MEASURED VISUAL ACUITY AS A FUNCTION OF PHENOMENAL SIZE

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TO THE MEMORY OF A FRIEND

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TABLE OF CONTENTS

	<u>page</u>
INTRODUCTION.....	1
METHOD.....	5
Apparatus.....	5
Acuity Targets.....	9
Field of View.....	10
Observers.....	10
Procedure.....	11
Instructions.....	12
Measures and Tests.....	13
RESULTS.....	14
DISCUSSION.....	18
SUMMARY AND CONCLUSIONS.....	23
REFERENCES.....	25

MEASURED VISUAL ACUITY AS A FUNCTION OF PHENOMENAL SIZE

Visual acuity is usually defined as "...the reciprocal of the minimal effective visual angle in terms of minutes of arc...." (6, p. 958). Such a definition implicitly assumes that acuity is independent of phenomenal size, provided the test object subtends a constant visual angle at the retina. Yet having once witnessed the size-constancy phenomenon, or the Honi-phenomenon, or the phenomenal magnification of objects viewed through an iconoscope, or their phenomenal minification when viewed through a telestereoscope--having witnessed any of these, one might elect to challenge the implied assumption. This question is naively resolved to: Is measured visual acuity bettered when the test object is made to appear larger even though its objective size on the retina remains constant?

A search of the pertinent literature^{1/} indicates that acuity is functionally related to many variables and, further, that as usually measured it is composed of several factors. However, only one study has primarily concerned itself with the topic here under discussion; this is Chapter VIII of McFadden's dissertation (22).

McFadden placed a visual acuity test pattern (parallel bars) first in the foreground, then in the background, of a "phenomenally tridimensional framework." In the first case, the test pattern

^{1/}See, for example, the recent reviews by Ogle (27), Senders (29), Sloan (30), and Walls (36), as well as the studies reported in the AGO monograph (1) and those in the Tufts Handbook (34).

appeared relatively close and small; in the second, it appeared relatively far and large. Although the objective sizes of the two figures were the same, the second yielded a higher visual acuity rating (was resolved farther from the observer) than the first.

This would seem to settle the issue except for Sloan's (30) report of Musylev's (26) findings that acuity changes when the extent of background is varied, all other things held constant. In McFadden's study, extent of background (or, at least, the extent of its "whiteness") varied as he moved the test pattern from the foreground to the background of his photograph of a country road. Furthermore, the homogeneity of the ground immediate to the test pattern also varied with the phenomenal size changes in McFadden's experiment, whereas in the same dissertation (22) homogeneity of ground was found to be a determinative factor in measured acuity. Thus, because of possible determinations by these covariants, McFadden's experiment can not be accepted as definitive with regard to the relation of apparent size to measured visual acuity.

The problem now is to measure visual acuity under conditions which effect changes in the phenomenal size of the visual acuity test object without concomitantly effecting changes in other variables of which visual acuity is known to be a factor.

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The reticle pattern in a binocular stereoscopic range finder subtends a constant visual angle at all times. As the reticle pattern is made to appear more distant (i.e., as one ranges farther into the field of view by reducing the convergence of the retinal images), one experiences a phenomenal increase in the apparent size of the reticle pattern. This phenomenal increase is so dramatic it is sometimes taken for granted as a more-or-less physical feature of the range finder, and is looked upon as a possible limiting feature of the instrument. Thus, in reference to a laboratory model binocular stereoscopic range finder, Harker and Brune (14) say,

"...The apparent relative size of the test object grows larger with increasing distance contrary to the behavior of a real object. This is a fundamental property of reticles. It arises from the fact that the reticle subtends a constant visual angle while the receding target subtends an ever smaller visual angle. Concomitant to this is the linear size relation of the test object to the reference object. If both objects are of the same shape, the assumption of linear perspective may operate to produce errors of localization...." (14, p. 7).

