EMMERT'S LAW AND SIZE-CONSTANCY

By ALBERT H. HASTORF, Dartmouth College, and JOHN L. KENNEDY, The Rand Corporation

This paper reports data bearing on the points at issue between Boring, Edwards, and Young with respect to the relation between Emmert's law and size-constancy.[1] In 1940, Boring proposed a formal relationship between size-constancy and Emmert's law. He interpreted Emmert's law as referring to the increase in *apparent size* of an after-image proportional to the increase in *distance* of the projection-screen. The operations recommended by Boring for measuring *apparent size* of the after-image have been challenged by Young. Boring's method of measurement involves the use of comparison-objects,[2] while Young espouses direct measurement by bracketing the after-image with small spotlights.[3]

We propose that the controversy hangs on the characteristics of the measuring operations, and we offer the hypothesis that these operations markedly affect the phenomenon being measured. Edwards, using the comparison-method, investigated the effect of reduction-conditions on the apparent size of after-images and found that Emmert's Law did not hold.[4] This result was not surprising to Edwards, nor should it be surprising to Young, because if Young were to repeat Edwards' experiment with the spotlight method of measurement, he would indubitably find that Emmert's Law does hold. We have confronted these two techniques of measurement with each other under reduction-conditions and find that the results come out that way.

Procedure. O was seated at one end of a 10 × 30-ft. room. In front of him was a 4 × 4 ft. projection-screen. To his right, at a 90° angle, was a comparison-screen (2 × 2⅓ ft.) which was kept at a constant distance of 3 ft. Two visual conditions were employed: (1) full binocular regard, with the room and the screens completely illuminated; and (2) monocular regard of the large screen, room illumination limited to the screens only, and view of the large screen through a reduction-screen. Judgments were made with the large screen at 20 ft.

There were four parts to the experiment. In Part 1, which dealt with size-constancy, *O*'s task was to equate the size of black stimulus-cards at the various distances and under the two visual conditions. In Part 2, in which after-images were compared, the conditions were the same, except that *O* projected an after-image on the front screen to compare with the black card on his right. To induce the after-image, *O*

* Received for publication November 4, 1955. The authors thank Jon Blum and Herbert Kleber who gathered the data described in this paper.

[1] E. G. Boring, Size constancy and Emmert's law, this JOURNAL, 53, 1940, 293-295; Ward Edwards, Emmert's law and Euclid's optics, *ibid.*, 63, 1950, 607-612; Edwards and Boring, What is Emmert's law?, *ibid.*, 64, 1951, 416-422; F. A. Young, Boring's interpretation of Emmert's law, *ibid.*, 63, 1950, 277-280; Concerning Emmert's law, *ibid.*, 64, 1951, 124-128.

[2] Boring, *op. cit.*, 53, 1940, 293-295.

[3] Young, *opp. citt.*, 63, 1950, 277-280; 64, 1951, 124-128.

[4] Edwards, Apparent size of after-images under conditions of reduction, this JOURNAL, 66, 1953, 449-455.

fixated a 1-in., white cardboard square on a black background at a distance of 3 ft. A 25-w. flashbulb in a reflector was held somewhat below the stimulus-square and set off while *O* was fixating. Following the flash, *O* closed his eyes and waited until he had a negative after-image, at which time he opened his eyes and projected the after-image on the front screen. In Part 3, which involved Young's technique of measuring after-images with a spotlight, *O* projected the after-image, induced as described above, on the front projection-screen and bracketed it with two small spotlights, after which *E* measured the distance between the spots of light with a yardstick. In Part 4, *O* entered the experimental room when it was completely dark. His task was merely to estimate the distance of the front screen plus black card in feet to make an absolute judgment of distance. A circle of light around the card was the only light in the room. *O* gave absolute estimates, first in the dark and then under binocular regard and full lighting conditions.

