Illusions in Perspective

DR HUMPHREY speculates on the thought processes of the Sung school and Italian primitive painters[1]. I, too, was puzzled by distortions in the tenth century "Midsummer Rest under a Locust Tree" and in Ugolino's "Resurrection".

If you apply a ruler to the graphic illustrations in Dr Humphrey's paper, it seems that the back edge of the philosopher's couch in Fig. 5 is in fact some 2 mm longer than the front; the corresponding inside dimensions of the lid of Christ's sarcophagus in the photograph in Fig. 6 differ by about 1.5 mm. Whatever the artists thought they were up to, they should not be accused of confusing their trapezoids with what Dr Humphrey perceives as a "perfect parallelogram". Not that I wish to question his explanation of the artists' distortions in terms of "mediaeval practice to prefer a formal rule to the mundane evidence of the senses".

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[1] Humphrey, N. K., *Nature*, **232**, 91 (1971).

Contrast Illusions in Perspective

THERE seems to be some confusion in Humphrey's account of "Contrast Illusions in Perspective"[1]. This may be due to over-compression, especially of a crucial paragraph (page 92, para. 3), which contains: "The nature of the optical projection to the eye is such that more distant objects on the whole give rise to smaller retinal images than near ones, and distance is therefore a guide to retinal size. The expected size of the further of two objects is less than that of the nearer, and hence if we see two lines which appear to be different distances but have the same actual length, we judge the further to be longer than the nearer". There are some curious features in this which though perhaps obvious should be spelled out, to avoid an already confused situation being worse confounded. (1) It is clearly not retinal image size which Humphrey supposes is "guided" by distance. Image size is given directly, by the geometry of object size and distance and the optical characteristics of the eye. The intended meaning must surely be along the lines of "perceived size"; but this is a very different matter from retinal image size—hence, indeed, the problem. (2) It is not the expected size of objects, lying at various distances, which is the issue but the image size corresponding to various object distances. (This is given directly by object size and distance, as stated.) (3) Perceived size (assuming this is what is meant, in place of "retinal size") cannot be given by distance *per se*. It would have to be given (or "guided") by available information of distance. This could be real-time sensory data; or it could be stored information, as of the shapes of familiar objects, such as tables.

It is a matter for experiment to discover the kinds of sensory data used for giving perceived size and distance. We know that perspective convergence of parallel lines and texture gradients are important; especially so for vision with a single fixed eye, as in viewing pictures. We know less about which object shapes are assumed for inferring size or distance from familiar objects; but we know this does occur, for example, from experiments with depth-ambiguous wire figures which change apparent shape as perception changes, though the retinal image (real-time sensory data) remains constant[2].

(4) Again we cannot suppose that signalled distance is a guide to retinal image size. Image size is given directly from the geometry of the situation (as stated in (1) above) and so cannot be "guided" by distance *per se* or by available (real-time or stored) information of distance. If, however, Humphrey does mean by "retinal size" something like "perceived size" or "apparent size", then he is saying that signalled or assumed distance affects perceived size. This is certainly so: it follows from the classical Emmert's law demonstration, from depth-ambiguous wire figures which change their shape with depth reversals[2] and many other demonstrations. But it is perceived size and not retinal size which changes as a function of signalled or apparent distance. To confuse the two is to wreak havoc with any discussion of these problems.

(5) Although for the normal world of objects sensory information and assumed distance affect perceived size, the case of line pictures is complicated by the fact that they are seen both as flat patterns of lines on a flat background which they physically are, and as depicted objects, in a different space, which they represent. The distortions evidently follow the depicted distances, rather than the physical distances which indeed are absent for a physically flat picture. Several implications follow. An account of the phenomena simply in terms of retinal patterns and directly associated physiological activity can hardly be adequate, for it is the significance of the patterns in terms of familiar objects, especially their usual shapes, which are determining apparent size. (This takes us to concepts like "software" computer concepts. Accounts in purely physiological terms seem inadequate, for they cannot handle significance or probabilities of object characteristics. Hence the need for "cognitive" concepts in perceptual theory. Cognitive processes will, however, be mediated by physiological processes—as computer hardware mediates the "software" mathematical and logical processes of a computer. Given the physiological/cognitive distinction, errors of size might be attributed to errors in physiological processes, mediating cognitive "programmes", or inappropriateness of the programmes themselves.

By invoking "expectancy" Humphrey is calling on a cognitive concept. I would agree that this is appropriate for the rectilinear projection distortions, though not for the "waterfall" after-effect of motion, in which object recognition is not involved. (The induced motion of the "waterfall effect" does not, as an after-effect of retinal image motion, depend on object recognition, either for inducing it or observing it.)

There is something odd, at least at first sight, about explaining something unexpected (the queer shapes of tables drawn in rectilinear projection) in terms of expectation. How can expectation give unexpectedness? I think it can, but the argument requires another and vital step. We may plausibly suppose that the usual perceptual scaling constants are applied to rectilinear projections of objects, much as though the depicted objects were seen with the normal perspective of retinal images when viewing the objects directly. Image size normally shrinks with increased object distance (giving retinal perspective), and this is normally compensated (giving size constancy), so we should expect depicted distance to be associated with expansion, in these zero-perspective pictures—if normally appropriate size scaling is evoked by the "recognition" of the picture as depicting an object, such as a table. Humphrey correctly points out that the distortions increase as the pictures are drawn more lifelike, apart from the absence of perspective. The more strongly it is recognized as a table, the greater the distortion. We may, I believe, describe the distortions by saying that the usual perceptual size corrections for compensating image shrinking with object distance are operating, according to the depicted objects, but that this is inappropriate for these pictures because there is no perspective to compensate[3]. Features depicted as more distant are perceptually expanded. They are expanded by the size scaling, itself established by many experiments, which normally compensates retinal perspective shrinking, to give size constancy in the three dimensional world of normal objects. In rectilinear projections there is no perspective shrinking with depicted distance: so the normally appropriate corrective scaling is inappropriate—and so generates the observed