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Surface geometry influences the shape of illusory contours

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Abstract

Geometric and neural models of illusory-contour (IC) synthesis currently use only local contour geometry to derive the shape of ICs. Work on the visual representation of shape, by contrast, points to the importance of both contour and surface geometry. We investigated the influence of surface-based geometric factors on IC shape. The local geometry of inducing-contour pairs was equated in stereoscopic IC displays, and the shape of the enclosed surface was varied by manipulating sign of curvature, cross-axial shape width, and medial-axis geometry. IC shapes were measured using a parametric shape-adjustment task (Experiment 1) and a dot-adjustment task (Experiment 2). Both methods revealed large influences of surface geometry. ICs enclosing locally concave regions were perceived to be systematically more angular than those enclosing locally convex regions. Importantly, the influence of sign of curvature was modulated significantly by shape width and medial-axis geometry: IC shape difference between convex and concave inducers was greater for narrow shapes than wider ones, and greater for shapes with straight axis and symmetric contours (diamond versus bowtie), than those with curved axis and parallel contours (bent tubes). Even at the level of illusory "contours," there is a contribution of region-based geometry which is sensitive to nonlocal shape properties involving medial geometry and part decomposition. Models of IC synthesis must incorporate the role of nonlocal region-based geometric factors in a way that parallels their role in organizing visual shape representation more generally.

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1. Introduction

The ubiquitous occurrence of occlusion in natural scenes poses a difficult challenge to the visual computation of objects. Objects can either be partly occluded by an interposed object, or be camouflaged by an underlying surface that happens to project the same color (a problem that is exacerbated in conditions of low illumination). Objects are also invariably self-occluded: a large portion of each opaque object—its "back" relative to the viewer—has no counterpart in the retinal images. Moreover, occlusion and disocclusion can take place dynamically, either due to the motion of one of the objects, or that of the observer's vantage point. Michotte's work stands out as the first unified treatment of the full range of completion phenomena in both static and kinematic displays—where the visual system fills in missing structure—and a systematic analysis of the image cues necessary to initiate processes of visual completion (Michotte, 1950; Michotte, Thinès, & Crabbé, 1991). To this day, Michotte's work continues to motivate research into these problems; the articles in this special issue attest to the long-standing influence of his insights (see Bertamini & Hulleman, 2006; Van Lier, de Wit, & Koning, 2006).

The current paper focuses on the context of "illusory" or "subjective" contours—vivid contours that can be perceived in image regions containing no local contrast (see, e.g., Fig. 1). Following Michotte et al., this form of interpolation is referred to as *modal* completion, to emphasize the fact that the percept has the same 'mode' as if image contrast were actually present: "... these additions present the same visual qualities (luminance and color) as the rest of the configuration ..." (Michotte et al., 1991). It is contrasted with *amodal* completion—the visual completion of partly occluded contours and surfaces—where no contrast is perceived along the visually interpolated contour, despite a compelling

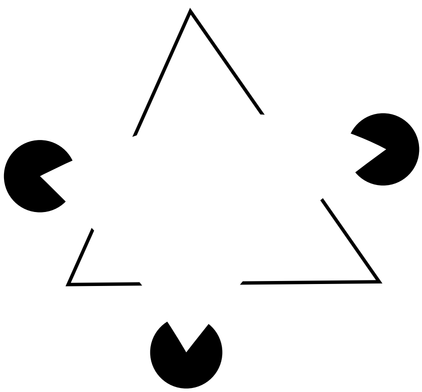

Fig. 1. An example of illusory contours. Vivid contours are perceived in image regions containing no local contrast.