five degrees, and twenty-two and one half degrees.

The figures were presented first with the glasses (condition I), and then without the glasses (condition II). This resulted in forty-eight drawings presented during each experimental period; twenty-four under condition I and twenty-four under condition II. When the experiment was terminated each observer had a total of 480 trials, 240 under each condition.

The order of presentation was randomly selected in regards to both the angle and the figure. The trials involving the glasses were always presented first and were followed by a rest period of about fifteen minutes before presenting the trials without the glasses. This rest period served to reduce fatigue and also to eliminate any tendency the observer might have to compare the figures as seen under conditions I and II.

Another feature of methodology involved the question of whether the stimulus object with and without magnification was the same. We are dealing with shape and not size. Accordingly S is to be considered an index of shape. The subjects drew figures indicating proportions of the forms seen. Sizes, orientations, etc., were not to be primary concerns of the perceptual task, although the features just mentioned may have been involved.

Shape then was indicated by the ratio of the minor to the major dimension of the object in each case. Shape, of course, involves factors that have to do with internal components of figures, but these were not expressed in the ratios used to designate shape.

For the real object, shape was indicated by the actual dimensions of the figures used regardless of their orientation to the observer. For the stimulus object with the unaided eye, shape was obtained by using the cosine function of the minor (vertical) axis of the real object divided by the major or horizontal axis. The dimension of the major axis remained constant for all angles of real-object tilt. For the stimulus object with optical magnification, shape was obtained by considering that the glasses increased both minor- and major-axis dimensions of the object with the unaided eye proportionately. This is to say that S with magnification was the same as with the unaided eye, although the relative over-all sizes of the two retinal images were something nearly like two to one. That the same S was used in both cases does not imply that the effective internal components of the two stimulus objects were the same. The diagrams in Figure 3 indicate that the proportions were actually different.

IV. RESULTS

An examination of Table I, shows that the mean of the ratios obtained when the observer was not wearing the glasses (condition II) was consistently greater than the mean obtained when the observer was wearing the glasses (condition I). It will be seen, however, that the differences are not of sufficient magnitude to be statistically significant in every case.

With the exception of form one at angle B, there appears to be a tapering off of significance as the angle of inclination approaches ninety degrees at the one end, and zero degrees at the other extreme. That is, the means do not differ significantly when a perfect circle or a near perfect circle were presented at ninety degrees or when the more elliptical figures were presented at an angle of twenty-two and one half degrees.

Observer number two was found to have an extremely high variability for the measurements obtained at angle D. It was for this reason that the data for angle D was computed both with and without these measurements. That this variability had influence on both the means and the standard deviations is evidenced by the difference in the respective t values of D and D'.

Referring again to Table I, it will be seen that the variability of the judgments without the glasses is greater than those obtained with the glasses. It will also be noticed that the extremely high variability found in angle D (forms one, two, three, and four)

TABLE I

t VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUBJECTS COMBINED

ANGLE A (90°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.990	1.022	.949	.975	.733	.823
σ	.05	.11	.09	.07	.11	.07
t_m	1.68		1.44		4.28	
t_{σ}	4.28		1.54		2.86	
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.659	.710	.522	.629	.490	.565
σ	.09	.08	.07	.07	.11	.13
t_m	2.68		6.69		2.78	
t_{σ}	.77		.00		1.05	

W.G. - With glasses

N.G. - No glasses

Note: For 78 d.f. a t of 2.63 is significant at the one per cent level and a t of 1.99 is significant at the five per cent level.

