Luminous-Design Phenomena

A year ago in a report in *Science* (*1*), I compared the fragmentation of luminous figures to that of stabilized retinal images. There is a similarity in the perceptually meaningful way that the two disappearance phenomena occur. Recently, J. T. Hart (*2*) has challenged this interpretation by demonstrating that the fragmentation of a small luminous figure is determined by the point of fixation, which is generally the portion of the figure to disappear.

In no way do Hart's data refute my position. His results are related to the fact that his figures, subtending a retinal field of less than 3 degrees, are impinging almost exclusively on the fovea, the retinal area least sensitive to light. At the point of fixation, the center of this relatively insensitive area, it is not surprising that the subject finds it difficult to maintain perception of a very weak stimulus. The perception is not being facilitated by central neural activity arising from stimulation of the rods, which lie mainly on the periphery of the retina and are specialized for vision in dim light.

The phenomenon that Hart reports is interesting (*3*), but it does not account for the large variety of meaningful disappearances I have observed. This can be demonstrated by making his figures as large as those I used, or by moving the subject closer to the figure so that comparable retinal angles are involved, roughly 13 degrees. Under these conditions, the subject still reports disappearances, but this time of the sudden, meaningful sort I described earlier. When I tested five subjects in this manner, each fixating each of the three points in Hart's Fig. 1*B* for 2 minutes, mere point-of-fixation disappearances accounted for only nine of the total of 103 responses, most of which were complete-line or whole-figure disappearances.

Basically, however, Hart's observations are important because they suggest a distinction between disappearances due to receptor insensitivity and those having a central neural basis. In the scotopic situation, the von Kries phenomenon, of which Hart's results are an excellent example, occurs when targets impinge only on the fovea. One might expect a corresponding receptor-related disappearance of targets impinging solely on the periphery of the light-adapted eye. Troxler's effect (*4*) would seem to fit this analogy perfectly, were it not for the recent excellent work of Clarke and his associates in England. They have demonstrated that the Troxler effect can occur at low levels of illumination (*5*), and they suggest on the basis of detailed evidence that the seat of this effect is probably in the lateral geniculates.

There are major differences, however, between these two effects and the phenomenon I reported. Both the von Kries and the Troxler effects refer to the disappearance of relatively small targets, the von Kries occurring in the fovea, and the Troxler occurring most readily in the more extreme periphery (20-degree eccentricity). The disappearances I observed occur with large targets, at the point of fixation and in the surrounding region simultaneously, if a sufficient area is being stimulated. Secondly, and most important, these latter fragmentations are characterized chiefly by the perceptually organized manner in which they occur.

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References

1. J. P. McKinney, *Science* **140**, 403 (1963).
2. J. T. Hart, *ibid.* **143**, 1193 (1964).
3. See R. S. Woodworth and H. Schlosberg, *Experimental Psychology* (Holt, Rinehart, Winston, New York, 1954), p. 366.
4. See H. Davson, *The Physiology of the Eye* (Little, Brown, Boston, 1963), p. 176.
5. F. J. J. Clarke and S. J. Belcher, *Vision Research* **2**, 53 (1962).

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We are interested to note the report by J. T. Hart which attacks McKinney's view that the subjective fading of extended stimuli under conditions of steady fixation occurs in an ordered manner very similar to that reported for the stabilized retinal image. In 1957 Clarke advanced the view (*1*) that the subjective fading of stimuli under steady fixation (Troxler's effect) and the fading of a stabilized retinal image were manifestations of the same underlying process. For simple stimuli viewed in extrafoveal vision with steady fixation, quantitative investigation has shown (*1–3*) that the relation between the fading effects and the experimental conditions (color, intensity, contrast, size, retinal location, and state of preadaptation) are closely similar to those described in the now extensive literature on stabilized images. Differences are merely of degree: the more nearly one approximates to the condition of complete stabilization of the image on the retina, the more marked are the phenomena. Thus with bright stimuli, the speed and degree of fading increases with eccentricity, as a consequence of the increase in coarseness of the functional units of the retina. However, with dim stimuli such as Hart and McKinney have used, the relative scotoma formed by the rod-free central fovea may complicate the situation, for a weak stimulus not much above threshold fades easily, as not much adaptive change is required to bring the resulting neural activity down to below the threshold. Nevertheless, the *kinetics* of fading do not depend on intensity (*1, 3*). It is interesting to note that the latency reported by McKinney agrees well with data published for both steadily fixated and fully stabilized images.

More recent work by Evans and coworkers (*4–6*) examines the nature of fading and disappearance phenomena in three conditions: (i) when simple patterned targets are viewed monocularly, in low illumination, and with headrest and dental bite (*4*); (ii) when similar targets are stabilized on the retina by a contact lens and telescopic focusing system (*5*); and (iii) when similar targets are viewed as prolonged afterimages (*6*). He has shown that "structured" or "meaningful" fragmentations occur in the three conditions, and that there appears to be no qualitative difference in the phenomena reported. Intensive quantitative measures of the frequency of "structured" fragmentation have been made for images stabilized by contact lenses (*5*), and similar studies are at present being undertaken for patterned afterimages (*7*).

