Size constancy does *not* fail below half a degree

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Ross, Jenkins, and Johnstone (1980) have recently claimed that visual size constancy, the tendency for objects to remain the same in perceived size as their distance from the observer varies, breaks down when the visual subtense of the object falls below half a degree. The claim is based on three sets of informal observations: failure of Emmert's law with small afterimages, elimination of the moon illusion with an optically reduced moon, and absence of size constancy for small figures in a picture. The first situation involves the "appropriate" occurrence of size constancy as distance varies, and the second and third, its "inappropriate" occurrence, causing illusions of size—the moon illusion and a pictorial illusion, respectively. The hypothesis proposed to account for these findings is that large and small images are differently calibrated; large objects, it is suggested, are subject to automatic size correction with changes in distance, while small objects are not, the latter providing absolute size information only.

Four experiments are described here. The first involved Emmert's law for small (.17 deg) and large (.87 deg) afterimages; the second, a variant of the moon illusion with a small (.17 deg) afterimage projected against the sky; the third, "inappropriate" size constancy for small (.23 deg) and large (.72 deg) elements in pictures; and the fourth, a direct test of size constancy in the classical tradition with objects subtending .25 and 2 deg. None of the outcomes support the claim that size constancy breaks down with a visual subtense of less than half a degree. Indeed, in the direct test (Experiment 4), it was nearly perfect for an object with a visual angle of .25 deg.

In the first experiment, an afterimage was induced by means of a photoflash (Sunpak MX118) held 1 m from the observer. Closely fitting black metal masks with circular apertures 4 and 15 mm in diameter gave afterimages of approximately .17 and .87 deg, respectively. These angles were well below and above the claimed critical value of .5 deg. Both induction and viewing were binocular. Square white surfaces mounted with their centers at eye level were placed 1 and 10 m from the seated subject in a large room. To maintain the same size relationships, the near surface was 10 cm along an edge, and the far surface, 100 cm. A small and a large afterimage was induced for 30 subjects, with the order balanced across the group. There was an interval of 10 min between the two trials to allow

complete dissipation of the first afterimage before inducing the second. The subject's task was to estimate in centimeters or inches the apparent diameters of the images projected at each surface. The surfaces were offset so that an image could be easily and quickly switched from one to the other, thereby facilitating confident judgments. In the preliminary instructions, the subjects were requested to compare apparent or perceived size of the projected images. For the .87-deg image, 19 of the 20 subjects estimated the far projection to be larger than the near projection and 1 estimated it to be the same. For the .17-deg image, 18 subjects estimated size of the far image to be larger and 2 judged it to be the same. The size ratio between the far and near projections was 10.7:1 for the large image and 10.4:1 for the small. If constancy had broken down, that is, if Emmert's law had failed, the ratio would have been 1:1. According to a *t* test, there was no difference between the ratios for the two conditions [$t(19) = 1.99$, $p > .05$], and, in almost all cases, Emmert's law obtained, with the far-projected image judged as larger.

In the second experiment, a variant of the moon illusion suggested by King and Gruber (1962), involving projection of the afterimage at the horizon and zenith of the sky, was used.¹ A group of 12 subjects projected the small (.17-deg) image only at the horizon and zenith of the sky in daylight from the roof of a 6-floor building from which there was an uninterrupted view. The subjects were first required to report whether the image projected at the horizon appeared smaller than, the same as, or larger than that projected at the zenith of the sky-dome, and then to estimate the size of the horizon image relative to that of the zenith image in percentage terms. Of the 12 subjects, 10 judged the horizon image to be larger than the zenith image and 2 judged it to be the same size. The mean size ratio between horizon and zenith images calculated from the percentage estimations was 1.16. This value was significantly different from 1 [$t(10) = 2.96$, $p < .01$].