This increase in apparent size is a manifestation of the size-constancy phenomenon--first subjected to experimentation by Martius in 1889^{2/}. "Size constancy" usually refers to the fact that as an

^{2/}For discussions of the size-constancy phenomenon see Boring (8), Graham (13), Koffka (21), and/or Vernon (35).

object is made to recede from an observer its retinal image diminishes in proportion to distance, while in perception it appears to remain constant in size. However, Holway and Boring (18) found, under conditions favorable to constancy, that when the receding object is made to subtend a constant visual angle, its apparent size increases as a function of distance. They found further that the degree of size constancy exhibited by an object is a function of the number of stimulus cues available—just as Thouless (32, 33) and Woodworth (37) had previously shown the same to be true with shape and brightness constancy, respectively.

It would seem reasonable, then, to use a binocular-stereoscopic-range-finder-type instrument with a visual acuity test as the reticle pattern to approach the present problem experimentally. The apparent distance of the test pattern could be changed under conditions favorable to size constancy, thereby effecting changes also in the phenomenal size of the test pattern. Then the same could be done under conditions not favorable to size constancy, thereby not changing the apparent size of the test pattern while varying all the other covariants. If measured visual acuity is a function of phenomenal size, then differences in the acuities measured at different apparent distances should occur under the first conditions, but not under the second.

To exhaust the logical possibilities, three other results might occur: (a) Should differences obtain under both conditions, then

acuity may be a function of phenomenal size, but it is certainly also a function of other covariants; (b) Should differences occur only under the second conditions, then acuity is a function of something other than phenomenal size; (c) Should differences obtain in neither experimental condition, then measured visual acuity is not a function of phenomenal size nor of any other covariant in this method of achieving changes in apparent size.

METHOD

In a day-light situation favorable to the operation of size constancy, 36 observers (S-group) read a retinally projected visual acuity chart at three convergences and, thus, at three apparent distances and three conditions of phenomenal size of the chart. An additional 36 observers (R-group) read the same retinally projected chart under similar conditions, but in a stimulus-reduced night situation not favorable to the operation of size constancy; for this group, phenomenal size of the test chart remained constant.

Apparatus

A stereoptometer was the apparatus used. Because this instrument is reported in principle elsewhere (2, 3), the description given below is limited to the minimum necessary for comprehension of the experimental procedure.

Basically, the stereoptometer is a unit base, unit power, binocular stereoscopic range finder. It consists of two USAF reflex gun sights, one mounted rigidly to a base, the other mounted on a bearing which allows rotation about the optical center. The tangent of the angle of rotation is found by use of a thousandths-inch dial gauge measuring at a calibrated 9.328 inches from the center of rotation. A schematic top view of the instrument is given in Figure 1.

The reflex sight consists of a source of illumination, a reticle disk placed at the focal point of a Mangin mirror, and a half-reflecting surface. The Mangin mirror transforms the divergent light rays from the pattern cut in the reticle disk into parallel beams of light. The half-reflecting surface reflects these parallel beams to the eye, while allowing transmission to the eye of light from the field of view. To an observer looking through the reflex sight, the reticle image appears to be located at some indefinite distance in the "real" field. When two such sights are used as in the stereoptometer, the reticle image appears to the observer to be located at a definite distance in the field of view, i.e., at the point determined to be at the intersection of extensions of the parallel beams from the two sights. A schematic side view of the reflex sight used is given in Figure 2.

It should be noted that two additional advantages accrue from the use of this type of optical system with its parallel beams.

Figure 1. Schematic top view of stereoptometer; adapted from (2) and (3).

Figure 2. Schematic side view of a reflex sight; adapted from (2) and (3).

First, accommodation is not required to focus correctly the reticle image since parallel rays call for accommodation to infinity.

Second, when two sights are used for binocular observation, as here, no adjustment for interpupillary distance is necessary since lateral displacement of one eye results in a like displacement of that eye's reticle image. Of course, differing interpupillary distances will result in differing apparent distances of the fused reticle image for a given convergence of the two sights.

