THE RELATION OF CERTAIN TARGET FACTORS TO PHENOMENAL DISTANCE

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Richard Warren Thompson

1959

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BY

Richard Warren Thompson

A THESIS

Submitted to the College of Science and Arts
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

Department of Psychology

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AN ABSTRACT

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The present study was designed to investigate the effect of picture size on the phenomenal distance of objects in pictures and, the effect of which way a man is facing in a picture on the phenomenal distance of that man.

A psychophysical method was used that enabled an observer to make comparisons between a small fixed standard target and larger comparison targets. By turning a crank, an observer could move the comparison target to a position so that it was phenomenally equal to the fixed target. The distance between the observer and the comparison target was a measure of the phenomenal difference in the two pictures.

Five photographic prints of increasing size of each of two scenes were used as comparison targets. A smaller print of each of these scenes was used as the standard target. One scene depicted a man standing in a road facing the viewer, the other depicted the same man with his back to the viewer. Each standard target was compared only to comparison targets that depicted the same scene.

Eighteen observers made five comparisons with each comparison target, or a total of twenty-five comparisons with each standard.

Specifically this experiment was designed to test the hypotheses that as picture size increases, the apparent distance of objects in the picture would decrease, and that a man in a photograph with his back to the viewer will appear closer than a man facing the viewer.

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If the hypotheses are true then the observer would place the larger targets farther from him than the smaller targets, and the photograph depicting a man with his back to the viewer farther than the photograph of a man facing the viewer.

The experimental results supports both hypotheses. As target size increased, the targets were moved farther from the observer. The targets with the man with his back toward the viewer were moved farther away than the targets showing a man facing the viewer. The distance obtained for both scenes were greater than would be predicted by the law of visual angle but did not demonstrate "metric indifference" that would be expected by the law of constancy. That the results were a compromise between the two laws was rejected on the grounds that there can not be a compromise between a finite distance and an infinite number of distances.

Approved by: S. Bartley

Date: May 20 - 1959

ACKNOWLEDGMENT

I deeply appreciate the continuous help and constructive suggestions given by Dr. S. Howard Bartley during the formulation and execution of this research.

I also wish to thank Dr. Charles Hanley and Dr. Stanley Ratner for reading the manuscript and offering helpful criticism.

R.W.T.

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INTRODUCTION

Painters and photographers have for many years manipulated the factors that determine the apparent distance of elements in paintings and photographs to achieve the effect of distance they desired. Only resently has psychological investigation of some of these factors been undertaken.

Ames (3) and Schlosberg (10) have listed several ways in which the depth effect in pictures can be enhanced. They suggested, to give only a partial list, viewing the picture from a distance, monocularly, or through a small hole.

Gaffron (9) presented an introspective analysis of the difference in phenomenal distance of elements in paintings due to their lateral orientation. She presented an "empirical glance curve" as a partial explanation for the apparent difference in the distance of objects in a picture and its mirror image. The object in the left half of a picture was seen as closer than an object in the right half. Adair and Bartley (1) and Bartley and Thompson (7) have investigated this problem of the phenomenal difference between the left and right in photographs by a psychophysical method. Adair and Bartley presented their Ss with a picture and its mirror image. They used several scenes of varying asymmetry, the picture and its mirror image serving alternately as the standard and comparison target. The standard picture was always smaller than the comparison picture. The Ss moved the comparison target out a track until it appeared the same distance from him as the standard.

The results indicated that the left half of a photograph was seen as closer than the right half. Bartley and Thompson using the same psychophysical method systematically varied the position of a man in a photograph from left to right and obtained essentially the same results.

The effect of viewing distance on the apparent distance of objects in pictures has been studied by several investigators using different methods. Smith (11) had his Ss view a large photomural of a corridor monocularly, their view was restricted to the image area of the mural. The Ss estimated how many paces from their viewing point to a point in the corridor depicted in the mural and from that point to the end of the corridor. The results indicated that as the distance from which a picture was viewed decreased, the apparent distance of objects in the picture decreased, i. e., the Ss estimated more paces for the photograph viewed farther away than for the one viewed closer.