Twelve undergraduate students were used as *Os* in Parts 1, 2, and 3. A new group of six *Os* was used in Part 4. One half of the *Os* went through Part 1 first, and then Parts 2 and 3, while the other group reversed this procedure. In addition, one half of each group started under the monocular conditions.

The instructions to *O* were patterned after Gilinsky's objective instructions,[5] the aim being to establish a set favoring constancy. The instructions were:

> This is an experiment to test how people judge size. Place your head in the chin rest. In front of you is a screen with a black card on it. To your right is another screen with a black card on it also. Your task is to equate these two cards so that if you placed the card on your right beside the one in front of you, or if you measured them with a ruler, they would be the same size. Look at the card in front; then turn to your right and tell me whether the card there is smaller, larger or equal to the one in front. You may look back and forth as often as you wish. Do you have any questions?

When the after-image was used, the instructions were suitably modified but the intent or set was not changed. *O* was given two practice trials with the after-image technique before data were taken. For Part 3, *O* was permitted to practice with the spotlights and was instructed to bring the spots together until the inner edges just touched the outer edges of the after-image. For Part 4, *O* was told to estimate the distance of the front screen to the nearest foot.

Results. Table I summarizes the data. The results for Parts 1 and 2 confirm Edwards' finding that the reduction-conditions affect both size-constancy judgments and after-image judgments at 20 ft.[6] The reduction in size at 20 ft. is significant at the 1% level for both size-constancy and judgments of after-images under monocular conditions. A second important variable, which made for some variation in *N*, was the initial condition under which *O* began to make judgments. With monocular regard as the initial condition, three *Os* in Part 2 were unable to give judgments, since the smallest comparison-card was still larger than the perceived size. An acquaintance with the size of the experimental room appears to be quite important in determining *O*'s judgments of size. We also suspect that the presence of a 'real' stimulus anchors the situation, since only one of the *Os* was unable to

[5] A. S. Gilinsky, Perception of size of objects at various distances, *Research Bulletin of Air Force Personnel and Training Research Center,* 1954.

[6] Edwards, *op. cit.,* this JOURNAL, 66, 1953. 449-455.

make judgments under monocular regard in Part 1. Part 3, utilizing Young's method of measurement, showed no difference between reduced and full binocular conditions. Part 4, conducted with six new *O*s, demonstrated clearly that the combination of unfamiliar room, complete darkness except for a circle of light around the stimulus, and monocular regard through reduction-screen does result in significant reduction of apparent distance when absolute judgments are required.

Conclusions. These data support Boring's proposed relationship between size constancy and Emmert's Law, and confirm Edwards' results on the size of after-images under reduced conditions of observation. Our data also support Young, in

TABLE I

JUDGMENTS OF SIZE AND DISTANCE*

Part	Mean size (in.)		Mean distance (ft.)	
	binocular	monocular	binocular	monocular
1	6.6	5.3		
2	5.7	4.7		
3	6.8	6.8		
4			20.5	13.4

* The size of the standard in Part 1 was 6.66 in., as was the predicted size in Parts 2 and 3. The distance was 20 ft.

that his spotlight technique for measuring apparent size of the after-image seems to be independent of reduction-conditions, that is, yields Emmert's law under reduction-conditions. It can be argued that these results are precisely what one would expect if one makes the assumption that Boring's technique for measuring apparent size is 'psychological' whereas Young's is 'physical.' There also is some evidence that the act of measuring with the spotlights in a darkroom provides a cue (probably movement-parallax) to the distance of the projection-screen. For example, *O*s increase their estimates of the apparent distance of the screen under reduced conditions after they have been permitted to explore the screen with the spotlights as they would in measuring an after-image. If Young's technique has a built-in distance-cue, it is no surprise that his measurements are unaffected by 'reduced' conditions, whereas Boring's are. The moral of this interpretation is that psychologists, as well as physicists, need to concern themselves about methods of measurement that interact with the phenomenon being measured.