It thus seems evident that the suspected link between Troxler's effect and the stabilized-image phenomena is clearly established. However, the location of the effect is not so clear: it cannot be all retinal (*3*), and may be either lateral geniculate (*3*) or cortical (*5*) in origin.

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2. ———, *ibid.* **8**, 121 (1961).
3. ——— and S. J. Belcher, *Vision Research* **2**, 53 (1962).

4. C. R. Evans and D. J. Piggins, *Brit. J. Physiol. Opt.* **20**, No. 4, 1 (1963).
5. C. R. Evans, *Brit. J. Psychol.*, in press.
6. H. C. Bennett-Clark and C. R. Evans, *Nature* **199**, 1215 (1963).
7. C. R. Evans, in preparation.

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In McKinney's comments he restricts his claim about the meaningfulness of luminous-figure disappearances to figures that extend beyond the fovea. This qualifying restriction was not made in his first report. It is pertinent, therefore, to point out that the stabilized-image disappearances reported by Pritchard, Heron, and Hebb (*1*), to which McKinney originally related his results, were obtained with stabilized target images that were entirely within a "central 2 degree field" (*1*, p. 69).

It is also relevant to mention that the figures I used, subtending an angle of 3 degrees, were approximately within the 5-degree area of the central fovea when a 2- to 4-centimeter end point was fixated. However, the figures were *not* confined to the rod-free, 1-degree-20-minute area of the foveola. Contrary to the statement of Clarke and Evans, the central fovea is not rod-free (*2*). Consequently, the rod-stimulated central neural facilitation that McKinney mentions should have occurred with the figures I used. It would be informative to conduct an investigation in which very small figures, figures that fall entirely within the rod-free foveola, were used. If I read McKinney and Clark and Evans correctly, these figures should disappear as wholes because of the rapid adaptation of the cones.

I have found that black figures on luminous backgrounds disappear as easily as luminous figures on black backgrounds. The black figures white-out, becoming indistinguishable from the luminous ground, whereas the luminous figures black out. Point-of-fixation effects are also demonstrable for the black figures. In effect, when the subject sees a disappearance of a part of a black figure (a white-out), he reports seeing light at a point where light should not be striking his receptors.

These effects, in which a part of a figure becomes indistinguishable from the background, are very difficult to explain solely in terms of the von Kries duplexity theory of vision, attributing the disappearances at the point of fixation to cone fatigue. Instead, these results suggest that the disappearance effects may represent a complex interaction of excitatory and inhibitory processes taking place at the boundaries of a figure. Certainly it is difficult to speak of adaptation when a subject is seeing light at an unstimulated area.

I agree with McKinney, and with Clarke and Evans, that the disappearances of unstabilized small figures are different from the disappearances obtained with larger figures. However, the difference is not simply a difference between point-of-fixation disappearances and meaningful disappearances. In my report in *Science*, I devoted two paragraphs to emphasizing the difference in size between McKinney's figures and mine. In one of those paragraphs I commented that pretesting had shown small figures to disappear more readily than large. Perhaps that comment should have been expanded, since the difference between the two figure sizes was not merely a statistical difference between group averages. The fact is that during pretesting I found some subjects who *never* reported disappearances when viewing McKinney's large figures, even when they were questioned at length and told specifically what to look for. Indeed, I have had some subjects look at a point on a large luminous figure for as long as 10 minutes (a task that is nearly unbearable) and still not report a single point, line, or whole-figure disappearance. In contrast, all subjects that I have tested report disappearances for the small figures.

After reading McKinney's letter, I followed his example, testing five subjects on Fig. 1*B* at two viewing distances, one distance giving a retinal-image angle of 3 degrees, the other of 13 degrees. All subjects reported disappearances, mainly point-of-fixation disappearances, for the 3-degree image. Two of the five subjects did not report disappearances of the 13-degree image during the two viewing periods, which lasted 3 minutes apiece. Of the three subjects who reported disappearances for the 13-degree image, two saw sudden whole-line disappearances of the kind mentioned by McKinney; the third saw only slow, fade-out disappearances and slow, fade-in reappearances. Significantly, point of fixation was an important determinant of the locus of the disappearance, even at the short viewing distance, but in a way opposite to its influence on foveal images. It was the point of fixation which seldom or never disappeared in images that extended considerably beyond the fovea. The results reported in McKinney's letter appear to confirm this observation.

The results I have reported from the pretesting and in the brief test just described can only be regarded as tentative, since they have not been made the subject of a careful experiment that would eliminate possible errors. (For example, the use of different viewing distances to vary retinal-image size concomitantly varies luminance.) Nonetheless, I have consistently obtained individual differences among subjects when they view large figures, or small figures at a short distance. I do not understand why neither McKinney nor Clarke and Evans have detected these individual differences, since subjects do appear to differ strikingly (i) in their ability to see disappearances in large figures and (ii), if they see disappearances, in the kinds of disappearances they report. Certainly these individual differences will need to be traced and explained before generalizations can be made about the meaningfulness of large-figure disappearances. At the present time, all that can be said is that some subjects report meaningful disappearances and some do not.

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