(Continued next page)

• • • • •
• • • • •
• • • • •
• • • • •
• • • • •

• • • • •
• • • • •
• • • • •
• • • • •
• • • • •

• •
• •

• •

•

•

•

TABLE I - CONTINUED

t VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF
RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUBJECTS COMBINED

ANGLE B (67.5°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.962	.987	.831	.928	.693	.750
ρ	.06	.10	.08	.13	.06	.10
t_m	1.32		4.04		3.00	
t_r	3.08		2.94		3.08	
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.625	.668	.563	.603	.483	.533
ρ	.08	.10	.06	.08	.09	.10
t_m	2.15		2.50		2.27	
t_r	1.43		1.82		.67	

(Continued next page)

TABLE I - CONTINUED

t VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUBJECTS COMBINED

ANGLE C (45°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.691	.851	.636	.795	.579	.733
σ	.07	.18	.08	.16	.08	.15
t_m	5.16		5.48		5.70	
t_{σ}	5.00		4.00		3.68	
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.534	.618	.476	.576	.426	.507
σ	.07	.12	.08	.12	.09	.10
t_m	3.82		4.35		3.68	
t_{σ}	3.33		2.50		.67	

(Continued next page)

TABLE I - CONTINUED

t VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF
RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUBJECTS COMBINED

ANGLE D (22.5°)

	Form 1		Form 2		Form 3	
	W.C.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.622	.718	.578	.675	.547	.606
σ	.14	.25	.13	.23	.14	.20
t_m	2.09		2.36		1.51	
t_σ	3.44		3.45		2.22	
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.505	.566	.429	.481	.417	.424
σ	.13	.21	.13	.12	.12	.11
t_m	1.56		1.86		.27	
t_σ	2.86		.50		.56	

(Continued next page)

TABLE I - CONCLUDED

t VALUES FOR DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF RATIOS OBTAINED WITH AND WITHOUT GLASSES FOR ALL SUBJECTS COMBINED

ANGLE D' (22.5°)*

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.565	.587	.519	.556	.499	.504
σ	.09	.12	.08	.11	.12	.09
t_m	.78		1.48		.17	
t_σ	1.58		1.67		1.58	
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
M	.451	.465	.377	.434	.381	.385
σ	.09	.10	.10	.10	.11	.09
t_m	.56		2.19		.15	
t_σ	.59		.00		1.11	

* Minus data for subject number 2.

Note: For 58 d.f. a t of 2.66 is significant at the one per cent level and a t of 2.00 is significant at the five per cent level.

• • • • •
• • • • •
• • • • •
• • • • •
• • • • •

• • • • •
• • • • •
• • • • •
• • • • •
• • • • •

• • • • •
• • • • •

is reduced to almost half, following the removal of the data collected from observer two (D').

Table I, also indicates a general increase in the variability as the angle of inclination approaches the horizontal. This increase of variability corroborates the statements made by the observers which were to the effect that it was much more difficult to draw the figure accurately as the angle of tilt increased (more toward the horizontal).

It should also be pointed out that at any given angle the significant difference between standard deviations (t_{σ}) decreases as the size of the ratio decreases. The only significant exception to this trend is found with form two at angle A.

Further analysis reveals that the t_{σ} values are extremely low for form six at each of the angles. This further supports the statements of the observers who had said that the forms possessing a small minor axis are more difficult to draw both with and without the glasses and that the difficulty increases as the angle of inclination increases.

Referring to Table II, it will be seen that the indices of phenomenal regression (R_g) are consistently greater for the measurements obtained without the glasses. On further examination of Table II, it will be noted that at angle A the values for the real object (R) and the values for the stimulus object (S) are equal. Theoretically then, when the angle of inclination is ninety degrees there is no possibility of obtaining any phenomenal regression and the formula

TABLE II

INDICES OF PHENOMENAL REGRESSION FOR ALL SUBJECTS COMBINED

ANGLE A (90°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	1.000	1.000	.900	.900	.800	.800
S	1.000	1.000	.900	.900	.800	.800
P	.990	1.022	.949	.975	.733	.823
Rg	-.01	.02	.05	.08	-.07	.02

	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	.700	.700	.600	.600	.500	.500
S	.700	.700	.600	.600	.500	.500
P	.659	.710	.582	.629	.490	.565
Rg	-.04	.01	-.02	.03	-.01	.04

