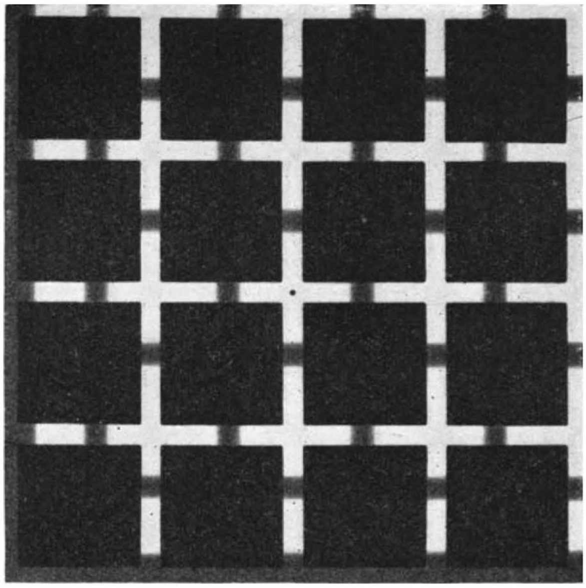

Fig. 2

light source fixed in complete darkness after the production (by electronic flash) of an after-image occupying a large part of the visual field, for example, of a pattern like Fig. 1, is generally reported to be in constant vibratory motion while the after-image object seems to be at rest. Similarly, the relative extension of the visual patterns can easily reverse the sensation of movement based on retinal information: when the unsharp part of a pattern like that in Fig. 2 is extensive and the sharp part small, for example, only one crossing-point, observers generally report that the sharp crossing-point vibrates with respect to the stationary unsharp pattern.

It seems that this illusion has something to do with Exner's *Punktschwanken* (point wobbling)[18] or that it is even identical with it. Exner distinguished between the continuous and smooth apparent movement of a spot of light in complete darkness, first described by Charpentier[19] and termed *autokinetische Empfindung* (autokinesia) by Aubert[20], and the apparent wobbling movements of a spot of light within a larger surrounding grey spot viewed in dim light. Hörwall[21] criticized Exner's idea that point wobbling would underlie the autokinetic illusion. Hörwall emphasized that point wobbling is only observed as an apparent irregular movement of small amplitude performed by the fixation point with respect to vague contours in its near environment, and that sharp contours inhibit the illusion. He ascribed the point wobbling illusion to the differences in latency time in localizing the retinal images of the vague contours and the sharp fixation point, both moving identically over the retina as a result of the involuntary movements of the eyes during fixation. It seems reasonable to suppose that differences in retinal movement information from the vague contour and the sharp fixation point, together with the different extension of both patterns, can account for Exner's *Punktschwanken*.

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[1] Verheijen, F. J., *Optica Acta*, **8**, 309 (1961).
[2] MacKay, D. M., *Nature*, **181**, 507 (1958).
[3] Barlow, H. B., *J. Physiol.*, **119**, 69 (1953).
[4] Maturana, H. R., Lettvin, J. Y., McCulloch, W. S., and Pitts, W. H., *J. Gen. Physiol.*, **43**, Second Supp., **129** (1960).
[5] Hubel, D. H., *J. Physiol.*, **147**, 226 (1959).
[6] Hubel, D. H., *J. Physiol.*, **150**, 91 (1960).
[7] Hubel, D. H., and Wiesel, T. N., *J. Physiol.*, **148**, 574 (1959).
[8] Hubel, D. H., and Wiesel, T. N., *J. Physiol.*, **160**, 106 (1962).
[9] Kuffler, S. W., *J. Neurophysiol.*, **16**, 37 (1953).
[10] Arden, G. B., *Nature*, **196**, 999 (1962).
[11] Rashbass, C., *J. Physiol.*, **159**, 326 (1961).
[12] Ludvigh, E., *Amer. Med. Assoc. Arch. Ophth.*, **48**, 436 (1952).
[13] Westheimer, G., *Amer. Med. Assoc. Arch. Ophth.*, **52**, 710 (1954).
[14] Brindley, G. S., and Merton, P. A., *J. Physiol.*, **153**, 127 (1960).
[15] Holst, E. von, *Brit. J. Animal Behav.*, **2**, 89 (1954).
[16] Ludvigh, E., *Amer. Med. Assoc. Arch. Ophth.*, **48**, 442 (1952).
[17] MacKay, D. M., in *Aspects of the Theory of Artificial Intelligence*, edit. by Muses, C. A., 339 (Plenum Press, 1962).
[18] Exner, S., *Z. Sinnesphysiol.*, **12**, 313 (1896).
[19] Charpentier, A., *C.R. Acad. Sci. Paris*, **102**, 1155, 1462 (1886).
[20] Aubert, H., *Pflügers Arch.*, **40**, 459 (1887).
[21] Hörwall, H., *Skand. Arch. Physiol.*, **27**, 50 (1926).

The essence of Dr. Verheijen's pleasing demonstration is that a blurred and a sharp contour, moving objectively with the same velocity over the retina, do not appear to move together. This could be caused by either: (*a*) a difference in the latency, or (*b*) a difference in the magnitude of the respective responses evoked in the visual system (or, of course, by both).

As a test of the first hypothesis, we have subjected sharp and blurred contours, successively and simultaneously, to oscillatory motion by reflexion in two mechanically rocked mirrors. If a signalling time-lag alone were responsible for the illusion, the estimated amplitude of movement should be the same for either image alone. In fact, it appears greater for the blurred contour, particularly if no stationary objects are present in the field to give cues to position, as distinct from amplitude.

By adjusting the relative phase of the two mirrors, it is possible to bring the blurred and sharp images approximately into step. The amplitude of 'motion' of the blurred image can then be seen to be the greater. If a signalling time-lag were responsible for the phase-difference, the phase setting required should vary with frequency of rocking. In fact, however, the 'phase lead' of the blurred over the sharp image is found to be practically independent of frequency.

We are thus driven to hypothesis (*b*), favoured by Dr. Verheijen, that more 'velocity information' is generated by the blurred contour; but since mere blurring, as distinct from mottling, does not increase the number of contours in motion, and since it diminishes the gradient of intensity, it is not easy to see why a greater number of 'movement detector units' should be stimulated.

A simple but striking experiment suggests that the spurious information here is generated in the detectors of intensity, rather than of motion. If the image of an 'optical wedge', projected on a screen, is displaced in the darker or lighter direction, the graded region appears lighter or darker respectively, so that the apparent displacement greatly exceeds the actual. Conversely, an increase or decrease in overall illumination gives rise to an impression of displacement in the darker or lighter direction, respectively.

Both phenomena invite a simple explanation in terms of local adaptation to intensity. If the graded image is displaced in the darker or lighter direction, then each intensity-detector finds itself under- or over-adapted, respectively, and the effect of this maladaptation is to enhance the change in response (by 'successive contrast')—as if the actual image-displacement had been greater. The effect is to make the perceived image 'lead' the actual (in space). Conversely, an overall change in illumination causes changes in response and in adaptation-level locally indistinguishable from those due to displacement of the graded image.

Our suggestion would therefore be that it is not the greater number of 'movement detectors' stimulated, but the spurious enhancement of the cues supplied to the movement detecting system, that accounts for the greater mobility of a blurred image.

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