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Notes and Comment

Comment on Warren's Visual information for object identity in apparent movement

JOHN B. PITTENGER
University of Arkansas—Little Rock
Little Rock, Arkansas 72204

and

ROBERT E. SHAW
University of Connecticut
Storrs, Connecticut 06268

Warren (1977) recently used an apparent motion paradigm as a method to test differential predictions made by two theories of the perception of object identity: one was the generally held constructive feature-comparison model (cf. Neisser, 1967) and the other was based on geometric transformations as a source of information for perception of objects and events. The second theory was initially suggested by James Gibson (1966a, 1966b) and developed by us (Shaw & Pittenger, in press). While Warren's use of the theory was appropriate and his results in fact support our claim, we wish to make two comments on his work. One is a theoretical clarification: while Warren used the theory to account for perceived object constancy for rigid objects rotating in three dimensions and thus changing the shape of the projected retinal image, our theory is mainly aimed at the less well-studied case of perceived identity of nonrigid objects undergoing transformation of their actual physical shape. Second, it seems to us that Warren's technique can be used both as a way to test the more general version of our theory and to study the nature of apparent motion.

Warren showed that if the two stimuli are retinal projections of a two- (or a three-) dimensional rigid object at two different rotations in depth (for example a square and a trapezoid), then observers see apparent motion of a single object rotating in depth. When the two objects are related, not by a projective transformation, but by an affine transformation (for example, a rectangle and a square) or by a topological transformation (for example, a square and a triangle), observers report both motion and a change in the nature of the object. That is, as the object moves, it becomes something else. Our theory claims that object identity is perceived on the basis of information for the transformability of one shape into another. Here the transformability of the square into a trapezoid by a projective transformation provides information for the perception of the event of a square undergoing rotation. Our theory was thus supported. Different predictions made on the basis of the feature-comparison theory were not confirmed. It should be noted that Warren's logic and experimentation are, in a way, parallel to the work of Gunnar Johansson. Johansson (1977) has recently reinterpreted his research on motion perception in terms of shape constancy and argues for use of the geometry of projective transformations. He uses continuous transformations in his displays rather than two "frozen" images as in Warren's work.

While Warren has made a valid application of our theory, the main thrust of our work is toward a somewhat different problem. Many objects change their actual physical shape over time rather than merely changing their projected retinal shape as they move. For example, the shape of the face varies with emotional expression, the proportions of the head and body change with growth, the configurations of body parts change as one walks, trees bend in the wind, etc. Perception of identity is also an issue in these situations: after aging, a person's face is still recognized as that particular person's face, even though many aspects have changed. We would argue that the basis for perception of the identity of the object lies in characteristics left invariant under the transformation (the structural invariants), while the particular transformation involved (the transformational invariant) specifies what event has occurred. It is worth noting that this class of problems concerned with shape changes has great generality: species evolve, galaxies grow and change their configurations, etc. While the problem is well-recognized in the natural sciences (cf. Thompson, 1942; Thom, 1972/1975) it has had relatively little impact on perceptual psychology. It has been studied from the feature comparison point of view by cognitive psychologists as the problem of concept formation.

Using Warren's technique to study perception of nonrigid objects might be useful in several ways. First, it is a promising method for testing the theory. In Warren's original situation, projective geometry may be validly applied to any rotating rigid object. In the case of nonrigid objects, there are strong constraints on the exact transformations that are ecologically valid for a particular object and event. For example, Warren found that strain (affine) transformations failed to produce perceived object constancy when applied to a square. However,

certain other types of strain transformations have been found to be ecologically valid for cranio-facial growth. In a different experimental paradigm than used by Warren, these (topological) transformations produce perceived preservation of identity and perception of aging when applied to human faces (Pittenger & Shaw, 1975). This suggests that one might consider other types of transformations in the place of those studied by Warren. Consider for instance, a human face and a flower, both transformed by transformations indicative of human facial growth. In Warren's paradigm, our theory should predict perceived identity with the face but not with the flower. This transformation is not an ecologically valid change for the growth of a flower, but constitutes a change of one flower into something else, at best into a different flower.

The technique might also help illuminate the nature of apparent motion. The theory provides a motivation for choosing the stimuli to be used. Since we can perceive nonrigid motion in objects which keep their identity in the real world, the question arises as to whether or not such perception is possible under apparent motion conditions. If the apparent motion paradigm permits perception of identity only for rigid objects, we then have evidence of a "deep" difference between real and apparent motion. Given application of appropriate (i.e., ecologically valid) transformations to the particular forms involved, identity across the forms might indeed be perceived. This would be important to Kolers' conclusions about apparent motion. In his major survey of apparent motion, Kolers (1972) holds that descriptive geometry and analysis by common features are not appropriate for stimulus specification. If, however, identity is seen under *appropriate* transformation, then a precise, geometric description of the stimulus seems possible.

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