Acuity Targets

The reticle disks were photographic^{3/} negative reductions of a visual acuity test chart^{4/}. Only the lower eight lines of the chart were used. These allowed readings of a total of 60 acuity figures: four at 20/80, five at 20/60, six at 20/50, seven at 20/40, eight at 20/30, nine at 20/25, ten at 20/20, and eleven at 20/15. After magnification of the reticle-disk pattern by the optical systems of the reflex sights, the test chart lines were calibrated as representing approximate Snellen ratings of from 20/112 through 20/21 at the position of the observer's eye. Although the smallest acuity test figure presented was larger than the "normal" 20/20

^{3/}On Kodalith—a high-contrast, fine-grain film manufactured under this trade name by the Eastman-Kodak Co.

^{4/}Bausch & Lomb Opt. Co.'s Snellen-rating, illiterate, direct-reading visual acuity test chart. The illiterate ("E"'s) chart was selected as probably being less biased with form perception than the usual letter charts.

Snellen rating, the reduced brightness and color contrast operated to lower the obtained acuities so that the pattern as presented was deemed adequate. As can be seen in the Results Section, all 60 letters on the chart were correctly identified only 13 times out of the total of 216 readings.

Field of View

The stereoptometer was positioned with the reflex sights about four feet from a window so that the field of view was a relatively unobstructed view of the sky. A number of auxiliary objects (window frame, roof line with dormers, trees, etc.) were present in the field of view to aid in localization of the fused reticle image during the day-light hours. At night the field of view was a relatively undifferentiated black. Variable polaroid filters, placed in front of the reflex sights, provided a means of reducing the brightness of the field of view. The letters of the reticle image appeared as yellow-orange images on either the day-light sky (S-group) or the night-black background (R-group).

Observers

Two groups of 36 observers each were used. The S-group consisted of 19 males and 17 females; the age range was from 17 to 41 years with median age at 22. The R-group consisted of 23 males and 13 females, 14 to 47 years of age with median age at 26. Two other

volunteers were rejected when they failed to exhibit fused binocular vision. Assignment of observers to groups was quasi-random, the limiting factor being the temporal availability of the volunteers (day or night). No attempt was made to match groups or individuals. Age and sex of specific observers are shown in the data tables of the Results Section.

Procedure

Visual acuity measurements were made under two conditions. The first (S-group) condition was one of full day-light stimulus cues; thus, this condition was favorable to the existence of the desired operation of the size-constancy phenomenon to effect changes in the phenomenal size of the test chart. The second (R-group) condition was one of reduced stimulus cues at night. This condition was not favorable to the operation of size constancy, but rather was favorable to apparent size following the law of the retinal image.

In each of these conditions, acuity was measured for each observer three times in succession, i.e., once at each of three different convergences of the reflex sights. Three angles were selected to provide for the apparent distance of the reticle image being once well within the accommodative range, once at about the normal testing distance, and once well beyond the accommodative range. The three convergences used were (A) $2^{\circ}30'$, (B) $30'$, & (C) $5'$.

For an interpupillary distance of 2.4 inches (61 mm.), these represent approximate radial distances of (A) 4 feet, (B) 23 feet, and (C) 1400 feet.

The order of presentation of convergence angles was varied systematically over observers; each group of six observers represented a replication of the six possible permutations (ABC, ACB, etc.). By so obtaining the three successive measurements from each observer, gross changes in illumination of field of view, sky background, etc., were controlled within observers, but not between them. In addition, a control for the learning of the specific letter sequence of the test pattern was obtained by requiring that each observer first read from left to right the entire chart, then from left to right the smallest three lines attempted, then these three lines from right to left.

Instructions

The following instructions were read to each observer before his first visual acuity measurement:

"When you look through these two sights, you will see a chart such as that used in an eye examination. You are to read down as far as you can, telling me 'up, down, right, or left' according to the position to which the open end of the capital 'E' is pointing. If you can not tell for sure in which direction a given

"'E' is pointing, guess—try to get as many as you can.