Smith (12) in another study presented his Ss with a photograph of a field with several stakes in it. His Ss viewed this photograph monocularly from each of two positions and estimated the distance in yards to one of the far stakes. The Ss estimated the stake was closest to them in the photograph that was viewed closest to them. Smith and Gruber (14) used another method and obtained substantially the same results. In this study, a photomural of a corridor was viewed monocularly from five different distances. This was the comparison target.

The standard target was the actual corridor depicted in the photomural. The Ss made ratio-judgments of the apparent depth of the mural in comparison with the corridor. As the photomural was moved closer to the eye of the S, its apparent depth decreased.

Bartley and Adair, (6) using the same phychophysical method described earlier by which a S could move a comparison target until it was perceptually equal to a standard target, got results in agreement with the workers mentioned above. These investigators presented their Ss with a small standard target at each of three distances. The Ss moved each of three larger comparison targets out a track until they appeared equal in distance to the standard. They found that as viewing distance decreased so did the distance at which the comparison target was placed, it appeared closer.

The effect of picture size is yet another variable that has been investigated. Smith, Smith, and Hubbard (13) used the following method to investigate this factor. The Ss in this experiment viewed four targets, a photograph, a line drawing with full detail, a shaded line drawing, and a line drawing, all of the corridor depicted in the photograph. A slide was made of each of these targets and projected on to a screen from each of five positions. These were the comparison targets. The standard was a slide of the photograph projected from the middle distance of the comparison targets. The Ss made ratio-judgments of the distance to the end of the corridor in the comparison targets in relation to the standard target.

The results of the experiment indicated the apparent distance of the end of the corridor increased as the projected image size decreased. Ratio-judgments were greater for the slide projected from near the viewer than for the far position. The obtained ratio-judgments were significatly different than those predicted by the law of visual angle. They found no consistent differences due to the amount of detail in the targets but this result was obscured because the slides for the various targets were found, subsequent to the experiment, to be of different sizes.

Bartley and Adair in the study mentioned earlier not only varied viewing distance but also target size. They used four photographic prints of the same picture, a 1 X 1, 3 X 3, 4 X 4, and a 6 X 6 inch enlargement. The 1 X 1 served as the standard and the other three the comparison targets. They found that as target size decreased apparent distance of objects in the target increased. This is the same kind of results as obtained by Smith, Smith, and Hubbard but by use of a different method.

Bartley and Adair also indicate that their results do not follow either the law of visual angles or the law of constancy. The law of visual angle predicts a definite distance for each target, the law of constancy predicts, that the targets would appear equal regardless of their distance to the eye. That is, any place on the track would be equally good for matching the apparent distance of the objects in the comparison target with objects in the standard (4,5).

The results they obtained range from 76 to 88 percent of what is expected by visual angle. To say that the results are a compromise between the two laws is not logical. They say, "How can a numerical compromise between a fixed value, and an infinite number of values all of which are equally good (constancy) occur?" It appears as if the law of constancy is not the salient factor involved.

Another factor mentioned briefly by Gaffron concerns the disposition of objects in pictures. In her analysis of Rembrandt's Return of the Prodigal Son she stated that the sense of nearness of the figure in the left foreground, kneeling with his back turned toward the viewer, was in part due to the sense of personal identification with the person with his back turned toward the viewer. She says,

> A person standing in the left foreground with his back turned toward us arouses a decided feeling of identification with ourselves, because his position comes nearest to the one we assume as spectators. For the same reason we feel that a person looking out of the picture from the left foreground is directly opposed to us.

To summarize, five factors have been investigated that have been found to influence apparent distance in pictures. The overall depth effect in a picture can be increased in several ways, one of which is viewing the picture monocularly. The left side of a picture is seen as closer than the right. Decreasing the size of a picture or increasing the distance from which it is viewed will increase the apparent distance of an object in a picture. It was also suggested that a front view of a person in a picture will appear farther from the viewer than a back view.

