PHENOMENAL DISTANCE IN PHOTOGRAPHS AS A FUNCTION OF TAKING LENS FOCAL LENGTH

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ABSTRACT

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Phenomenal distance, as opposed to metric distance, may be defined as the apparent or perceived distance between an observer and some object which he observes. Previous studies have demonstrated that phenomenal distance in photographs perceived as three dimensional scenes is a function of several variables; among them, metric distance, photograph size, horizontal asymmetry, and higher order meanings. This study investigated the effect of the focal length of lenses used to produce photographic targets.

Twenty observers who met a visual acquity criterion of 20/20 positioned three large photographic targets so that the person appeared to be as far from the observer in the large target as in the small stationary target of which there were also three. The person in the scene depicted by the target was in the center midground and faced the camera. In all large targets and in all small targets the person's metric size was fixed. The effect of lens focal length on the targets was evident in the variation of the size of other objects

in the pictures (trees, buildings, etc.) with variation of lens focal length. 35 mm., 50 mm., and 135 mm. Schneider lenses were used with a 35 mm. frame single lens reflex camera.

The results of the study failed to show a statistically significant relationship between lens focal length and phenomenal distance.

Several suggestions for further research were discussed.

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CHAPTER I

INTRODUCTION

It is well known that objects located the same distance from an observer may appear to him to be at different distances. The reverse of this may also be true. Phenomenal distance, as opposed to metric distance, then, may be defined as the apparent or perceived distance between an observer and some object which he observes.

A great deal of work has been done in an attempt to isolate and qualify the variables associated with phenomenal distance and it will be useful to examine some of what has been done to date.

In several studies (4, 12, 16, 3) it was shown that <u>metric viewing distance</u> is related to phenomenal distance. This would, of course, be predicted from the geometry of the situation, but it appears that the geometry fails to account completely for the research results. Bartley and Adair, (4) Bartley and Thompson, (6) and Bartley (3) working with photographic targets have demonstrated that the visual angle subtended by an object in a photograph is not the sole determiner of the phenomenal distance of that object from an observer. When a subject is asked to make a distance judgement by comparing an item with a standard, "metrically enlarging the comparison item reduces its phenominal distance much faster than would be expected from the angular subtense involved." Bartley and Adair (4) report "a certain narrow range of percentages (mostly 76-88%) of what would be expected according to the law of visual angle." In another study, Bartley (3) found phenomenal distances to be roughly 200% of those expected from the visual angles involved.

Gaffron's suggestion that the laws of composition in pictures might be based upon differences in perception of their right and left portions has led to a number of studies the results of which indicate that horizontal assymetry in photographs has broad effects on phenomenal distance. Adair and Bartley, (1) and Bartley and Thompson (6) showed that objects on the left side of a photograph are seen nearer than when the same objects appear on the right. And, there is evidence supporting the position that, up to a point, the greater the horizontal assymetry the greater the effect upon phenomenal distance.

The statements in the preceding paragraph apply primarily to foreground and middleground items. In a study of the effects of background items Bartley and DeHardt (5) showed they are not necessarily seen as nearer when they appear on the left than when they appear on the right. However, Ranny (11) has shown that horizontal imbalance of large background items has an effect on the phenomenal distance of smaller midground items. Further, this effect would seem to be proportional to the position and relative sizes of the midground and "irrelevant" background objects.

Smith (13) and Bartley and Adair (4) in different experimental situations have observed what they call "distance constancy," i. e., relative to photographs, the distance of objects in the print increases with print size and metric viewing distance.

Most of the studies mentioned to this point have used monocularly viewed photographs rather than real three-dimensional scenes as targets, and one might reasonably ask what effects the optical system used in making these photographs could be expected to have upon the phenomenal distance of objects in the scenes. The critical difference among photographic objective lens systems of comparable good quality is focal length. More specifically, then, one might ask what is the effect on the geometry of the visual field of a change in lens focal length.

