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Notes and Comment

Illusory contours are not caused by simultaneous brightness contrast

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Contours without a physical brightness gradient can easily be perceived in displays constructed of inducing elements with opposite contrast. This simple but direct demonstration shows that simultaneous brightness contrast is not a cause of our perception of subjective contours and supports the notion that higher level cognitive operations and not lower level sensory processes are responsible for our percepts in these situations.

There are conditions in which contours are perceived in areas of visual field where the physical stimulation is in fact homogeneous (Kanizsa, 1955; Schumann, 1904). Despite the apparent simplicity of the displays (which sometimes consist of only three elements), there is no generally agreed upon explanation of the phenomenon, and there is still much disagreement about the causes of the illusion.

In order to understand our perception of illusory contours, one has to explain the origins of illusory stratification (perception of one surface in front of the other), the illusory brightness difference between the "figure" and the "ground" that usually accompanies the illusion, and the existence of illusory contour (perception of edges in the regions of homogeneous stimulation (Figures 1a and 2a). The proposals put forward to explain the illusion can be divided into two broad classes. The "active" (top-down) approach is favored by most "cognitive" theories (Coren, 1972; Gregory, 1972; Kanizsa, 1979; Rock & Anson, 1979). It holds that certain stimulus features elicit a conceptual structure that is then tested against the other available evidence. It is the consequences of the conceptual structure chosen to account for the available data that are responsible for our perception of subjective contour, apparent stratification, and illusory brightness enhancement.

The second approach is a more "passive," bottom-up processing based on the current ideas about the working of low-level sensory processes. Common to these accounts is the belief that some form of the simultaneous brightness contrast (induced by lateral inhibition) is responsible for the illusory brightness enhancement, which is then the direct cause of the perception of the illusory contour, which in turn gives rise to the perception of occlusion. This general approach is perhaps best exemplified by hypotheses that claim that a region of enhanced brightness (induced by line ends and at the boundaries of the features), once formed, spreads out to fill the shape outlined by small features such as line ends and points

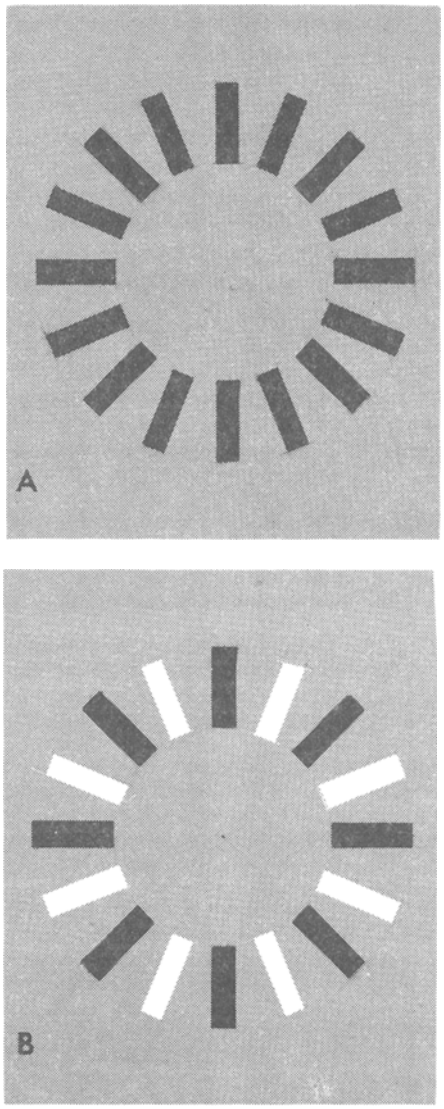

Figure 1. (a) Black bars on a gray background produce the familiar "sun illusion." (b) Qualitatively, the same percept can be obtained even when some of the bars have the opposite contrast.

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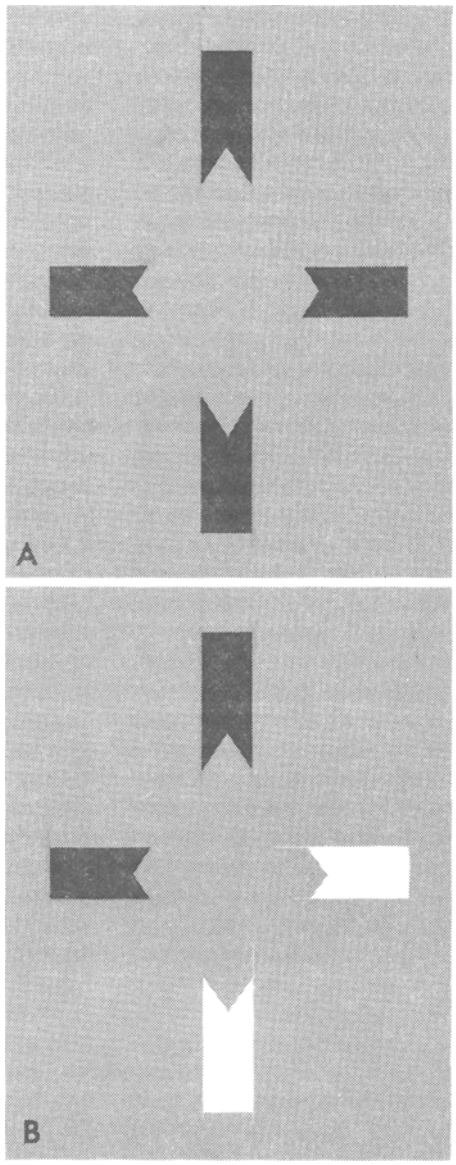

Figure 2. (a) A diamond occluding a cross can be seen when four black bars with a cut-out are painted on a gray background. (b) The same diamond is perceived even when two of the bars have opposite contrast. Observe that (unlike in Figure 1b) no diamond can be perceived if one set of the bars (either dark or light) is removed.

(Brigner & Gallagher, 1974; Day & Jory, 1980; Frisby, 1980; Frisby & Clatworthy, 1975).

Much of the difficulty in determining the causes of the illusion is inherent in the fact that the various contributing factors tend to covary during the perception of subjective contour. Thus far, researchers have been unable to pinpoint a single attribute that is necessary and sufficient for the perception of the illusory contour. We present direct evidence showing that simultaneous brightness contrast is not a cause of the illusion. The evidence consists of a simple demonstration (Figures 1b and 2b). The existence of illusory contours clearly visible in displays similar to Figures 1b and 2b will be difficult (and probably impossible) to explain within the framework of any theory using the simultaneous brightness contrast as the causal agent. This is because the elements of opposite contrast induce simultaneous brightness contrast of opposite sign. An explanation based on the spread of the region of enhanced brightness would require that the spreading regions of opposite contrast do not interact with each other and, at the same time, that they do interact with bounding features of the opposite (and the same) contrast. A theory satisfying both these requirements simultaneously will probably not survive Occam's razor.

Our demonstrations shows that the illusory brightness enhancement within the region bounded by the subjective contour (if present at all) does not participate in the causal link leading to the perception of the illusory contour. We feel that one can reject theories that rely on the simultaneous brightness contrast as the causal agent. It remains to be determined which of the competing "cognitive" theories offers the best explanation of the three phenomena (illusory stratification, brightness enhancement, and contour without gradient) that comprise subjective contours.

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