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# 22 *Changes in the size and shape of visual after-images observed in complete darkness during changes of position in space*

[The next item, a too short paper with a too long title, reports a series of observations, which changed my view of perception. They provided the basis and the first inkling of the Inappropriate Constancy Scaling theory of distortion illusions, to be developed later.

The first point is that after-images can change in size systematically as the observer moves forwards or backwards, or change shape as he walks round the (invisible) place where they are 'projected' from his eyes. The changes at once appeared to be related to Size and Shape Constancy. If nothing else, this shows that Emmert (1881) was wrong in thinking that after-images only change size when 'projected' on to a visible screen. This extension of Emmert's Law to the case of *no* screen has several consequences which are far from trivial:

(i) The change of size of after-images cannot be due merely to the changing relative areas of the retinal image of the *screen* (or its texture) and the *after-image* on the retina. (This point is generally overlooked in discussions of Emmert's Law. It is still unclear how far Emmert's Law is due merely to the changing relative areas of image and after-image with distance for it could be *partly* due to this.)
(ii) The residual size change could be given by an *active scaling process* giving Size Constancy;
(iii) This is *not always set directly by visual data,* but may be set by the observer's *hypothesis* of distance, which
(iv) May be *wrong,* to generate error.

The reason for trying out the change-of-size-of-after-images-effect in the Farnborough human centrifuge was to discover whether the size changes are given directly by *sensory* data, or whether they are given by the observer's *hypothesis* of how he is moving through space.

It turned out that the hypothesis story was the correct one. This has interesting implications.

It was these observations which gradually made my thinking deviate sharply from the position held, and argued so well, by Professor J. J. Gibson, and his wife, Eleanor. The position adopted here is very different from the Gibsons' 'pick-up of information' theory of perception, in which the perceptual system is regarded as essentially static, but by perceptual learning is tuned to pick up externally available patterns. I regard Helmholtz as right, in arguing for a great deal of 'unconscious inference' – computing – going on to derive perceptions from data, the perceptions being far more than selection of data.

The basic observation was made accidentally, by Jean Wallace and myself, when we were using an electronic flash for quite another reason – attempting to test Donald MacKay's theory of the origin of his ray pattern effects, by stabilizing them on the retina as after-images. We then built a chair on wheels for moving the observer passively. This became the 'train' and 'swing' apparatus, to be described later.

F. W. Campbell is a distinguished visual physiologist of the Physiological Laboratory, Cambridge. The late Professor R. C. Oldfield gave valuable help with the centrifuge observations; he noticed the basic effect quite spontaneously while visiting the laboratory. This independent report was useful confirmation that we were not deluding ourselves, as at that time we had no 'objective' way of measuring the effect. Carolus Oldfield was Professor of Psychology at Reading; then at Oxford, following George Humphrey; he then became Director of the M.R.C. Psycho-linguistics Unit at Edinburgh. I would like to thank Squadron Leader (now Group Captain) Tom Whiteside, for letting us use the Farnborough centrifuge, and being in every way so helpful for what might have looked a way-out experiment – whirling round with a flash gun, looking at nothing!]

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It is well known that if a visual after-image is 'projected' upon a wall, or screen, in a semi-darkened room, the apparent size of the after-image is a function of the distance of the surface upon which it is 'projected'. The size increases with distance, almost in direct proportion to this distance. This is known as Emmert's Law (Emmert, 1881). It is of considerable interest, for it is a convincing demonstration that apparent size is not a simple function of the size of the retinal image, and that many perceptual factors influence the apparent sizes, and distances, of objects. The history of this idea, together with the classical experiments, are described by E. G. Boring (1942).

In carrying out some experiments on after-images produced by a short bright flash of light provided by a 110 joule 1 m.sec. flash tube, a number of curious effects have been observed which would seem to be related to Emmert's effect. It is important to stress that the effects to be described were observed in complete darkness, after the flash, and thus differ in an essential respect from the conditions for Emmert's effect. Since the flash duration was only 1 m.sec. no appreciable movement of the eyeball could occur in the stimulus period. This technique gives after-images of great clarity and detail, which is essential for these new effects.