As focal length increases, frame size remaining constant, several things happen:

1. The relative lateral displacement of objects from the center of the picture increases.

2. The field of view angle decreases.

3. The depth dimension along the line of regard is shortened. All of these effects are the result of optical

magnification and so will be observed to occur in the enlargement of photographs. The point is this, in photographs of the same scene taken with objective lenses of different focal lengths the sizes of background objects and their locations relative to midground and foreground objects may be shown to vary as a function of the difference in the focal lengths of the lenses. Since the size and displacement of background objects have been shown to have an effect on the phenomenal distance of other objects in the picture, one can argue that the optical system employed in making photographic targets to be used in research of this nature should be much more explicitly defined than has been common practice.

The primary purpose of this experiment is to observe the effects of variation in focal length on phenomenal distance. It is predicted that as focal length increases, and the absolute size of the critical object remains constant, phenomenal distance will increase as a result of the relative increase in size of background objects as the visual field is shortened (due to magnification) along the line of regard.

In preparing to test this hypotheseis, a study of the geometry of the visual field brought a rather interesting fact to light. There should be only one viewing distance which will produce the correct perspective relationships in a photograph. That distance is the focal length of the optical system used in making the negative multiplied by the number if diameters of enlargement employed in making the print.(10)

The effect of departure from the theoretically correct viewing distance is readily observed as the extremes. For example, a close-up photograph of a prone figure taken from the feet with a relatively short focus lens shows these appendages to be much too large for the remainder of the figure. In order for the perspective relationships to be correct here the picture would have to be enlarged beyond reasonable proportions or the viewing distance reduced beyond the capability of the eye to accomodate without special lenses. However, if these lenses could be provided, the perspective would appear "realistic."

The specific hypotheses to be tested in this study, then, are:

1. As focal length increases the phenomenal distance of the critical object increases if the size of the object remains constant.
2. When the theoretically correct viewing distance is provided, phenomenal distance will approximate metric prediction from the law of visual angle.

CHAPTER II

METHOD

Observers

Subjects were University student volunteers, all of whom met an acuity criterion of 20/20 corrected in the right eye. Subjects were not checked for eye dominance. (See Thompson, 1959). Group one was composed of ten men; group two, of five men and five women. None of the subjects had knowledge of the purposes of the experiment.

Apparatus

The targets furnishing the stimuli were photographs of two outdoor scenes. Scene "A" showed a woman in a long coat, exactly centered in the picture, standing on the edge of a road which was parallel to the line of sight, formed the major part of the foreground, and disappeared in the background. The other objects in the picture (trees, houses, etc) were behind the figure.

Scene "B" was essentially the same, but the figure stood on the opposite side of the road and the road was lined with forest from foreground to background. (See Figure 1).

Scene A. 50mm.

Scene A 135mm.

Scene B 50mm.

Scene B 135mm.

Fig. 1. Scene A and Scene B taken with 50mm. and 135mm. lenses.

The negatives were made on Kodak Panatomic-X film with a Retina Reflex S and the following Schneider-Kreutznach lenses: f/4, 135 mm; f/2.8, 50 mm.; and f/2.8 35 mm. One frame was made of each scene with each lens making six frames in all. The camera, mounted on a tripod, was at a height of five feet above the ground. The figure was made to exactly fill vertically the ring etched on viewfinder center. This occured at a figure to lens-face distance of 144.5 feet in the case of the 135 mm lens; 54.5 feet for the 50 mm lens; and 40 feet for the 35 mm lens.

Eight by ten inch enlargements without cropping were made on matte paper of each frame and the figure measured to be certain that it was exactly centered and the same size in all cases. Several attempts were made before these conditions were met. The photographs thus obtained were used with both groups of observers and were referred to as the large or moveable targets.

For group "A" a 2X enlargement on matte paper was made of the 135 mm and 50 mm frames of each scene. The former for reasons mentioned in the previous section and the latter because it represents a considerable departure, as reguards perspective, from 135 mm, and, because it is the lens which most nearly approximates the visual field of the human eye.

The same series of prints was used with group II, but the enlargement in this case was 3X. The 2X and 3X enlargements were referred to as the small or stationary targets.

