

## Clues to the site of origin of the complementary image

PATTERNS of near-parallel black-and-white lines induce an anomalous state of the visual system, in which a superimposed test field of dynamic noise (such as the 'snowstorm' on a detuned TV receiver) seems to stream in directions roughly perpendicular to the inducing contours<sup>1</sup>. The illusory streamers form a 'complementary image' (CI) which for the stimulus of Fig. 1a comprises a family of wavy circles, as sketched by J. P. Wilson<sup>2</sup> in Fig. 1b. When two orthogonal gratings are superimposed, the streamers lie at 45° to both, as if the resulting bias obeys the rule of vector summation<sup>3</sup>. J. P. Wilson<sup>4</sup> has observed rudimentary signs of directional bias and streaming even at a single black/white contour; and M. E. Wilson<sup>5</sup>, using only simple pairs of test spots illuminated in sequence, found that the illusory 'phi' motion seen between the spots was enhanced for directions orthogonal to the contours of a superimposed grating. When the inducing pattern is presented to one eye and the noise field to the other, however, little or no CI is observed<sup>1,6</sup>. It has seemed logical<sup>1</sup> to attribute these phenomena to some form of adaptive cooperative activity among orientation-sensitive cells of the visual system, leading to a kind of 'simultaneous contrast' in the orientation domain, that is, a bias of the signalling system for motion and contour orientation in favour of the orientation(s) not present in the inducing stimulus.

Human observers can perceive contours outlined only by contrasts of texture or colour almost as readily as those due to differences in luminance. It would therefore help in locating the site of origin of the CI to know whether the system responsible can be directionally biased by patterns outlined only by contrasts of texture or colour. Hammond and I<sup>7,8</sup> have recently found that 'simple' cells in area 17 of cats, which respond briskly to a suitably orientated moving black bar, show no response to a similar (clearly recognisable) bar of random visual texture moving over a static textured background of the same mean luminance. Although the colour sensitivity of simple cells in area 17 of primates is still controversial<sup>9,10</sup>, it seems that most are also insensitive to boundaries outlined by colour contrast alone. Thus, if the CI could be induced by patterns of texture or colour contrast alone, this would suggest that it originated in a system not dependent on simple cells for its input (unless human simple cells differed in this respect from those of cat and monkey). If, however, induction of the CI required the patterns to be outlined by luminance contrast, this would point to the simple-cell system as the likely site of origin.

In the first experiment, a 60-ray pattern 12 cm in diameter, similar to Fig. 1a, was cut from white paper and placed over the screen of a detuned TV receiver generating dynamic visual noise. The paper pattern was front-lit at a luminance of 30 cd m<sup>-2</sup>. With the mean luminance of the TV display either higher or lower than that of the paper pattern, the normal CI was clearly visible in the noise. When the mean luminance was adjusted to the same level (30 cd m<sup>-2</sup>), however, the CI disappeared, although the white ray pattern remained clearly perceptible by contrast with the dynamic noise between its spokes. (Some 60 observers have confirmed these findings).

An analogous experiment was then carried out using patterns outlined by colour contrast. A pair of conventional 100-W slide projectors with red and green filters (Cinemoid nos 14 and 24) were used in conjunction with a mixer cube to project on to the noise-filled TV screen the same 60-ray figure outlined at ~20 cd m<sup>-2</sup> in red and green. The mean luminance of the (white) noise field alone was adjustable for optimum effect. When the luminances of the interleaved red and green rays were matched the CI was absent or much reduced for all of five observers, although with the red or green rays alone (that is, one projector switched off) it was clearly visible.

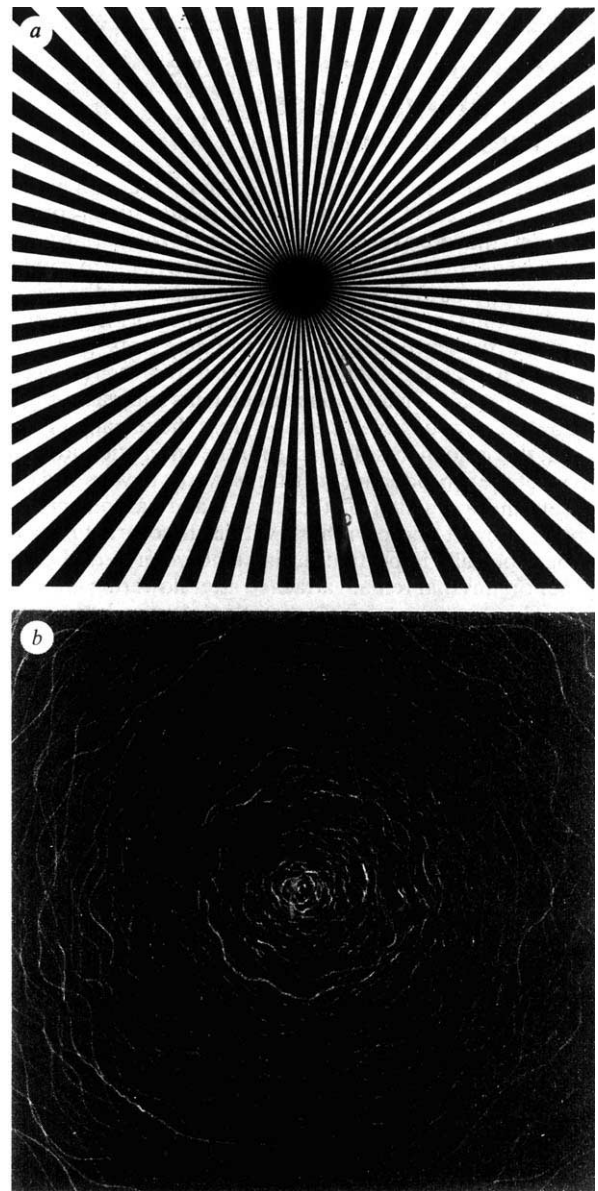


Fig. 1 a, The stimulus used for the production of a CI. b, The family of wavy circles obtained.

It therefore seems that the anomalous physiological condition responsible for the CI arises not at the level of the pattern-recognising system *per se*, but at an earlier stage of visual information processing which is specifically sensitive to contrasts of luminance, although not of texture or (perhaps) colour. The absence of significant interocular transfer suggests a location in the monocular visual sub-system. The parallel with the preferences shown by simple cells in area 17 of cats and monkeys points to these cells, or others dependent on them, as likely candidates.

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