W.G. - With Glasses

N.G. - No Glasses

R - Real Object

S - Stimulus Object

P - Phenomenal Object

Rg - Index of Phenomenal Regression

(Continued next page)

TABLE II - CONTINUED

INDICES OF PHENOMENAL REGRESSION FOR ALL SUBJECTS COMBINED

ANGLE B (67.5°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	1.000	1.000	.900	.900	.800	.800
S	.924	.924	.832	.832	.739	.739
P	.962	.987	.831	.928	.693	.750
Rg	.50	.83	-.15	1.41	-.75	.18
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	.700	.700	.600	.600	.500	.500
S	.647	.647	.554	.554	.462	.462
P	.625	.668	.563	.603	.483	.533
Rg	-.42	.40	.196	1.06	.55	1.87

(Continued next page)

TABLE II - CONTINUED

INDICES OF PHENOMENAL REGRESSION FOR ALL SUBJECTS COMBINED

ANGLE C (45°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	1.000	1.000	.900	.900	.800	.800
S	.707	.707	.636	.636	.566	.566
P	.691	.851	.636	.795	.579	.733
Rg	-.17	.49	.00	.60	.38	.71
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	.700	.700	.600	.600	.500	.500
S	.495	.495	.424	.424	.354	.354
P	.534	.618	.476	.576	.426	.507
Rg	.32	.60	.68	.86	.49	1.05

(Continued next page)

TABLE II - CONCLUDED

INDICES OF PHENOMENAL REGRESSION FOR ALL SUBJECTS COMBINED

ANGLE D (22.5°)

	Form 1		Form 2		Form 3	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	1.000	1.000	.900	.900	.800	.800
S	.383	.383	.345	.345	.306	.306
P	.622	.718	.577	.675	.547	.606
Rg	.39	.54	.42	.59	.49	.61
	Form 4		Form 5		Form 6	
	W.G.	N.G.	W.G.	N.G.	W.G.	N.G.
R	.700	.700	.600	.600	.500	.500
S	.268	.268	.230	.230	.192	.192
P	.505	.566	.429	.481	.417	.424
Rg	.55	.69	.54	.68	.73	.75

$(P-S)/(R-S)$ is not applicable. There were, however, discrepancies found between the axis-ratio of the phenomenal object (P) and the axis-ratio of the real object (R). Therefore the values which otherwise would be indicated as indices of regression for angle A are actually the differences between the axis-ratio of the phenomenal objects and those of the real objects. The values are experimental errors and serve to demonstrate the probable size of the "chance" components in the regression indices for the other forms and angles. It will be noticed that at no time is this fluctuation greater than eight-hundreths.

V. INTERPRETATION OF RESULTS

The major finding in the present investigation was the fact that "regression to the real object" was less in most every case with optical magnification than with the unaided eye. The values indicated by the index of regression may be thought to involve not only the factor of regression itself, but the operation of a different set of retinal cues for shape than which operate with the unaided eye. Although we used the same *S* value for the aided and unaided eye, shape values not expressed in *S* would seem to be operative. The justification for using the same *S* in the two cases was given on page 13a.

In considering the effect of using the two-power optical magnification, it must be recognized that the observers did not see the objects as being twice as large as normal but approximately twice as near. This calls for the comparisons made in Figure 3, wherein it will be seen that bringing an object closer by an actual mechanical shift and by optical magnification are by no means similar. The resulting relations of the parts of the retinal images are not the same. In dealing with retinal images, one must not only consider shape per se, but the distribution of the images about the fovea. Images are said to be asymmetrical when they are not equally distributed on the two opposite sides of the fovea even though as geometrical patterns they are uniform. This is to say that the image of a square is asymmetrical if the fovea is not in the middle of the image. Figure 3 indicates that the vertical distributions of the images of the objects are different with the aided and the unaided eye. With the unaided eye, there is greater asymmetry. Whereas the angles indicative of parts of the image are increased proportionately when the size of the retinal image is enlarged by optical magnification (upper