We shall do this three times; sometimes with the chart close, sometimes far. Ready?"

Measures and Tests

The data collected were the number of letters correctly identified out of the 60 possible. Since there was no reason to assume normality of the distribution of correctly identified letters^{5/}, it was decided a priori to use a non-parametric statistic to test the overall significance of results. Friedman's Chi-square-r (11) provided such a test. Thus, for each observer, the three convergence conditions were rank ordered on the basis of the acuity performance. These rank scores for the convergences were then summed, and Chi-square-r's were computed separately for the S- and R-groups.

The working hypothesis that acuity is a direct function of phenomenal size would indicate that for the S-group the acuities obtained at C should exceed those obtained at A, and likewise B should exceed A, and C should exceed B. To test these predictions would require a non-parametric equivalent of the critical ratio. Brandt's sign test (9) was selected as satisfying these statistical requirements of this study.

^{5/}Indeed, because the separate lines of the test pattern represented discrete changes in visual angle, and therefore in measured acuity, there was every reason to expect a non-normal distribution of raw scores.

RESULTS

Table 1 presents the raw scores and rank scores for the 36 observers of the S-group (size-constancy group). Friedman's Chi-square-r test on the sums of ranks yields a Chi-square-r of 34.764; for two degrees of freedom, a Chi-square of 13.82 is associated with a probability value of 0.001. Consequently, the hypothesis of no difference other than chance among these three conditions is rejected. Furthermore, Brandt's sign test applied to the pairs of conditions rejects the null hypothesis at probability values less than 0.001 in the case of each pair. From this we conclude that the acuities at C exceed those at A, those at B exceed those at A, and those at C exceed those at B.

Table 2 presents the raw scores and rank scores for the 36 observers of the R-group. The Chi-square-r obtained for the summed ranks here is 0.514. This is associated with a probability value between 0.70 and 0.80, and so the null hypothesis is not rejected. Furthermore, Brandt's sign test applied here says that differences in measured acuity as great or greater than those obtained between C and A, B and A, and C and B, could have occurred by chance alone with probabilities of 0.491, 1.000, and 0.617, respectively.

The strength of the ranked relation is pictured in Figure 3 where the sums of ranks (and Mean ranks) for both groups are plotted along with the values expected for perfect and zero relations.

TABLE 1

- 15 -

NUMBER, AND RANK ORDER, OF LETTERS CORRECTLY IDENTIFIED
BY 36 OBSERVERS (S-GROUP) AT THREE CONVERGENCES
IN A DAYLIGHT SITUATION FAVORABLE TO SIZE CONSTANCY

Observer	Sex	Age*	Number#			Rank Order		
			A	B	C	A	B	C
1	M	24	56	56	57	1.5	1.5	3
2	F	31	53	57	58	1	2	3
3	M	28	53	54	55	1	2	3
4	M	21	56	57	57	1	2.5	2.5
5	M	23	59	53	59	2.5	1	2.5
6	M	20	41	44	43	1	3	2
7	F	27	53	57	59	1	2	3
8	M	24	56	58	59	1	2	3
9	F	36	55	58	59	1	2	3
10	F	34	46	55	58	1	2	3
11	F	27	59	60	60	1	2.5	2.5
12	M	41	59	60	60	1	2.5	2.5
13	M	37	43	48	51	1	2	3
14	M	22	50	53	52	1	3	2
15	F	38	58	56	58	2.5	1	2.5
16	F	22	50	54	57	1	2	3
17	M	26	57	58	60	1	2	3
18	M	22	56	57	58	1	2	3
19	M	20	59	59	60	1.5	1.5	3
20	F	19	58	57	58	2.5	1	2.5
21	F	19	52	57	58	1	2	3
22	M	24	45	47	48	1	2	3
23	M	32	31	33	34	1	2	3
24	F	22	57	56	57	2.5	1	2.5
25	F	18	56	58	59	1	2	3
26	M	20	56	56	57	1.5	1.5	3
27	F	17	53	55	57	1	2	3
28	M	19	52	56	58	1	2	3
29	F	18	42	57	57	1	2.5	2.5
30	F	18	36	42	47	1	2	3
31	M	19	60	52	58	3	1	2
32	M	18	55	58	57	1	3	2
33	M	18	39	39	39	2	2	2
34	F	20	55	52	56	2	1	3
35	F	20	54	58	58	1	2.5	2.5
36	F	19	57	60	59	1	3	2
Sums			1877	1947	1997	47.5	71.0	97.5
Means			52.1	54.1	55.5	1.32	1.97	2.71

