DISTAL AND PROXIMAL SIZE UNDER REDUCED AND NON-REDUCED VIEWING CONDITIONS

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Of the many aspects or properties of objects a person can perceive, the perception of size has loomed large as a field of investigation. A recent review by Epstein, Park and Casey attests to continuing interest in this area.[1] Early investigations dealt with the processes by which a person perceives the size of an object that accords with its real or distal size. There is ample evidence that a person can judge the distal size of an object accurately under favorable conditions. In addition to this ability, he can also judge the visual angle subtended by the object, the proximal size, with some degree of accuracy when instructed to do so, and under restricted viewing conditions.[2] Thus, one can perceive two attributes or properties of the size of objects, and theories on the subject have attempted to include both types of perception.

One early interpretation of perceived size was an extension of Titchener's context theory. Boring characterizes as core in the perception of size the sensory data derived from the size of the retinal image and as context all the sensory data pertaining to the distance of the object, as well as the properties of the brain that influence perception.[3] The perceived size was thought of as the integration of information from retinal size and from the context of the retinal image. Later, Boring suggested two extreme types of perception, representing in part the results of two observational attitudes. These correspond perhaps to Gibson's distinction between the visual field

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[1] William Epstein, John Park, and Albert Casey, The current status of the size-distance hypothesis, *Psychol. Bull.,* 58, 1961, 491-514.

[2] For the influence of instructions, see J. C. Baird, Retinal and assumed size cues as determinants of size and distance perception, *J. exp. Psychol.,* 66, 1963, 155-162; V. R. Carlson, Overestimation in size-constancy judgments, this JOURNAL, 73, 1960, 199-213; Size-constancy judgments and perceptual compromise, *J. exp. Psychol.,* 63, 1962, 68-73; Epstein, Attitudes of judgment and the size-distance invariance hypothesis, *J. exp. Psychol.,* 66, 1963, 78-83; A. S. Gilinsky, The effect of attitude upon the perception of size, this JOURNAL, 68, 1955, 173-192; Noël Jenkins and Ray Hyman, Attitude and distance-estimation as variables in size-matching, this JOURNAL, 72, 1959, 68-76. For the influence of restricted conditions, see A. H. Hastorf and K. S. Way, Apparent size with and without distance cues, *J. gen. Psychol.,* 47, 1952, 181-188; A. H. Holway and E. G. Boring, Determinant of apparent visual size with distance variant, this JOURNAL, 54, 1941, 21-37; William Lichten and Susan Lurie, A new technique for the study of perceived size, this JOURNAL, 63, 1950, 280-282.

[3] E. G. Boring, The perception of objects, *Amer. J. Phys.,* 14, 1946, 99-107.

and the visual world.[4] But Boring suggests that perceived size in fact falls between two extremes. Brunswik, in his probabilistic functionalism, also makes size a function of attitude. The perception of visual angle was thought to reflect an analytic attitude; whereas the perception of actual size was thought to reflect the realistic attitude.[5]

When two contrasting instructions are given, it is consistently found that different size estimations result. However, brief and ambiguous instructions, such as "make these objects look alike," lead some *S*s to set the variable stimulus close to the distal size and lead others to set it close to the proximal size.[6] Thus, it is not clear whether one type of perception is preferred or more natural for a person and whether there are different preferences in different viewing conditions.

The purpose of the present study was to investigate which type of perception is actually employed by *S*s under two different viewing conditions when no specific instructions were given. To investigate this problem, a task with learning and transfer sessions was employed which required *S* to form his own concept of what was necessary. *S*s were asked to discover the correct association between a number of standard and comparison stimuli. We called the comparison stimulus "correct" for some *S*s when it had the same measured distal size as the standard stimulus. For others we defined the comparison stimulus as 'correct' when it had the same proximal size as the standard stimulus. Furthermore, we had two viewing conditions: a non-reduced condition (normal unrestricted viewing) and a reduced condition (elimination of distance cues). The question asked was which response class is easier to learn under each of the two viewing conditions? The assumption was that more rapid learning would reflect the natural tendency of the perceiver.