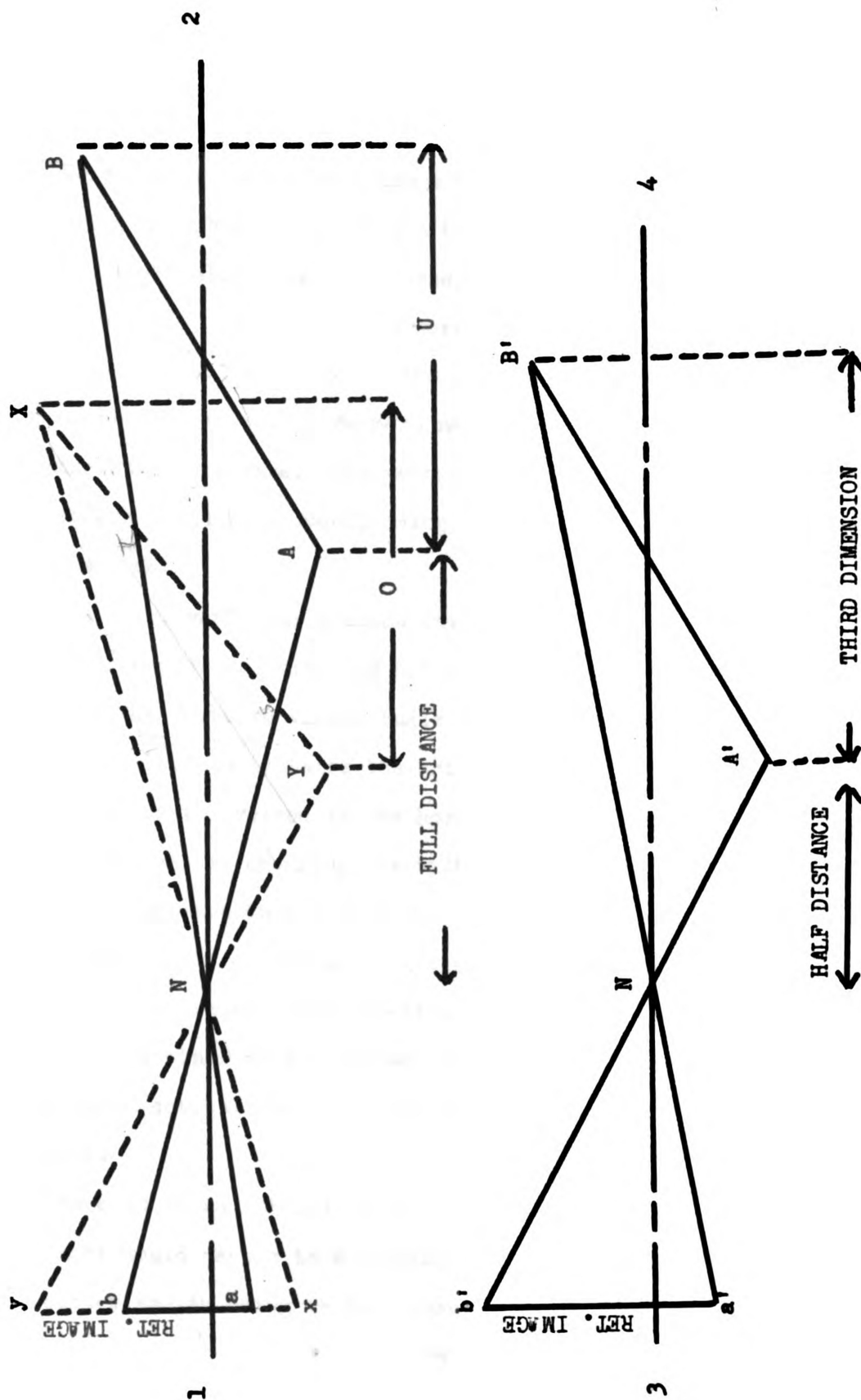


Figure 3. The effects of optical magnification on a tilted plane figure

drawing, Fig. 3), the angles are increased disproportionately when the size of the retinal image is enlarged by actually moving the observed object closer to the eye (lower drawing, Fig. 3).