*In years. #Sixty possible correct identifications.
(A) 2°30', (B) 30', and (C) 5' convergence.

TABLE 2

- 16 -

NUMBER, AND RANK ORDER, OF LETTERS CORRECTLY IDENTIFIED
BY 36 OBSERVERS (R-GROUP) AT THREE CONVERGENCES
IN A STIMULUS-REDUCED NIGHT SITUATION

Observer	Sex	Age*	Number#			Rank Order		
			A	B	C	A	B	C
1	M	29	58	58	57	2.5	2.5	1
2	M	19	45	46	45	1.5	3	1.5
3	M	25	58	58	58	2	2	2
4	M	29	28	34	36	1	2	3
5	F	18	39	36	38	3	1	2
6	F	20	55	55	54	2.5	2.5	1
7	F	20	56	53	57	2	1	3
8	F	20	45	46	45	1.5	3	1.5
9	M	36	55	59	56	1	3	2
10	M	26	46	58	52	1	3	2
11	M	22	48	41	46	3	1	2
12	F	41	53	58	55	1	3	2
13	F	47	53	56	53	1.5	3	1.5
14	F	27	53	55	55	1	2.5	2.5
15	M	37	46	46	46	2	2	2
16	M	33	58	57	59	2	1	3
17	F	20	58	60	60	1	2.5	2.5
18	F	20	57	57	57	2	2	2
19	M	26	52	51	51	3	1.5	1.5
20	F	18	57	52	54	3	1	2
21	M	22	49	51	48	2	3	1
22	M	14	56	54	56	2.5	1	2.5
23	M	32	40	39	46	2	1	3
24	M	37	35	33	33	3	1.5	1.5
25	M	28	30	32	35	1	2	3
26	F	27	58	52	55	3	1	2
27	F	22	35	34	35	2.5	1	2.5
28	M	27	54	59	56	1	3	2
29	M	23	56	55	56	2.5	1	2.5
30	M	23	56	57	56	1.5	3	1.5
31	M	20	38	36	39	2	1	3
32	M	21	60	58	59	3	1	2
33	M	36	38	39	38	1.5	3	1.5
34	F	38	58	60	60	1	2.5	2.5
35	M	34	57	57	57	2	2	2
36	M	27	56	55	57	2	1	3
Sums			1796	1807	1819	70.0	70.5	75.5
Means			49.9	50.2	50.5	1.94	1.96	2.10

*In years. #Sixty possible correct identifications.
(A) 20'30', (B) 30', and (C) 5' convergence.

Figure 3. Expected and obtained rank scores for S- and R-groups under three convergence conditions. (Data of Tables 1 and 2.)

DISCUSSION

Before concluding that measured visual acuity is a function of phenomenal size, it is first necessary to entertain the possibility that changes in accommodation occurred in such a way as to account for the results obtained. This consideration is necessary since blurring of the parallel rays of light and consequent lowering of the measured acuities would occur with increasing accommodations.

There appear to be two possible ways in which accommodation could have systematically varied: (a) It might have covaried with the changes in convergence; or (b) It might have covaried with the apparent distance of the test chart. The first would indicate a function of convergent accommodation; the second, proximal accommodation.