These findings must be taken into consideration in designing any experiment to investigate factors involving apparent distance in pictures.

The present study was designed to investigate the effect of picture size on the apparent distance of objects in pictures and Gaffron's statement that the direction a person is facing in a picture will, in part, determine his apparent distance. The specific hypotheses to be tested are:

a. As picture size increases the apparent distance of objects in the picture will decrease.

b. That in a picture depicting a man with his back turned toward the viewer the man will appear closer than in a picture showing him facing the viewer.

METHOD

SUBJECTS: The Ss for this experiment were 15 men and 3 women students from an introductory course in psychology. The Ss were volunteers and received class credit for participating in experiments. All the women Ss were 19 years of age, the men Ss ranged in age from 19 to 29 years. Five additional Ss participated in the experiment but their data are not included in the analysis because more than three of their judgments for any one target were beyound the range of the apparatus. None of the Ss had any knowledge regarding the purpose of the experiment. To discourage questions about the experiment, the Ss were told it was part of a larger experiment to be explained later.

APPARATUS: Six photographic prints of each of two scenes were used as stimuli or targets in this experiment. In Fig. 1 is a print of each of these scenes. The scene in each case depicts a man standing in the middle of the road and are symmetrical except at the extreme left and right edges. The only difference in the two scenes is that in one the man is facing the camera and in the other his back is turned toward the camera. The photographs were taken with a 4 X 5 Speed Graphic camera with a 135 mm Graflex Optar lens. The photographs were taken at a height of five feet two inches above the ground. The man was 52 feet from the camera.

A 2 X 2 inch cropping of both the original negatives exactly centering the man in the scene was used to make a

1 X 1 inch reduction, a 2 X 2 inch print, and a 3 X 3, 4 X 4, 6 X 6, and a 8 X 8 inch enlargement on white matt photographic paper. The 1 X 1 print for each scene was called the Front and Back standard. The larger prints were the comparison targets. Each of these prints had a 1/8 inch white border and were mounted on a plywood standard painted flat black so that a 1/8 inch black border surrounded the print. This made the over-all size for each target greater by one half inch.

In Fig. 2 is a picture of the main part of the apparatus with a blank standard and comparison target in the positions as they would appear to the S. The main part of the apparatus was a 280 inch track along which adjustments were made. A movable rider on the track held the comparison targets. This rider could be moved, by turning a crank on the left side of the viewing stand, as close as 21 inches and as far as 276 inches from the eye. Standard targets were mounted on the right side of the viewing stand 14 inches from the S's eye. The track was calibrated in one inch intervals.

On the S side of the viewing stand was a chin rest and nose slot to assure each S had his head and eye in the same position in relation to the two targets. Both targets could be seen at the same time. An eye shield for either left or right eyed viewing assured monocular viewing and prevented the S from seeing the track.

Fig. 1

Sample Targets

Fig. 2

Picture of the Apparatus

Both the standard and comparison targets were at the same level no matter where the comparison target was on the track.

The S was seated in an ordinary chair so that he could comfortably place his chin in the chin rest. No attempt w as made to limit the peripheral vision of the S.

The targets were viewed against a flat black background. The experimental room was lit by four equally spaced incandescent bulbs with diffusion bowls which illuminated the targets equally anywhere on the track.

PROCEDURE: Each S was brought into the experimental room, seated at the apparatus, and given the following instructions to read:

> This is an experiment in distance judgment. You will be presented a small standard target on the right and several comparison targets on the left. You are to place your chin in the chin-rest with your nose in the slot and view these targets with one eye (the experimenter will tell you which eye to use.) By turning the handle on the left side of viewing stand you are to move the comparison target to such a distance that the man in the standard and comparison targets appears the same distance from you. You will make five practice judgments and then 50 the experimenter will record. Are there any questions?

If the S had any questions concerning the procedure, the E clarified them by paraphrasing the original instructions.

