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Size constancy and accommodation

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In a previous publication we presented evidence to the effect that the state or effort of accommodation is correlated with the perception of size constancy (Maturana et al 1972).

Our argument has been questioned by Deregowski (1981) who, in line with Graham (1965), is of the opinion that beyond 1 m accommodation plays no role. In this he seems to agree with a current opinion found, for example, in the well-known text by Kaufman (1974) that states: "In a very real sense it may well be wrong to say that accommodation is a cue to depth" (page 250). This view seems to be based on purely optical considerations about the curvature of the lens, and its effect on blur circles on different parts of the image (Kaufman 1974).

What is critical in our argument, however, is the state of activity of the neuronal system involved in effective accommodation or in the effort of accommodation, and the role it plays in correlation with other centrally determined neuronal states that participate in the experience of size. Accordingly, we think that although the changes of curvature of the lens in accommodation beyond 1 m may be irrelevant to a physicist that looks at the eye as an optical instrument the neuronal mechanism that controls them is relevant in the establishment of perceptual relations of relative distance and size, either through the proprioceptive consequences of very slight changes in muscle tone arising in the effort of sharpening blurred circles, or through its direct internal effect on other neuronal processes.

In fact, it is apparent in everyday experience that accommodation is involved in our discrimination of distances to a far greater extent than the supposedly usable range of accommodation of 1 to 2 m. This may be verified simply by accommodating on objects at larger distances than these, and by noticing the blurring of other objects still further away in a manner similar to what occurs at short distances. The main consequence of accommodation when looking at objects at different distances should be a change in the depth of focus. If the perceptual effects of accommodation followed optical conclusions like those quoted above, then any attempt to look at distances greater than 1 m should result in a sharp increase of the depth of focus to infinity. This is in patent contradiction to experience.

In order to make this observation more precise we designed the following experiment. Two checkerboards were constructed in such a way that the widths of the squares were close to the limits of resolution of the eye at the distances of 7 and 15 m respectively (2 and 4·5 mm respectively). The observer placed himself at a distance d_i, such that the pattern was still sharp but would become blurred when the distance d_i was slightly increased (figure 1). From this fixed position the observer viewed the checkerboard pattern through a mesh of black or white stripes, so as to have a target for accommodation. The task of the observer was to instruct the experimenter to move the mesh towards him until the fixed checkerboard pattern which he could simultaneously see through it became as blurred as when he increased the distance d_i. This new distance, Δd_i, was noted and was taken to represent an

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estimation of the depth of focus for that observer under the given illumination conditions and state of light adaptation.

The results are shown in figure 2 for six observers, the two authors and four other volunteers who had no knowledge of the purpose of the measurements. From these results, two things are immediately apparent: (i) accommodation operates in a perceptually effective manner for distances far beyond the usually assumed limit of a few (around 2 to 4) metres; (ii) the perceptual correlates of accommodation are involved in the discrimination of distance at distances well beyond the quoted limits. In other words, if accommodation had no effects beyond these small distances, one would expect a sharp rise in the curve, that is, a power or exponential relation, instead of a linear increase.

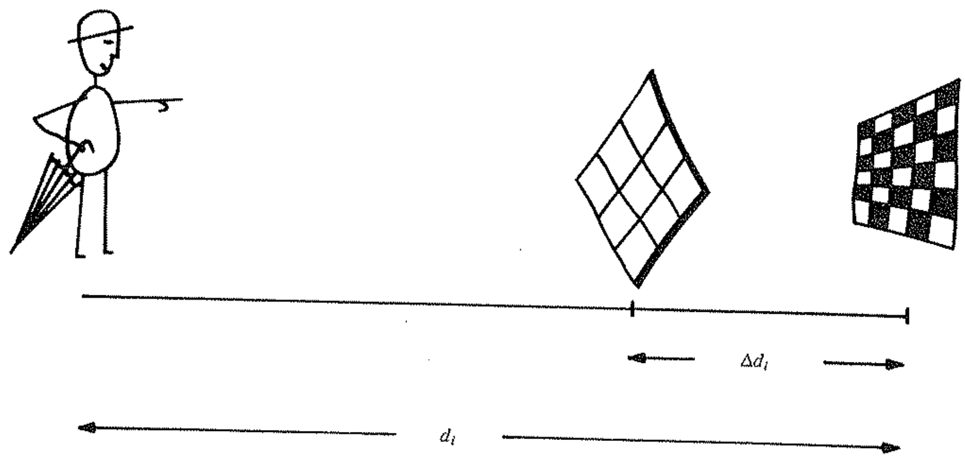

Figure 1. Observer viewing a checkerboard set at a maximum distance d_i at which he still sees the pattern sharply. The mesh on which he then focuses is moved towards him until the checkerboard begins to lose its sharpness. The distance between the mesh and the checkerboard, Δd_i, is a measure of the depth of focus for the observer under the given conditions.

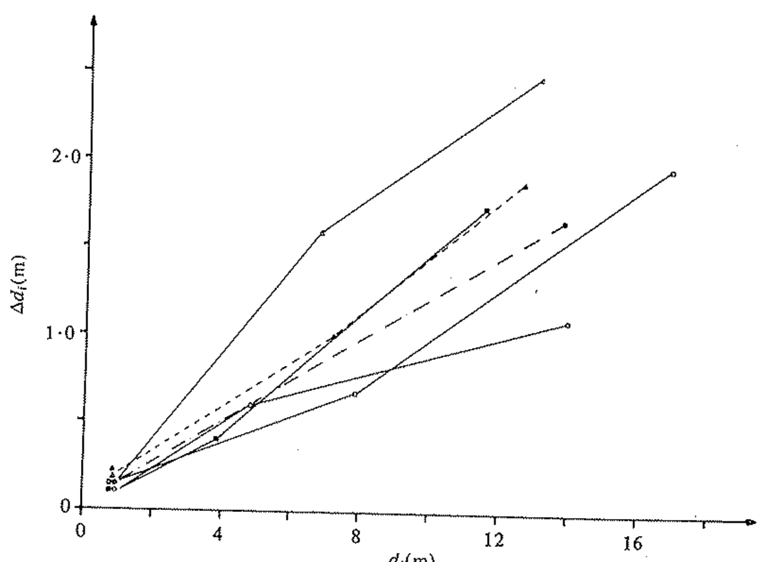

Figure 2. Plot of Δd_i as a function of d_i for six observers.

Hence we conclude that the effect of neuronal mechanisms of accommodation on size constancy cannot be rejected by an argument stemming from purely physical optics considerations. In fact, if we accept that we understand accommodation in terms of the neuronal processes involved in image focusing, regardless of their circumstantial effectiveness in changing the curvature of the lens, then the observations presented here reinforce our contention that the phenomenon of size constancy is best explained by its link to the neuronal activity involved in the effort of accommodation.

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