Spatial Vision, Vol. 13, No. 2,3, pp. 241–253 (2000)

Recognizing depth-rotated objects: A review of recent research and theory

IRVING BIEDERMAN*

Department of Psychology and Neuroscience Program, Hedco Neurosciences Building, MC2520, University of Southern California, Los Angeles CA 90089-2520, USA

Received 20 September 1999; revised 27 March 2000; accepted 29 March 2000

Abstract—Many of the phenomena of object classification can be derived from a representation specifying a nonaccidental characterization of an object's parts (geons) and relations, termed a geon structural description (GSD). Such a representation: (a) enables the facile recognition of depth-rotated objects, even when they are novel, (b) provides the information that is employed not only to distinguish basic-level but also highly similar members of subordinate-level classes, and (c) enables mapping onto verbal and object-reasoning structures. Recent psychophysical and neural investigations of object recognition have provided additional support to this theory of object representation.

1. INTRODUCTION

Theories of the representation mediating object recognition are often termed 'controversial', particularly in accounting for the effects of rotation in depth. The apparent controversy centers on whether 'view-based' templates (e.g. Poggio and Edelman, 1990) are to be preferred to structural descriptions that posit simple viewpoint-invariant part primitives (geons) and explicit categorized relations (i.e. geon structural descriptions, GSDs) (Biederman, 1987; Hummel and Biederman, 1992). GSDs place heavy reliance on nonaccidental properties (NAPs), which are largely unaffected by rotation in depth. NAPs provide a ready basis for distinguishing one object's parts and relations from another. In contrast, neither NAPs nor explicit parts nor explicit relations are specified by view-based templates. We note here that some of the leading proponents of view-based templates (e.g. Riesenhuber and Poggio, 1999) have very recently abandoned templates in favor of feature

*E-mail: bieder@usc.edu

lists in which features are translationally and scale invariant. This development is discussed in a later section.

After an initial demonstration contrasting object recognition with and without distinctive GSDs, recent empirical and theoretical work on the issue of the recognition of depth-rotated objects will be considered. Insofar as the evidence for the employment of NAPs (and parts) provided a strong evidential basis for the abandonment of templates, this review is still timely.

1.1. A demonstration

Imagine performing a matching task in which you are to determine if two sequentially presented novel objects are the same or different, irrespective of their orientation in depth. Before scrutinizing Fig. 1, please cover the objects with your hand.

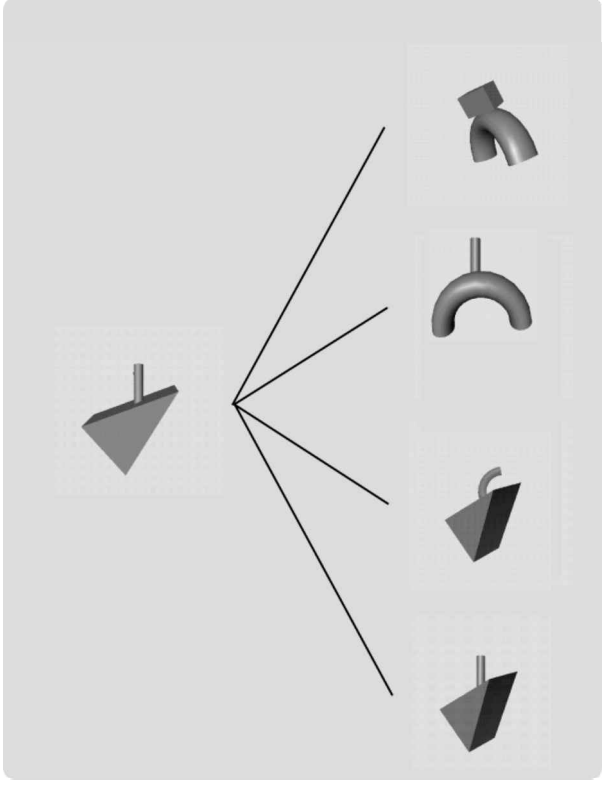

Figure 1. An illustration of four trials in a Same/Different matching task of two-geon novel objects taken from Biederman and Bar (1999). The object on the left is S1, the first stimulus for all four trials. The four objects in the right column are possible S2s. The top object differs in both geons; the second and third in one geon, and the bottom object is the same, but rotated in depth. Observers should have no trouble accurately performing same/different judgments. Nor should they have any difficulty in describing the objects and how they differ from each other. Only the third and fourth S2s would have been trials in the Biederman and Bar (1999) experiment.