METHOD

Apparatus and stimuli. The apparatus consisted of a lighted panel, used as a standard stimulus, and two sets of black rectangles, used as comparison stimuli. The lighted standard panel was located in a 4 × 5½ × 32-ft. reduction-tunnel. This was constructed by draping black cloth over two wires to cover the 32-ft. space.

The standard was a rectangular field centered at the eye-level of the seated *S*. This was provided by a light-proof box, one side of which was a uniformly illumi-

[4] Boring, Visual perception as invariance, *Psychol. Rev.*, 59, 1952, 141-148.

[5] Leo Postman and E. C. Tolman, Brunswik's probabilistic functionalism, in S. Koch (ed.), *Psychology: A Study of a Science*, I, 1959, 502-564.

[6] See, for example, Gilinsky, *op. cit.*, 173-192; B. E. Holiday, Die Grössenkonstanz der Sehdinge bei Variation der inneren and äusseren Wahrnehmungsbedingungen, *Arch. ges. Psychol.*, 88, 1933, 419-486; Sylvia Klimpfinger, Über den Einfluss von intentionaler Einstellung und Übung auf die Gestaltkonstanz, *Arch. ges. Psychol.*, 88, 1933, 551-598; T. M. Martin and R. W. Pickford, The effect of veiling glare on apparent size relations, *Brit. J. Psychol.*, 29, 1938, 91-103; M. R. Sheehan, A study of individual consistency in phenomenal constancy, *Arch. Psychol.*, 31, 1938 (No. 222), 1-95.

nated milk-glass screen. It was located behind an opening in a flat-black board at the end of the tunnel. The size of the standard stimulus was varied by placing a rectangular frame in front of the milk-glass. There were five standard stimulus sizes: 9 × 0.9-cm., 22 × 2.2-cm., 27 × 2.7-cm., 33 × 3.3-cm., and 54 × 5.4-cm. The standard stimuli were placed at two distances in the tunnel.

The comparison-stimulus panels were placed 10 ft. to the left of *S*. A panel consisted of 13 black rectangles pasted on an 80 × 100-cm. white background. The bases of the rectangles were at the same level, and the sizes were randomly ordered. The two panels differed in that the rectangles were in a different random order. Below each rectangle was a letter of the alphabet, starting with 'A' on the left and ending with 'M' on the right. The sizes of the comparison-stimuli on each of the panels were chosen as follows: five were the same size as the five standard stimuli; five were half the size of the standard stimuli (*e.g.* half of the 9 × 0.9-cm. rectangle was 4.5 × 0.45-cm.); and five were one-third the size of the standard stimuli. When duplicates were eliminated, there were altogether 12 comparison-stimuli. To make less obvious the gap between the 54 × 5.4-cm. and the 33 × 3.3-cm. stimulus, a 44 × 4.4-cm. stimulus was added. Thus, there were 13 comparison stimuli. Each of the stimuli, except the 44 × 4.4-cm. rectangle, was classified as 'correct' under one or more of the experimental conditions. The comparison-stimuli were presented without restriction in viewing for all the experimental conditions.

Procedures. When *S* was seated in front of the tunnel, the following instructions were given:

Instructions. The purpose of this experiment is to find out how students learn to associate two things. This is how we shall proceed: We will show you a vertical bar of light. Your task is to learn which of the bars on the panel to your left is associated with it. The same bar may occur more than once. First you must guess. I will tell you whether your choice is correct. If it is incorrect, you are to make another choice. You may look back and forth as often as necessary to make each choice. When you have made the correct choice for one bar, we shall go on to the next bar of light. Your task is completed when you have learned the correct association for all bars presented to you. Do you have any questions?

For half of the *Ss* the lighted standard stimulus was first placed in the tunnel at 20 ft.; for the other half it was first placed at 30 ft. A trial began when *E* opened a guillotine door in front of *S*. Lifting the door confronted *S* with either a 1 x 1-ft. aperture or a ⅛-in. diameter aperture, depending on the experimental condition. Any given trial lasted until the correct response was given. When a correct response was given, *E* lowered the door. A block of trials consisted of the presentation of each of the five standard stimuli in random order. The criterion for learning was completion of a block of trials with no errors. When *S* met this criterion, he was sent out of the room and the distance of the standard stimulus was changed either to 30 ft. from 20 ft., or vice versa. At this time the panel with the comparison-stimuli was also changed. *S* was then brought back into the room and was told that his task was the same as before. For the sake of easier description throughout this paper, the first part of the experiment will be referred to as the learning session, and the second part will be referred to as the transfer session. The criterion of learning in the transfer session was the same as for the learning session.