Each S used his dominant eye for viewing the targets. Eye dominance was determined in the following way. The E told the S to line up his finger, using both his eyes, with a vertical line some ten feet away. He was then told to close his left eye being sure not to move his head or eyes.

If the finger remained lined up, he was considered right eye dominant and used his right eye in making judgments. If the finger did not remain lined up, he was considered left eye dominant and used his left eye to make judgments.

The practice comparisons were made with the same standard that was used first in making the recorded judgments. The comparison targets were presented starting with the smallest and ending with largest for these practice judgments. The standard used first varied randomly from S to S.

After the five practice judgments, the E answered any further questions the S had concerning the procedure. The S then made twenty-five judgments, five comparisons with each of the comparison targets, for each standard. A cross comparison between Front and Back Targets was not made. Each S completed all his judgments with one standard before making any judgments with the other. The comparison targets were presented in a random order with the exception that the same comparison target was never presented twice in succession.

After each judgment had been completed, the E moved the rider on the track to a different position so that the S never moved the target just away from or just toward him to make judgments.

The assumption in this procedure was that an S would be able to move a comparison target on the track to a position that would equalize the apparent distance of the man in the two targets.

The measure of apparent distance was the distance in inches from the S to the comparison target.

The E recorded each judgment on a data sheet. The S had no knowledge of his results.

RESULTS

Fig 3 shows the mean distance in inches for each target for the two sets of five targets, Front and Back, for 18 Ss. The distance predicted by the law of visual angle for each target size is also plotted in this figure. The two curves drawn for the observed distances were fitted by inspection.

In Table 1 the observed mean distance for each target and the predicted distance by the law of visual angle for these targets are tabled. These means are based on the median of five judgments of each of 18 Ss for each target.

Of the 18 Ss, 11 were right eye dominant and 7 were left eye dominant. The two groups were combined for analysis after an inspection of the data indicated that the only difference between the two groups would be in absolute distance for each target. The mean distance for the left eye dominant Ss for most targets was greater than for the right eye dominant Ss. This could be accounted for on the basis that the left eye Ss viewed the standard target from a slightly greater distance and the comparison target from a slightly lesser distance than the corresponding targets for the right eye dominant Ss. In view of the influence of viewing distance on the apparent distance of objects in pictures, the results obtained were the results expected. The conclusions drawn for the two groups separately would be no different than for the two groups combined. (2)

Graph Showing the Relationship Between Target Size and Phenomenal Distance and the Facing of the Man in the Target and Phenomenal Distance. Phenomenal Distance is Indicated by the Distance in Inches Each Target was Moved. Distance Predicted by Law of Visual Angle is also Plotted