All pictures had a standard 1/4 inch white border and were mounted on identical flat black painted plywood holders.

The apparatus was composed in part of a track 280 inches long calibrated in one inch intervals along which the large moveable targets could be moved through a distance of 21 to 276 inches from the eye by turning a crank on the left side.

The viewing end of the track was supplied with a viewing stand having a nose slot and chin rest. The small targets were placed on the right side of the stand at a distance from the viewer's eye (measured with a standard bar interposed between the eye and the target) of 270 mm in the case of group I, and 4-5 mm in the case of group II. These distances represent the focal length of the lens, in this case, 135 mm times the diameters of enlargement, two and three, respectively.

Both targets could be seen simultaneously and on the same level. A large flat-black screen was positioned at the end of the track opposite the viewer in order to provide a more or less neutral and homogeneous viewing background. The experimental room was uniformly illuminated by fluorescent lights with diffusion grates.

Figure 2 shows the apparatus provided with blank targets in the setting in which the experiment took place.

Procedure

Each observer was given a black eye-patch and asked to place it over his left eye. He was then comfortably seated at the apparatus and given the following instructions:

> This is an experiment in distance perception. Your task will be to position the large picture, using the crank at your left (crank pointed out) so that the figure in the large picture (figure pointed out) appears to be as far from you as the figure in the small picture appears to be. Is this clear? You will be asked to perform this task with several sets of pictures. There is no hurry. You may rest whenever you wish. At the conclusion of the session I will try to answer any questions you may have concerning the experiment or your performance.
>
> Now, I will give you six practice trials to familiarize you with the task, then I will begin to record your responses.

If O had questions about what he was to do, pertinent parts of the instructions were repeated; however, this was seldom necessary.

The pairs of targets were presented to each subject in a different random order. Six responses were recorded for each target pair, three with the large target initially near O, and three far. Every large target was paired with every small target. O then, made a total of 72 judgments, exclusive of practice trials. The time required for this varied from 40 to 90 minutes, approximately.

Fig. 2. The Apparatus with blank targets.

E recorded the judgments on a data sheet after each trial and repositioned the target. He varied the position of the target and his own position relative to the apparatus so as not to provide any constant position referent.

The measure of phenominal distance was in inches from the eye of O to the large target.

CHAPTER III

RESULTS AND DISCUSSION

Table 1 shows the observed group mean distance in inches for group I on each condition of the independant variable for each scene and for both scenes.

Either because of the small visual angles involved or because of the rather close placement of the small stationary target, there was a great deal of variation in the distance of the large moveable target for _O_'s in group I. Many _O_'s stated that the task was very difficult and indicated displeasure with their performance. _O_'s often required several minutes to make a single placement and remained dissatisfied with it after it was made.

It was finally decided to make the task easier for group II by increasing both the print size and the viewing distance for the small stationary print. The visual angle subtended by the critical object was thus increased from 2°6.1' to 2°13.5' and the viewing distance from 10.63 inches (270 mm) to 15.94 inches (405 mm). The same relationship between focal length and viewing distance was maintained for group II as for group I, i. e., the viewing distance was equal to the focal length of the taking lens times the number of diameters of enlargement employed in the print.

TABLE 1

OBSERVED GROUP MEAN DISTANCE IN INCHES FOR GROUP I ON EACH CONDITION OF THE INDEPENDENT VARIABLE FOR EACH SCENE AND FOR BOTH SCENES

Scene	135L	135S 50L	35L
A	112.9	107.1	102.6
B	99.2	92.7	88.6
M	106.0	99.9	95.6
Scene	**135L**	**50S 50L**	**35L**
A	96.1	98.8	100.7
B	102.5	106.8	101.5
M	99.3	102.8	101.1
A *M*	103.0	135S *M*	98.4
B *M*	96.4	50S *M*	101.1
Group I *M*	99.7		

The primary reason for thus altering the task performed by O was to reduce the amount of time he spent in making his placements, and thus, the amount of time during which extraneous features of the situation acted upon him. The amount of time was, in fact, considerably reduced as was variability in placement distance for single O's on single conditions.