White noise was present throughout the experiment in order to mask any sounds *E* might make while changing the standard stimulus.

After the transfer sessions were finished, each *S* was asked to estimate from memory the distances of the two locations used for the standard stimulus. Then he was asked to describe how he solved the problem.

Four experimental conditions were employed, as follows: In the nonreduced-distal (*NR-D*) condition, *S* viewed the standard stimulus through the large aperture with binocular regard. The cloth on one side of the tunnel was lifted up and two or three lights were visible on the tunnel floor, two when the standard was at 20 ft. and three when the standard stimulus was at 30 ft. Under this condition, the correct response was defined as the distal or objective size.

In the non-reduced-proximal (*NR-P*) condition, *S* viewed the standard stimulus under the same open conditions, but the correct response was now defined as the proximal, that is, the retinal stimulus-size. For example, when the standard stimulus was 9 × 0.9-cm. at 20 ft., the correct answer was the 4.5 × 0.45-cm., stimulus on the comparison stimulus panel (same visual angle).

In the reduced-distal (*R-D*) condition, the cloth was draped on both sides of the tunnel, and the only light in the tunnel was from the standard stimulus. *S* viewed the standard stimulus through the very small aperture with monocular regard. The correct response was defined as the distal size.

In the reduced-proximal (*R-P*) condition, the viewing condition was the same as in the *R-D* condition, and the correct response was the proximal stimulus size.

Subjects. Forty-nine Stanford undergraduates (41 men and 8 women) participated in the experiment as part of the introductory psychology course. All *S*s were naïve. The ratio of men to women was the same for the four conditions. Except for this restriction, the *S*s were randomly assigned to the experimental conditions. One *S* in the *R-D* condition was dropped from the analysis because he did not meet the criterion of learning in the learning session after one hour. After eliminating this *S*, there were 12 *S*s in each condition.

Experimenters. Two students at Stanford University served as *E*s. They were not naïve concerning the purpose of the experiment. A graduate student, man, changed the standard stimulus when he received a signal and an undergraduate, woman, read the instructions, recorded the *S*'s responses, and asked questions after the experiment.

RESULTS AND DISCUSSION

The main results were the number of errors made before meeting criterion. For each condition, the data obtained from the *S*s who started with the standard at 20 ft. were combined with those with standard at 30 ft. The same was done for the data from the transfer session. Fig. 1 represents the cumulative errors made after each two blocks of trials for the four experimental conditions in the learning and transfer sessions. Each point represents the cumulative number of errors made by 12 *S*s on 10 trials in the two blocks added to the errors made in previous blocks.

One should note that the ordinate applies to both the learning and the transfer sessions. The last point on each line represents the total number of errors for each experimental condition. The last point also represents