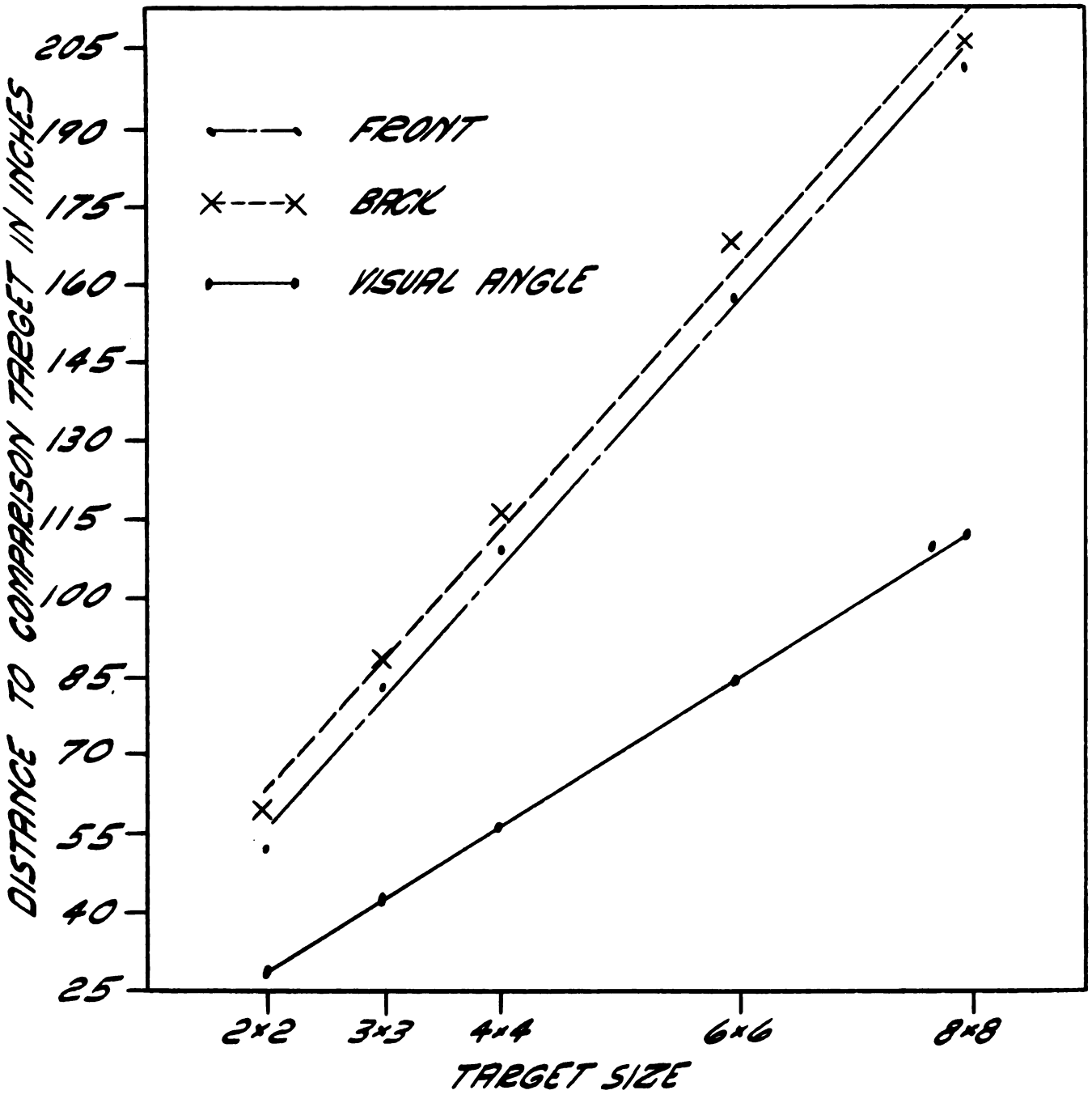

Fig. 3

The data (using the median of each S for each target as a score) were tested for homogeneity of variance by Bartlett's test and were found to be heterogeneous, $X^2 = 58.15$, df = 9, $P < .01$. The data were transformed by the square root transformation and again tested for homogeneity of variance by Bartlett's test and were found to be homogeneous, $X^2 = 8.55$, df = 9, $P > .30$. (8) The transformed data were analyzed by analysis of variance and a summary of the results is presented in Table 2. (2,15)

As can be seen, the statistical analysis of the data supports the graphic presentation. As target size increased the apparent distance of the man in the target decreased and the target was placed farther away from the S. The effect of target size was significant, F = 671.31, df = 4 and 68, $P < .01$, (the S X O interaction was the error term). The significant interaction of Sizes with Observers, F = 3.25, df = 68 and 68, $P < .01$ (the error term was the S X F X O interaction), indicates there was a differential effect of target size for different Ss. Although the ranking of the targets was the same for all Ss, the distance between the targets was not.

The difference between the two sets of targets, Front and Back, was also significant, F = 5.50, df = 1 and 17, $P < .05$ (the F X O interaction w as the error term). The man with his back to the Ss was seen as closer and therefore moved farther away from the S than was the man facing the S.