The results for group II are shown in Table 2.

A simple analysis of variance was performed on the data obtained from each group to test the significance of the differences between the means for the six experimental conditions. The differences were small, unsystematic, and far from statistical significance at the 10% level of confidence. In addition, a "t" test was performed on the differences between the means for scene A and scene B, for each group. These differences, too, were not significant at the 10% level of confidence.

Since neither significant F's for the experimental conditions nor t's for the scenes could be obtained, conclusions based on selected mean differences would be unwarranted. We must, therefore, conclude that the results of this study fail to show that:

As focal length increases, the phenomenal distance of the critical object increases if the metric size of the object remains constant.

TABLE 2

OBSERVED GROUP MEAN DISTANCE IN INCHES FOR GROUP II ON EACH CONDITION OF THE INDEPENDENT VARIABLE FOR EACH SCENE AND FOR BOTH SCENES

Scene	135L	134S 50L	35L
A	65.4	66.3	61.3
B	65.1	62.6	67.3
M	65.2	64.4	64.3
Scene	135L	50S 50L	35L
A	65.3	65.4	66.2
B	67.5	64.2	66.9
M	66.4	64.8	66.5
A M	65.0	135S M	64.6
B M	65.6	50S M	65.9
Group II M	65.2		

The second hypothesis to be tested by this study was:

<u>When the theoretically correct viewing distance is provided, phenomenal distance will approximate the prediction from the law of visual angle</u>.

The law of visual angle predicted a distance of 38.8 inches for the appropriate conditions in the case of group I and 39.4 inches in the case of group II. The observed phenomenal distances were 106.0 inches and 65.2 inches respectively. Again, we are forced to conclude that the results of the study do not support the hypothesis tested.

The fact that no statistically significant differences between the means of experimental conditions were found is significant at least two points. The first is that we may now place more confidence in the relevance of the results of studies, the photographic targets of which were made with different lenses, to each other. It might still be shown, however, that the effect we were not able to demonstrate in this study is observed when extremely long or extremely short focal length lenses are used or when very short camera to critical object distances are employed. The obvious perspective distortion resulting when these conditions obtain would seem to justify further research on this question.

The second point of significance is that, though the observers did not demonstrate them to be important, there are clear differences between the photographs made with different lenses. Metrically, the only thing which is constant from one picture to the next is the size of the critical item. Although it is clear that the law of visual angle does not account for the data, the size of the critical item seems to be the most important determiner of phenemonenal distance.

Ranney (11) suggested varying the size of an irrelevant background object to test the hypothesis that phenomenal distance is a function of the relative sizes of the critical item and the irrelevant background item. It will be observed that the tree of the right of the person (critical item) in scene A is approximately two thirds the size of the person in the photograph made with the 50 mm lens while it is roughly twice the size of the person in the photograph made with the 135 mm lens. It is also somewhat further away in the latter case due to angular magnification. The results of the present study fail to support the previously mentioned hypothesis, but it is noteworthy that both the critical and irrelevant item appear at or near the center of the target and that the distance between them is not constant from picture to picture. It is also true that the selection of the person for the citical item is probably a poor one for the testing of this hypothesis since the observations may be affected by size constancy.

Two related features of photographic targets remain to be examined: color and contrast. Color is related to contrast by the selective response of even the best panchromatic films to different parts of the spectrum. In this study every effort was made to control contrast in the targets by selecting a group of prints whose contrast was about the same.

This study as several others, (1, 2, 3, 4, 6, 11, 14, 17) is predicted on the assumption that monocularly viewed photographs are experienced as three dimensional scenes. However, it does not follow that observers experience monocularly viewed photographs in exactly the same way that they would monocularly viewed actual scenes. One would predict that as contrast in photographic targets was diminished the phenomenal distance of the critical item would increase. The conditions for aerial perspective are simulated. Decreasing contrast would also tend to degrade the textural gradient. A test of this hypothesis would be very useful since it is quite difficult to control contrast in a series of prints.

In conclusion, the results of the present study fail to show that taking-lens focal length is related to the phenomenal distance of objects in monocularly viewed photographic targets.

