The boundary of entoptic space

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Thirty-eight male Ss viewed an after-image entoptically and then opened their eyes and adjusted the distance of a projection screen so that the apparent size of the now projected after-image equalled that of the previously seen after-image. Subsequently Ss were asked to estimate the apparent size (diameter) of the entoptic after-image. The mean projection distance obtained was significantly larger than that predicted by Emmert's law. The present finding is interpreted to support the general notion of a bounded entoptic space.

Zehender (1881) noted that the entoptic after-image of an object projected upon the field of the closed eyes appeared to be of a different size from the direct image of the object itself. Emmert (1881) observed that such after-images appeared smaller than the inducing object and inferred that their estimated distance must be small.

Gibson (1950, p. 32) claimed that entoptic after-images did not have any precise distance or size and appeared to "float in what might be called an indefinite space." Contrary to Gibson's claim, Stanley (1966) reported that male Ss were able to make consistent size estimates of an entoptic after-image induced by a circular green luminator of 2-1/4 in. viewed from 45 in. Nevertheless, distance estimates were highly variable, ranging from a few inches to several feet.

To account for the consistency of size estimates reported by his Ss, Stanley (1966) proposed that although the subjective impression is of boundless space, with eyes closed the sensory system processes size information as if the eyes were fixated at a constant distance. Assuming Emmert's law, the projection plane of this fixated distance was estimated to be 5 in. The present study was designed to test this hypothesis by having Ss view an after-image entoptically and then to open their eyes and adjust the distance of a projection screen so that the apparent size of the projected after-image equals that of the entoptic after-image.

Subjects

Ss were 38 male students from an introductory psychology class who were screened on the Bausch and Lomb Orthorater and had an equivalent of 20/20 vision in their right eyes.

Apparatus

The after-image inducing stimulus was a circle of 2-1/4 in. diameter lighted by a 24 v Grimes C-3A inter-aircraft control lamp fitted with a green filter. The projection screen was viewed by S through a 1 in. aperture mounted at the end of a 39 in. rule and consisted of an 8 in. square of white plastic mounted on a slide fitted to the rule. It was possible for the screen to be adjusted from 0-39 in. The room was feebly illuminated, the luminance of the projection screen as

measured by a Macbeth Illuminometer being 0.03 apparent ft. candles.

Procedure

Ss were tested individually and when seated were read the following instructions: "In this experiment I want you to use your right eye. Could you place this eye patch over your left eye?... Now will you look at the center of this circle (*E points*). I am going to shine a green light in your eye for a few seconds. Then you will be required to close your eyes until an after-image appears. When the after-image appears I want you to get a clear impression of its size and then to look through this aperture (*E points*) and project your after-image onto this screen. You will be required to adjust the distance of the screen by sliding it up and down the rod until the size of the after-image projected on the board equals that obtained when your eyes are closed. Is that clear? Any questions?... Now will you look at the center of this circle again while I shine a light into your eye. It may feel a little unpleasant but it will not harm your eye. Keep looking at the center and try not to move your eye. (*light on for 30 sec*). Now close your eye. (*10 sec. pause*). Can you see an after-image? Get a good impression of its size. (*2 sec. pause*). Now look through this aperture and adjust the projection screen until the projected after-image appears equal in size to the after-image you just observed with your eyes closed. *After S has completed his adjustment:* Now tell me the diameter of the circular after-image you saw with your eyes closed."

Results and Discussion

The mean of the projection screen distance adjustments was 8.44 in. ($\sigma = 3.04$) and the mean estimate of size (diameter) was 0.31 in. ($\sigma = 0.14$). From the apparent size estimates expected projection distances were computed for each S on the basis of Emmert's law. A *t*-test (related samples) between obtained and expected distances indicated that the former were significantly greater than predicted by Emmert's law ($t = 3.6$; $p < .01$).

Price (1961) while studying Emmert's law noted that, although the law held over a range of projected distances, the apparent size of projected after-images was smaller than predicted on the basis of the dimensions of the inducing stimulus. The present discrepancy between obtained and predicted projection distances may simply be a reflection of this tendency to see the after-image smaller. If this were the case, then the obtained distances would represent a more accurate measurement of the "boundary" of entoptic space than estimates derived from size judgments. In the present instance the predicted and obtained distances could be equated assuming the diameter of the after-image was

seen as approximately 25-30% smaller than expected from the dimensions of the inducing stimulus.

Under entoptic conditions S cannot make consistent estimates of apparent distance (Stanley, 1966), but the present adjustments of the projection plane to produce an equivalent-size projected after-image were relatively consistent. Although such distance adjustments do not fit the distance formerly predicted (Stanley, 1966), they support the notion that the sensory system processes information about size as if the eyes are fixated at a relatively close distance. Despite the subjective impression of boundless space, the visual system seems to function as if entoptic space had a distance boundary of approximately 8.44 (± 3.04). In the present studies Ss were simply asked to close their eyes; it is possible that the "boundary" of entoptic space could be in-

fluenced by the state of tension in the eye (cf. Urist, 1959).

References

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Note

1. The author is grateful to Lee Price for assistance in collecting these data.

Comment on non-parametric tests in the one-sample case by Rogers Elliott

In a recent study I was faced with the question of establishing whether a set of correlation coefficients was reliably positive, as follows: -.55, .57, .18, .18, -.12, .12, .17, .76, .61, .74. The correlations represented the degree of intrasubject covariation in each of 10 adults between heart rate and muscle tension across occasions during an experimental session. The correlations were not homogeneous and therefore could not strictly be averaged to permit a parametric test of the significance (relative to the zero correlation assumed by the null hypothesis) of the average. I was using two-sided tests, because, although I expected mostly positive correlations, the expectation was empirical rather than theoretical.

Therefore, I sought an appropriate non-parametric test. Siegel (1956) lists four tests in the one-sample case. The runs test was inappropriate, order of observation not having been relevant; the Kolmogorov-Smirnov test was appropriate to the assumption that half the scores would be negative and half positive, but this reduced it to application to a very crudely specified theoretical distribution; the chi-square test was appro-

priate to the same distribution; and the binomial test was, of course, appropriate. None of the last three appropriate tests yielded significance at the .05 level, two-sided, and, since the binomial test had been the one uniformly adopted, no acceptable significance was reported.

Nevertheless, it seems reasonable to treat the set of scores just as one would treat them if they were difference scores, with essentially the same null hypothesis that the scores are not different from zero. So considered, the more powerful Wilcoxon test applies, and in the present case yields a T of 7.5, $p < .05$, two sided. The logic here is the same, in fact, as using the sign test (a binomial test) on the signs of difference scores, and the same binomial test in the one-sample case. In the same sense, the formula for the t-test on D scores is equivalent to that on scores of a single sample, when both sets of scores are assessed for the reliability of their mean difference from zero. In sum, these considerations would seem to justify the use of the Wilcoxon paired-replicates test in the one-sample case, when the expected average score is zero.

Reference

- Siegel, S. *Nonparametric statistics*. New York: McGraw-Hill, 1956.