To simulate the retinal image produced by magnification one would have to tilt the object more toward the perpendicular as it is mechanically brought closer. This, of course, would be the result perceived by the observer. If, however, there were something which at the same time limited the vertical exposure of the object in some way, the resulting image, as the object were made more nearly upright, would remain the same rather than increase. The vertical-to-horizontal ratio of the perceived object would be reduced, owing to the appearance of reduced vertical dimension.

Actually, while the glasses involved the shift of the object toward the perpendicular, they did not involve a different vertical visual angle. The vertical visual angle was the same as specified for the mechanical shift, namely twice the original angle, and also it was the same angle as that involved in the horizontal enlargement of the image. Thus the mere fact of changing the tilt of the object did not involve a consequent increase in the vertical visual angle, or an enlargement of the "face" of the object seen. It was simply a change in tilt, and consistent with this we could expect a reduction in the perceived dimensions of the minor axis. The smaller indices of regression for the cases in which optical magnification was used is consistent with this expectation.

There is an additional factor to be considered in making comparisons in what would happen in enlarging the retinal image by bringing the object closer and in using optical magnification. As the vertical

dimension of the retinal image with the unaided eye is doubled the horizontal dimension is slightly more than doubled. Thus while the "aided" image is uniformly enlarged the unaided image would be slightly distorted. The horizontal dimension would increase faster than the vertical. This would reduce the minor-major axis ratio. Thus on the one hand certain factors work toward reducing minor-major axis ratio with the aided eye; others work in the same direction with the unaided eye. Whether the net is in favor of perception without glasses we did not directly determine, but the smaller indices of regression with optical magnification are in favor of the idea that certain basic conditions lie in the nature of the retinal image itself.

The amounts of difference, as mentioned earlier, were not significant in all cases. If we were to make diagrams as in Figure 3, to indicate amounts of expected differences between moving the object closer and using optical magnification, it is clear that the differences would not be great at the two extremes (near the perpendicular and near the horizontal).

It is also possible, that with optical magnification the factor of minor-axis reduction might be great enough to more than offset regression so that the net result would be a phenomenal figure with the minor-major fraction even less than that represented by the original stimulus object. This was actually found to occur in some cases. It can be seen by referring to Table II, (page 21) that the cases where this phenomena did occur are those indices which are preceded by a minus sign.

The rather large variability which is shown on Tables I and II, (pages 15, 21 respectively) may be attributed to several possible factors. Thouless (3) has shown that phenomenal regression is influenced by the intelligence, training in art, sex, and possibly the age of the observer. He goes further to point out that the existing conditions of the experiment also have tremendous influence in determining the amount of regression which will occur. Some of these conditions are the angle of inclination, the perceptual cues, and the relative brightness and distances involved. The fact of the dependence of phenomenal regression on the presence of perceptual cues and the real character of the object, makes it certain that the numerical amount of the regression obtained will depend on the whole of the experimental conditions, and that measurements made under different experimental conditions will not be comparable.

It is this experimenter's belief that the high variability and the apparent lack of uniformity of significance which was found in this study can be partially attributed to the individual differences

of the observers. There is also evidence (3) which indicates that as the angle of inclination approaches the horizontal, the complexity of the perceptual cues increases. This would substantiate the above findings which indicate that as the angle of inclination approaches twenty-two and one half degrees, the variability of the judgments increased. The data here show that the increase of the complexity of the perceptual cues, and thus the increase in variability, affect both the judgments with and without the glasses.