1. When the head is moved, even by a few centimetres, forward or backwards, the after-image changes in size. It increases in size as the head is moved back, and decreases as it is moved forward. Ten of the subjects were experienced research workers in the psycho-physiology of vision. In addition, the effect has been demonstrated in some 40 relatively naïve subjects, mainly undergraduates. All subjects have observed this effect.

2. A similar effect may be observed with the head stationary. The subject 'projects' the after-image of the flash tube on to his out-stretched hand, still in complete darkness, and slowly moves his hand to and from his eyes. One of two effects may be observed. (*a*) The after-image may seem to remain on the hand, in which case it shrinks as the hand recedes and expands as it approaches. (*b*) The after-image may seem to remain fixed in space and to remain the same size. If the proprioceptive locus of the hand lies between the after-image and observer, the after-image may wholly or partially disappear, as though occluded by an opaque object.

Whether (*a*) or (*b*) occur evidently depends on the 'set' of the observer. Of the ten trained observers, three have reported the 'occlusion' effect on some occasions. All have observed the size change under these conditions.

3. When the observer's hand, or a screen held in his hand, is kept at constant distance, say at arm's length, and the observer moves his head and shoulders and the hand or screen back and forth, then the after-image remains of constant size. It is perceived as an object situated at constant distance.

4. If the flash tube is directed on to the subject's hand, so that an after-image of the hand is produced, some curious phenomena may be observed, but these are difficult to describe briefly. The visual and proprioceptive loci of the hand may separate in a disconcerting manner. Further complex effects occur if the subject attempts to pick up an object viewed as an after-image.

5. When the observer changes his position in space, perspective changes may take place in the after-image. For example, an after-

image may be obtained of a view down a long corridor. With the flash technique this will have unusual clarity. If the observer then walks across the corridor, looking down it, as it were, then his after-image may change in perspective as he moves. These perspective changes are not easy to assess, however, for they vary from time to time.

To observe these effects, it is most important that the eyes be steadily fixated while the after-image is being observed. The short flash technique for producing the after-image ensures that movement of the retina is unimportant during the production of the after-image, which is unusually detailed, but large eye movements after the initial flash temporarily disrupt the after-image and cause it to fade rapidly. The reason for this is not known.

We thought it important to discover whether at least the main effect – the change in size of the after-image with change in position of the observer – is directly related to acceleration forces applied to the observer. To test this, we have examined the effect under conditions of maintained angular acceleration in the Farnborough human centrifuge. Angular accelerations up to 3 g. were used. This was arranged through the kindness of Squadron Leader T. C. D. Whiteside who, with Professor R. C. Oldfield, R. L. G. and F. W. C., acted as observers. The sensation of movement in the centrifuge is marked during deceleration, when the well-known 'tumbling' sensation occurs, the observer apparently falling forward head over heels. In this situation the after-image of the flash tube may expand, as though the observer is falling into it. It seemed clear to all four observers that the magnitude of the effect is not a simple function of 'g', but may be related to the subject's impression of his movement, or the movement of his head, in space.

As a speculation, we may suggest that at least some of these phenomena, and also Emmert's original observation of after-images 'projected' on to a visible screen, may be related to Size Constancy. When an object is viewed normally, decrease in the observer's distance from an object will produce a corresponding increase in the size of the retinal image, but the perceived size of the object may remain almost constant. In the special case of the after-image the image on the retina does not change size as the observer changes his position in space. If the compensation system which normally maintains perceptual size almost constant when the retinal image changes in size were functional in the after-image situation, then we should expect the kind of effects reported here when the observer changes his position in space. If this interpretation is correct, it gives us a technique for studying the Constancies in dynamic situations.