TABLE 1

Obtained Mean Distance in Inches and Distance Predicted By Law of Visual Angle for Each Comparison Target

Target Size	Front	Back	Visual Angle
2 X 2	53.1	58.7	28
3 X 3	82.5	88.3	42
4 X 4	108.9	116.1	56
6 X 6	156.5	167.6	84
8 X 8	201.0	205.5	112

TABLE 2

Summary of Analysis of Variance for the Transformed Data Based on the Median of Each S for Each Target

Source	df	MS	F
Sizes	4	261.81	671.31**
Facings	1	4.40	5.50*
Observers	17	17.44	145.33**
S X F	4	0.06	0.50
S X O	68	0.39	3.25**
F X O	17	0.80	6.67**
S X F X O	68	0.12	
Total	179		

**Significant beyond the 1 percent point.
*Significant beyond the 5 percent point.

The significant interaction of Facings with Observers, $F = 6.67$, $df = 17$ and 68, $P < .01$ (the S X F X O interaction was the error term), indicates that not all the Ss saw the Front and Back targets in the same way. An inspection of the data reveals that ten Ss placed the Front targets closer to them than the Back. Two Ss placed the Front targets farther from them than the Back. Four Ss placed four of the five Front targets closer than the Back and one S placed four of the five Front targets farther than the Back. The other S was not consistent in which target was placed closest.

The interaction between Target Size and Facings which was not significant, $F = 0.50$, $df = 4$ and 68, indicates that the curves plotted are essentially parallel. (The S X F X O interaction was the error term.)

The significant difference between Observers, $F = 145.33$, $df = 17$ and 68, $P < .01$ (the S X F X O interaction was the error term), indicates that the Ss differed in their absolute response to the targets.

In Table 3 the confidence interval, $P < .01$, for the mean of each target is tabled along with the distance predicted by law of visual angle for the transformed data. This confidence interval was computed using the Sizes by Facings by Observers interaction as the error mean square. (2) It can be seen by this table that the confidence interval for each target does not include the distance predicted by the law of visual angle but is greater than that distance.

TABLE 3

Confidence Interval at the One Percent Level for the Mean Of Each Target Based on the Transformed Data and the Square Root of the Distance Predicted by the Law of Visual Angle for Each Target

Target	Confidence Interval	Visual Angle
2 X 2 Front	6.99 -- 7.41	5.29
2 X 2 Back	7.37 -- 7.79	
3 X 3 Front	8.80 -- 9.22	6.48
3 X 3 Back	9.10 -- 9.52	
4 X 4 Front	10.14 - 10.56	7.48
4 X 4 Back	10.45 - 10.87	
6 X 6 Front	12.25 - 12.67	9.17
6 X 6 Back	12.64 - 13.06	
8 X 8 Front	13.85 - 14.27	10.58
8 X 8 Back	14.04 - 14.46	

DISCUSSION

The results of this experiment supports both of the hypotheses stated in the first part of this paper.

a. As picture size increases the apparent distance of objects in the picture will decrease.

b. A man in a picture with his back turned toward the viewer is seen as closer than a man in a picture facing the viewer.

In a very consistent manner 18 untrained Ss placed each target progressively farther from their eye as the target size increased. The distances obtained were significantly greater than would be predicted by the law of visual angle.

The decrease in apparent distance with the increase in target size are in keeping with the results obtained by Smith, Smith, and Hubbard although a different method was used in each study. These investigators also found their results significantly different from visual angle predictions.

It would be expected that the results obtained in this experiment and the results obtained by Bartley and Adair would be consistent since almost the same method and targets were used in both studies. The general conclusion of decrease in apparent distance with an increase in target size is the same in both studies. The results of the two studies differ in the absolute distance at which the targets were placed.

Bartley and Adair obtained distances that were less than those predicted by the law of visual angle while the results in the present study are significantly greater than visual angle predictions.

There are several differences in the two studies. One is the distance used for the standard target. Bartley and Adair used 16, 24, and 32 inches, the present study, 14 inches. From the results mentioned earlier concerning the effect of viewing distance on the apparent distance of objects in the picture, it would be expected that the Ss in Bartley and Adair's study would place their targets even farther than the Ss in this study.