As was just mentioned, the variability of the judgments depends partially upon the presence of perceptual cues. When viewing the figures with the glasses, the visual field would be narrowed and the perceptual cues would tend to be diminished. It would then follow that with a decrease in perceptual cues, the variability of the judgments would also decrease. An examination of the standard deviations recorded on Table I, (page 15) will indicate that there was actually greater variability in the judgments obtained with the unaided eye.

Even though the reduction of perceptual cues may or may not tend to reduce the variability of judgments it might be expected to reduce the regression to the real object. In other words, if the existing conditions are such as to limit the cues, either dimensional or distance, the observer finds it more difficult to perceive the characteristics of the real object. This results in the observer drawing an object that is more unlike the real object, and more like the stimulus object, which in this case would be an ellipse with a reduced minor axis.

In concluding, we may say that two general sorts of factors seem to be operative in the present situation in which the two modes of observing ellipses were compared. The use of glasses would seem to reduce the collateral cues which otherwise might have aided in perceiving the nature of the real object. This reduction of cues would tend to reduce regression. This possibility was not checked, although by a series of observations with a reduced visual field, without glasses, it could have been.

The major factor was the operation of optical magnification in shifting the asymmetry of the retinal images. As has already been shown, this was in the direction consistent with the reduced minor axis indicated by the observational data. Since optical magnification materially changed the stimulus object (S) itself, it is definitely to be relied upon, as a factor in producing the shifts obtained. Other factors, mentioned or ones which were unrecognized may contribute in the way suggested, but their influence, if any, was not tested. It does not seem probable that they have as great a weight as the shift in the stimulus object, i.e., the shift in asymmetry of the retinal images.

VI. SUMMARY

The purpose of this experiment was to determine the effects of optical magnification on the perception of ellipses.

The four observers used in this experiment were all graduate students in the department of psychology of Michigan State College. The true purpose of the experiment was not revealed to the observers throughout the entire procedure.

The apparatus was designed to minimize any extraneous cues which might influence the judgments of the observers.

Six figures (forms) were presented to the observer of which five were ellipses and one a circle. Each figure was presented at four angles, ninety degrees, sixty-seven and one half degrees, forty-five degrees, and twenty-two and one half degrees. The observers were asked to draw the figures as accurately as possible but were told that the experiment was not one of artistic ability but that the experimenter was interested primarily in the proper proportions.

Forty-eight judgments were recorded during each experimental session, twenty-four with the glasses and twenty-four without the glasses. Two sessions were held each week for five weeks, which made a grand total of 480 trials for each observer, 240 trials under each condition.

The ratios of the figures were then measured and the means, standard deviations, and t scores computed. The results indicated that the means of the minor-major ratios obtained with the glasses were smaller. This decrease in the means was found consistently

throughout the experiment, although the differences were not statistically significant in all cases.

It was also discovered that the amount of phenomenal regression was reduced with optical magnification. This was found to be true in all cases.

The minor axis reduction which was obtained with optical magnification was attributed to two general factors. The reduction of perceptual cues which was brought about by the binoculars, and the reduced retinal asymmetry which was a result of the optical magnification.

It was concluded that the major factor was the reduced asymmetry of the retinal image and that the factor of reduced cues was of lesser importance in determining the shape of the phenomenal object. It was suggested however that the influence of cue reduction on phenomenal regression could be investigated by making a series of observations where the perceptual cues were reduced by means other than optical magnification.

VII. BIBLIOGRAPHY

1. Thouless, Robert H. Phenomenal regression to the real object. I.
Brit. J. Psychol., 1931, 21, 339-359.
2. Thouless, Robert H. Phenomenal regression to the real object. II.
Brit. J. Psychol., 1931, 22, 1-30.
3. Thouless, Robert H. Individual differences in Phenomenal regression. Brit. J. Psychol., 1932, 22, 216-241.

ROOM USE ONLY ⁴⁰ 20 ⁷³² 82 *pd.*

AP 18 '53
AP 15 '53
MY 19 '53

Feb 3 '58

ROOM USE ONLY

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03177 5210