With regard to the first, Morgan (23, 24, 25) has found no convergent accommodation operative within the limits of convergence used in the present study. Even so, were it operative here, the acuities measured at the greatest convergence (and, therefore, at the greatest convergent accommodation) would have been less than those obtained at the other convergences for both S- and R-groups. Because the measured acuities did not differ for the different convergences of the R-group, we may conclude that the changes obtained with the S-group were not due to convergent accommodation.

The second presents a more difficult picture. Proximal convergence (convergence occurring as a function of the observer's conscious estimate of the position of a viewed object) is known to operate under certain conditions (5, 15, 17, 23, 24, 25, 28, 31). The data for proximal accommodation are less convincing; Morgan (23, 24) and Hofstetter (15) say that there is none, but Ittelson and Ames (19) claim to have demonstrated both proximal accommodation and proximal convergence. This was done in a monocular task wherein apparent distance was changed by use of different sizes of a familiar object suspended at a constant distance. Hofstetter (16) has argued that the convergence thus demonstrated is fully explained as accommodative convergence, granting that the reported accommodation changes were induced. Furthermore, with binocular observation and introspective reports from three observers, Ittelson and Ames (19) report accommodation changes (blurring of a starpoint) as the projected size of a familiar object was continuously varied to give the impression of an object of constant size moving back-and-forth radially. Measurements of the exact accommodation changes were not made in this situation, but measurements of convergence showed no changes. This is confusing in itself, for if accommodation changed as reported, one would expect changes in convergence as a function of the operation of accommodative convergence!

Assuming, nevertheless, that proximal accommodation does exist, and that it operated perfectly under the S-group conditions in the

present study, then the accommodations for the three apparent distances would have been approximately $1/425$, $1/7$, and $1/1.2$ diopter at C, B, and A, respectively. In other words, the accommodative difference between distances C and B would have been approximately $1/7$ diopter, whereas that between distances B and A would have been approximately $5/7$ diopter—roughly five times as great. On this basis the differences expected between the acuities measured at A and B would be much greater than those between the acuities measured at B and C. Since this was not the case, it would appear reasonable to infer that proximal accommodation did not operate here.

The results seem to establish, then, that measured visual acuity is a function of phenomenal size. The finding that the greatest actual mean difference was of the order of only four letters or so (between the C-A difference in the S-group) indicates that this effect is of little practical or clinical importance. It is of theoretical significance, however, in illustrating once again that, as Senders (29) concludes,

"In attempting to determine the basis on which an observer makes a discrimination of a small angular separation, it is no longer possible to consider nothing more than a distribution of intensities on the retina. Nervous processes...are most certainly involved...." (29, p. 488)

--a conclusion similar to one drawn by Boring with reference to interpretation of the Aubert-Foerster phenomenon (8, p. 249).

The type of central factor in acuity supported by these data, however, is certainly not of the order of that reported by Beebe-Center, et al (7) as being formulated by Jaensch (20) who, in an attempted explanation of the Aubert-Foerster phenomenon, concluded that the essential factor is apparent size. He assumed that when objects differ in apparent size their central excitations differ in extension whether or not the retinal images differ. Then he argued that the greater the extension of excitation, the more diffuse and undifferentiated the margins of excitation, and the less the differentiation. If his theory were correct, then measured visual acuity would be an inverse function of apparent size rather than the direct function obtained in this study.

The results obtained here cast a new light on the interpretations to be made of the Aubert-Foerster phenomenon itself. This phenomenon refers to a situation of equal retinal images, equal illuminations, and both large and small acuity test objects. With these conditions it is found that the smaller (and, therefore, closer) objects are resolved farther out in the periphery than the larger (and farther) objects. The results of the present study indicate that it is incorrect to generalize Aubert's results to refer to a greater centrally measured acuity for smaller (and closer) objects than for larger (and farther) objects, both of equal retinal

size and illumination. Perhaps it is best to keep the Aubert-Foerster phenomenon specific to the periphery, rather than generalize it to the central retinal region—even for short distances (7).