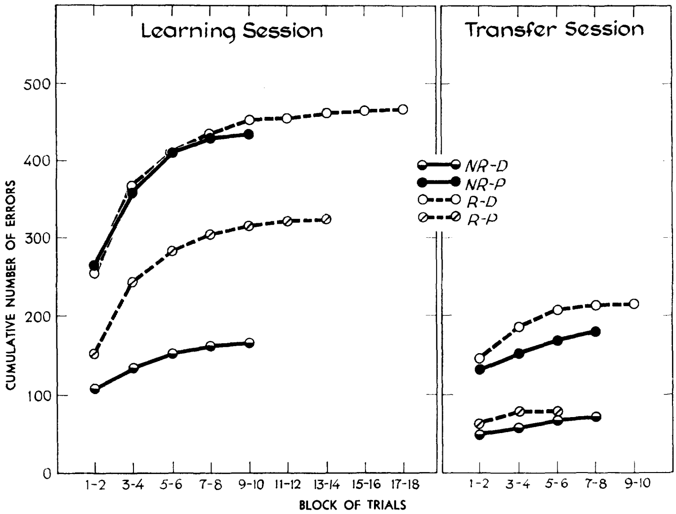

FIG. 1. CUMULATIVE ERRORS AS A FUNCTION OF BLOCK TRIALS FOR THE FOUR EXPERIMENTAL CONDITIONS

TABLE I

AVERAGE NUMBER OF ERRORS FOR LEARNING AND TRANSFER TRIALS

		Non-Reduced Condition			Reduced Condition		
		NR-D	NR-P	Significance level	R-D	R-P	Significance level
Learning Trials	$\bar{X}$	13.75	36.00	$U=19$ $p<.002$	38.83	27.00	n.s.
	S^2	86.75	490.91	$F=5.658$ $p<.02$	277.97	256.91	n.s.
Transfer Trials	$\bar{X}$	5.67	14.83	$U=25$ $p<.02$	17.83	6.50	$U=11.5$ $p<.002$
	S^2	22.79	109.70	$F=4.813$ $p<.02$	40.33	20.27	n.s.

the block of trials prior to the one on which the slowest learner in that particular condition met the criterion of no errors. One should not, however, attribute a great deal of significance to this value because it is the result of data from only a few *S*s.

The mean number of errors per *S* and the variance in each condition are shown in Table I, with relevant statistical comparisons. The emphasis is upon the comparison of the distal and proximal conditions. The variance in the *NR-P* condition was significantly greater than the variance in the *NR-D* condition in both the learning and the transfer sessions. Because of this, a non-parametric test (the Mann-Whitney *U* Test) was used to compare the central values.

Examination shows that in the non-reduced condition the *S*s learned to respond with the correct distal size more easily than with the correct proximal size. The *S*s and the *NR-D* condition made fewer errors compared to those in the *NR-P* condition. The direction of the difference was found to be the same for both the learning and the transfer sessions, and both differences of the *NR-D* and the *NR-P* conditions were statistically significant.

The results from the reduced conditions were contrary to those of the non-reduced conditions. The *S*s found it easier to associate the proximal sizes of the standard and comparison stimuli than their distal sizes. The *S*s in the *R-P* condition tended to make fewer errors than those in the *R-D* condition in both the learning and the transfer sessions. Although the difference between the mean number of errors in these two conditions for both sessions was in the same direction, only the difference in the transfer session was statistically significant.

Our interpretation of the significant difference between the *NR-D* and the *NR-P* conditions is that it is the natural tendency of the *S*s to judge the distal size rather than the proximal size under normal unrestricted viewing. That is, a person tends to pay attention to the distal size rather than to the proximal size of an object; thus, the *S*s learned with fewer errors under the *NR-D* condition. In support of this, examination of the *S*s' errors under the *NR-P* condition showed that the errors tended to be in the direction of the distal size. Also, post-experimental interviews with the *S*s showed that most of them, under the *NR-P* condition, did not try to match the visual angle to solve the problem. Most of them estimated the distal size and then attempted to solve the problem by rote learning.

It is thought that these differential tendencies were due to past experience. In the normal life of a human being the chance of being reinforced for judging the proximal size is very rare indeed—unless one is being trained as an introspective psychologist or an artist. Thus, it is reasonable to expect that the *S*s would tend to estimate the distal size rather than the proximal size under normal viewing conditions.

At this point the limited generality of these findings should be noted. The distances employed in this study were from 10 to 30 ft., and at greater distances our conclusions may not hold. As a matter of fact, Gilinsky's study, which included distances between 100 and 4000 ft., suggests that a person tends not to estimate the distal size at greater distances.[7] Her *S*s reported that they made the

[7] Gilinsky, *op. cit.*, 173-192.

'retinal' setting with much greater ease and confidence than the 'objective' match. Thus, the conclusion that the natural tendency of the *Ss* is to estimate the distal- rather than the proximal-size under normal viewing conditions should be limited to closer distances than that of Gilinsky's study.

As noted before, under the reduced conditions, the *Ss* in the *R-P* condition made fewer errors than those in the *R-D* condition in both the learning and the transfer sessions, although only the difference in the transfer session was statistically significant. A possible interpretation of the results is that the *Ss* tended or learned to estimate the proximal size under the reduced conditions; or, to state it differently, they can acquire or maintain a retinal attitude appropriate to the particular viewing condition. This interpretation is consistent with Rock and McDermott's notion that under reduced conditions the *Ss* respond to visual angle *per se.* They argue that the *Ss* under reduced conditions perceive size in terms of the extent to which an object "subtends much of the visual field or little of it, to loom large or small, quite apart from its objectively seen size."[8] Their main contention is that under reduced conditions perceived size is not a product of an *S*'s attempt to estimate the distal size.