SUMMARY

This study examined the effect of photographic lens focal length on the phenominal distance of a person in a scene photographed with three different lenses, 35 mm., 50 mm., and 135 mm., on the same camera.

Twenty observers positioned three variable photographic targets so that the person in the picture appeared to be as far from O in the large target as in the small stationary target, of which there were also three. The person in the scene was in the center midground and faced the camera. In all large targets and in all small targets the person was the same size. The effect of lens focal length on the targets was evident in the variable size of background objects (trees, buildings, etc.).

The results of the study failed to show a statistically significant relationship between lens focal length and phenominal distance.

Suggestions for further research were discussed.

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APPENDIX

SCORES FOR EACH SUBJECT ON EACH CONDITION

GROUP ONE

Sub.	135SA 135LA	135SA 50LA	135SA 35LA	50SA 135LA	50SA 50LA	50SA 35LA
1)	49.1	45.9	47.8	47.3	45.9	40.0
2)	86.8	92.5	88.6	81.9	77.0	84.5
3)	120.4	144.2	101.6	88.3	113.5	108.0
4)	140.2	116.0	110.5	101.5	119.0	118.3
5)	136.0	125.4	158.5	133.2	138.0	166.5
6)	120.0	102.6	102.0	103.2	111.6	91.6
7)	113.4	128.5	116.2	111.2	114.0	110.9
8)	148.0	99.7	98.3	103.7	70.7	86.5
9)	126.0	122.3	112.5	106.4	117.4	115.0
10)	89.0	93.5	90.3	83.9	81.1	85.4

	135SB 135LB	135SB 50LB	135SB 35LB	50SB 135LB	50SB 50LB	50SB 35LB
1)	36.5	36.1	39.3	35.1	35.4	34.2
2)	90.0	84.5	83.0	107.0	94.5	100.0
3)	124.2	143.0	128.0	114.4	147.2	116.5
4)	130.7	106.4	101.0	129.3	154.0	131.7
5)	99.2	112.6	92.4	118.4	125.5	119.3
6)	105.7	98.0	101.4	103.8	100.0	105.4
7)	105.8	92.2	89.0	108.6	103.8	104.5
8)	71.2	67.7	72.7	83.0	84.0	83.3
9)	118.0	99.3	95.5	119.0	126.0	118.2
10)	101.4	87.6	84.2	106.9	97.3	102.0

GROUP TWO

Sub.	135SA 135LA	135SA 50LA	135SA 35LA	50SA 135LA	50SA 50LA	50SA 35LA
1)	50.0	50.6	48.6	54.3	60.7	52.9
2)	44.1	44.7	47.0	56.0	58.6	51.1
3)	99.7	122.2	111.7	86.0	102.0	113.0
4)	86.7	93.2	93.7	82.2	84.5	98.5
5)	74.5	63.7	58.0	83.2	71.5	74.2
6)	88.0	89.5	89.5	79.7	80.7	77.5
7)	49.7	43.7	38.0	51.0	48.2	48.5
8)	54.0	42.0	41.5	46.0	42.0	37.7
9)	51.6	54.4	38.9	54.1	50.0	51.3
10)	55.5	59.1	47.2	60.2	56.3	57.2
	135SB 135LB	135SB 50LB	135SB 35LB	50SB 135LB	50SB 50LB	50SB 35LB
1)	36.4	44.5	59.9	51.6	41.7	53.1
2)	42.9	46.6	48.1	43.5	45.1	43.5
3)	117.5	112.7	117.7	119.5	117.0	129.5
4)	80.2	83.5	77.5	74.7	77.7	75.7
5)	90.7	81.7	93.5	99.0	82.0	87.5
6)	81.2	80.7	82.0	81.5	79.2	75.7
7)	54.5	37.0	48.2	54.5	51.5	53.2
8)	44.5	45.7	46.5	45.7	45.5	47.0
9)	56.1	46.3	51.0	56.7	54.9	55.5
10)	46.6	47.8	49.0	47.9	47.8	48.1

ROOM USE ONLY