Another facet of these results concerns the relationship of measured visual acuity and the distance between the test object and the observer. Beebe-Center, et al (7) reviewed the earlier studies of this question in 1945 and noted many contradictory findings. He and his colleagues concluded that those previous studies failed to present a definitive answer because such factors as learning, extent of field-of-view, illumination of background, etc., were not adequately controlled. Their own studies (7) showed visual acuity independent of distance from the eye for a range of from 12.5 feet to 2.83 miles. Dimmick and Rudolph (10), in 1948, found similar results; acuity was independent of distance for the range 5.94 feet to 113.20 feet. In 1952, Altman and Rowland (4) found no difference between acuities obtained at 20 feet and those obtained in a commercial device which optically simulates the distance of 20 feet. However, Giese (12) measuring visual acuity in 1946 at eight distances over the range 0.20 to 10 meters found acuity increasing significantly from 0.20 to 1.0 meters. In her review of this topic, Sloan (30) concludes that "...For distances of two meters and greater, it seems probable that under adequately controlled conditions acuity is practically independent of distance... (but) there appears to be valid evidence that at relatively short

"distances acuity decreases significantly with decrease in distance....." (30, p. 19)^{6/}. The point to be made here is that perhaps some of the differences among these seemingly contradictory studies can be properly explained in terms of differences in phenomenal size changes of the test object within the separate studies. Such an explanation is suggested here.

SUMMARY AND CONCLUSIONS

In a day-light situation favorable to the operation of size constancy, 36 observers (S-group) read a retinally projected visual acuity chart at three convergences and, thus, at three apparent distances and three conditions of phenomenal size of the chart. An additional 36 observers (R-group) read the same retinally projected chart under similar conditions, but in a stimulus-reduced night situation not favorable to the operation of size constancy; for this group, phenomenal size of the test chart remained constant. The results and conclusions were:

1. Acuties obtained at the three convergences differed significantly among themselves for the S-group, but not for the R-group. This seems to establish measured visual acuity as a function of phenomenal size of the test chart.

^{6/}This conclusion of Sloan's militates, as do the results obtained here, against the generalizability of the Aubert-Foerster phenomenon to the central retinal region.

2. This effect was so small (less than one Snellen rating), it appears to be of little practical or clinical importance. It does offer support, however, to those theories allowing for central factors in measured visual acuity, though one such theory has been shown to be inconsistent with the data.

3. Evidence for convergent accommodation was negative, as was evidence for proximal accommodation.

4. The data suggest that the Aubert-Foerster phenomenon is specific to the periphery and should not be generalized to the central retinal region.

5. It is suggested that some of the differences among the seemingly contradictory results reported with regard to the relation of acuity to distance of measurement can be properly explained in terms of differences in phenomenal size changes of the test object within the separate studies.

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- 28 -
AUTOBIOGRAPHY

I, Earl Arthur Alluisi, was born in Richmond, Virginia, June 11, 1927. I received my secondary school education at Benedictine High School, Richmond, Virginia. My undergraduate training was obtained at Virginia Polytechnic Institute, the University of Minnesota, Yale University, and the College of William and Mary. I received the degree Bachelor of Science from the College of William and Mary in 1949. While in residence there, I acted in the capacity of undergraduate assistant to Dr. Edgar M. Foltin during the year 1948-49. From The Ohio State University, I received the degree Master of Arts in 1950, after which I was recalled into active federal service in the U. S. Army. From May 1951 to December 1952, I served as a Research Psychologist at the Army Medical Research Laboratory, Fort Knox, Kentucky. In January 1953, I returned to The Ohio State University, where I have been in residence while completing the requirements for the degree Doctor of Philosophy. I held the positions of Graduate Assistant and Assistant in the Department of Psychology in 1953. In 1953-54 I was appointed a University Fellow at The Ohio State University. During the summer sessions of 1953 and 1954, I served as Visiting Instructor in Psychology at the College of William and Mary. Since September 1954 I have held the appointment of Research Associate with the Laboratory of Aviation Psychology, The Ohio State University.