A possible alternative hypothesis is that the *Ss* actually attempted to estimate the distal size and that the results are due to their assumption of equal distance from himself to the standard stimulus and to the comparison stimulus. The investigators who favor the equal distance hypothesis argue that under reduced conditions the *Ss* perceives size not in terms of proximal size, but perceives it in terms of distal size based on the assumption that the distances are equal for the two objects compared.[9] Data here from the post-experimental interviews does not support this hypothesis. Most of the *Ss* reacted with uncertainty to the question concerning the distance of the standard stimulus and often said their estimates were sheer guesses. The range of the distances by the *Ss* of the reduced conditions was 2 to 20 ft., and almost two-thirds of them estimated the distance to be less than 4 ft. for both learning and transfer sessions. This does not support the prediction of 10 ft. derived from the equal distance hypothesis. Furthermore, there were 3 *Ss* who clearly did not assume equal distance for the two stimuli compared. These *Ss* reported that the larger standard stimuli appeared closer than the smaller one and vice versa. In fairness to the hypothesis, however, it should be noted that the distance data were obtained during the post-experimental interview and were based on memory. Thus, it is possible that the perceived distances during the experimental sessions might have been different from their later estimates.

Although we believe that Rock and McDermott's assertion accounts for our results under reduced conditions better than the equal-distance hypothesis, we do not suggest that the *Ss* were 'consciously aware' of the proximal size or the visual angle. If the *Ss* were responding in terms of visual angle, they did not succeed in communicating this to *E* at the end of the experiment. In the post-experimental

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[8] Irvin Rock and William McDermott, The perception of visual angle, *Acta Psychol.* 22, 1964, 119-134.

[9] R. S. Woodworth and Harold Schlosberg, *Experimental Psychology,* 1954, 481; Epstein, Park, and Casey, *op. cit.,* 491-514; Hans Wallach and V. V. McKenna, On size-perception in the absence of cues for distance, this JOURNAL, 73, 1960, 458-460.

interview, most of the *Ss* in the *R-P* condition reported that they were trying to match the "sizes" of the standard- and comparison-stimuli, but left a clear impression that they had no idea of a distinction between the visual field and the visual world, or between proximal and distal sizes. Using verbal report as an index of their phenomenal experience, one cannot say that the phenomenal experiences of size under the reduced and non-reduced conditions were different. It is thought that, without a specialized language system such as the one used by psychologists, describing the phenomenal experience of retinal size would be difficult. Possibly the phenomenal experience of retinal size is hard to attain without the specialized language system.

SUMMARY

The purpose of the experiment was to investigate whether there was a tendency to judge more readily distal or proximal size under reduced and non-reduced viewing conditions when no specific instructions were given. A task requiring *S* to form his own concept of the stimulus variable was employed. There were four experimental conditions. In the non-reduced-distal (*NR-D*) condition, *S* viewed the standard with binocular regard and with distance cues. *S* was required to associate the distal size of standard and comparison stimuli. In the non-reduced-proximal (*NR-P*) condition, *S* viewed the standard stimulus with binocular regard, and his task was to associate the proximal sizes. In the reduced-distal (*R-D*) condition, *S* viewed the standard stimulus under restricted viewing conditions with monocular regard and his task was the same as in the *NR-D* condition. In the reduced-proximal (*R-P*) condition, the viewing condition was the same as in the *R-D* condition and *S*'s task was to associate the proximal sizes.

It was found that under the non-reduced condition the *Ss* learned to associate the distal size more easily than the proximal size. This was thought to be due to the natural tendency of *Ss* to respond to the distal size rather than the proximal size under normal unrestricted viewing conditions. Under the reduced conditions, the *Ss* tended to associate more rapidly the proximal sizes of the standard and comparison stimuli. It is argued that *S* acquired or maintained retinal attitude under reduced conditions.