In the third experiment, 30 subjects judged whether the upper, or "far," circular elements in the pictures shown in Figure 1 were smaller than, the same size as, or larger than the lower, or "near," elements. The scene with a roadway was taken from Gibson (1950, p. 139) and that with railroad tracks from Gregory (1970, p. 91). Circular elements were used to avoid familiar-size judgments likely to occur with pictured common objects. The large elements were 12.5 mm in diameter and the small elements, 4 mm. The viewing distance was 1 m. At this distance, the larger elements subtended a visual angle of about .72 deg and the smaller, one of about .23 deg. The orders of presentation of the two scenes and of the small and large

Figure 1. Pictured scenes with "near" and "far" circular objects used in the third experiment. At 1 m, the large disks subtended a visual angle of about .72 deg and the small disks one of about .23 deg.

elements were balanced across subjects. The frequency of "larger than," "same as," and "smaller than" judgments in Figures 1A and 1B were, respectively, 18, 10, 2 and 20, 10, 0, and in Figures 1C and 1D, respectively, 30, 0, 0 and 27, 3, 0. These frequencies clearly indicate the occurrence of "inappropriate" size constancy in both scenes. The difference between the frequencies for large and small elements was not significant for either scene, according to a sign test.

The final experiment involved a direct test of visual size constancy in the classical tradition. The standard was a piece of white dowel, 20 cm long and 1.2 cm in diameter, placed vertically on a table in a long well-lit corridor, rich in perspective information for distance. The standard was clearly visible mounted against a black background on the table. The viewing distances were 5.7 and 45 m. At the shorter distance,

the rod subtended a visual angle of 2 deg and at the longer, one of .25 deg. The standard was never seen by the subject from a distance nearer than 5.7 m. The subject sat at a table on which there were 10 white comparison rods of the same diameter as the standard, ranging in length from 13 to 22 cm in 1-cm steps. The comparison rods were arranged in order of length across the table. The task was to select the rod whose length most nearly matched the apparent length of the standard. Viewing was binocular. Instructions stressed that the match should be to the *apparent* length of the standard, that is, to how long the standard appeared to be. Each of 20 subjects made two matches, one at the longer distance and the other at the shorter, with the order alternating across the group. The mean matched length for the .25-deg condition was 20.45 cm (SD = 1.61); for the 2-deg

condition, it was 20.35 cm ($SD = 1.04$). At the smaller angle, 11 subjects exhibited overconstancy, and at the larger, 10 did so. The difference between the mean matches fell far short of significance according to a t test for correlated scores. It must therefore be concluded that, with binocular viewing in good light, visual size constancy for an object subtending a visual angle of .25 deg is nearly perfect and no different from that of an object subtending 2 deg.

Taken together, the outcomes of the four experiments do not support the claim that size constancy in the situations described by Ross, Jenkins, and Johnstone (1980) breaks down when the judged elements subtend visual angles of less than half a degree. In point of fact, the data indicate that size constancy in these situations for elements subtending angles markedly less than .5 deg is virtually as robust as it is for those of about 1 deg. The last experiment involving a direct test of size constancy clearly supports the conclusion that constancy occurs with visual angles well below .5 deg.

Two points can be made in conclusion. First, in the two anecdotal examples of breakdown in size constancy at small angles given by Ross, Jenkins, and Johnstone (1980)—aircraft viewed from the ground after taking off and objects on the ground viewed from an aircraft—there is a marked loss of constancy probably due, not to the small visual angle, but to the absence of distance cues, so-called “reduced” viewing. These are excellent teaching examples of what happens to constancy when distance information is either reduced or eliminated. Second, Ross, Jenkins, and Johnstone enjoin readers to rely on observations that they can make and repeat themselves, since naive observers might confuse apparent size with the area

of the visual field occluded by the object. Therefore, as suggested, we have ourselves repeatedly observed people across a university campus “when their image size is less than half the size of the fingernail.” For persons between 1.5 and 1.8 m tall, the approximate viewing distances to match this rough standard are about 280 and 340 m. For what it is worth, we have found almost perfect constancy to obtain. Individuals so observed certainly do not appear doll-like, as claimed. We take “doll-like” to mean about 60 cm or less in height.

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NOTE

1. Projected afterimages, rather than optical reduction of the moon itself, were preferred, since viewing the moon through a tube with lenses would give rise to framing in a circular field, the consequences of which are not known. In any case, change in the retinal size of an object through an optical instrument changes the apparent distance of an object, not its size (Thouless, 1968). The significance of this for the observations reported by Ross, Jenkins, and Johnstone (1980) are not clear.

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