Another variable that was different in the two studies was the number of comparison targets used.

In both studies there were significant differences between Ss and the S variability was great. These may be the factors that account for the difference in the results.

As was mentioned before, the generalization of the relation of picture size to apparent distance in pictures is not changed by the different results in the two studies.

Nor does the result of this study contradict the analysis Bartley and Adair gave their data concerning the law of visual angle and the law of constancy. The results of this study do not fit the law of visual angle nor do they fit the law of constancy, i. e., "metric indifference".

If the law of visual angle had been followed, the Ss would have placed their targets near the points predicted by this law. Only one S's data was close to these predictions. The other Ss made judgments greater than the law of visual angle predicts.

If the Ss had been following the law of constancy, their results would have indicated not one consistent distance but "... that no matter where the comparison target was put, or no matter what its size, the scene in it always looked as far away as the same scene in the fixed reference print." (5) The Ss in this experiment did not show this "metric indifference." They were able to make the judgments in a very systematic way.

Regardless of what the crucial factors are in explaining the results obtained in these two studies, it is apparent that one is not a compromise between the two laws nor does the law of constancy predominate.

The finding regarding the second of the two hypotheses is quite in line with the introspective analysis of Gaffron mentioned earlier. That is, a person with his back turned toward the viewer is seen as closer than a person facing the viewer in a picture. Because the results are based on only one picture, any generalization would be premature although it might be suggestive for more research with this variable.

The object that was reversed in the present study occupied a dominant place in the picture as a whole. Would the same relationship hold for objects that do not occupy such a dominant place?

Gaffron has suggested that the difference in the front and back in pictures is due to the viewer's sense of identification with the person depicted. Would this sense of identification hold for animals or inanimate objects? Further research is necessary before any generalization about the front and back in pictures can be made with any confidence.

To summarize briefly, the following factors have been found to enhance the nearness of objects in pictures.

a. Having the object in the left foreground.

b. Viewing the picture from close rather than far away.

c. Using a large picture rather than a small picture.

d. Show the rear view of an object rather than a front view.

A variable that has not been investigated but one that might well be a determinant is the size of the object in relation to the rest of the picture. In the present study the size of the man increased in the same amount as the whole photograph. What would be the effect of increasing the size of the man, holding picture size constant?

SUMMARY

An experiment was carried out to determine (1) the effect perceptually of increasing photograph size on the apparent distance of objects in the photograph, and (2) if there was a phenomenal difference between the front and back view of a man in a picture.

Eighteen observers were asked to compare a small fixed standard picture with each of five larger comparison pictures, enlargements of the small standard, (in which the crucial object in the picture was a man standing facing the observer, or standing with his back turned to the observer.) The observers could move the larger comparison targets toward or away from them by turning a crank and in this way set them at a distance perceptually equal to the standard. In each comparison, the scenes were identical except for the size of the pictures.

The results indicate the following conclusions can be drawn:

(1) As picture size increases the apparent distance of objects in the picture decreases.

(2) A man in a picture facing the viewer is seen as farther away than a man in a picture with his back turned toward the viewer.

(3) The distance obtained for each target does not follow either the law of visual angle or the law of constancy--"metric indifference".

A summary of the variables influencing the apparent distance of objects is pictures was given together with some suggestions for future research.

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APPENDIX

Mean Distance in Inches for Each Target For Right and Left Eye Dominant Observers

Target	Right	Left
2 X 2 Front	53.41	52.61
2 X 2 Back	59.36	57.64
3 X 3 Front	82.07	83.11
3 X 3 Back	88.57	87.85
4 X 4 Front	106.48	112.71
4 X 4 Back	110.82	124.46
6 X 6 Front	151.50	164.93
6 X 6 Back	164.23	171.50
8 X 8 Front	189.70	212.29
8 X 8 Back	201.73	209.43