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REPRESENTATIONAL MOMENTUM AS A NEW GESTALT PRINCIPLE

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Abstract

Gestalt principles of perceptual grouping have been considered to reflect dynamic aspects of mental representation. Another phenomenon considered to reflect dynamic aspects of mental representation is representational momentum (when memory for a target is shifted in the direction of target motion), and similarities of consequences of Gestalt principles of perceptual grouping and consequences of representational momentum are discussed. These similarities involve (a) displacement in remembered location, (b) reflection of environmental regularities, (c) decreases in the amount of information to be processed, (d) bases in isomorphism, (e) contributions to aesthetics and artistic expression, (f) effects of context, (g) production of laboratory-based illusions, and (h) automaticity of application. It is concluded that representational momentum represents a new class of Gestalt principle.

Gestalt psychologists proposed several grouping principles that govern which elements in a sensory field would be grouped together. Although examples of these principles found in textbooks usually involve static figures (see Figure 1), these principles actually reflect dynamic processes. More recently, another phenomenon suggested to reflect dynamic processes, representational momentum, has been documented (for review, Hubbard, 2005). Representational momentum is a displacement in the direction of motion of the remembered location of a target (see Figure 2). Given that Gestalt grouping principles and representational momentum both result from dynamic processes, it is possible these phenomena are more similar than previously realized. It will be suggested here that consequences of Gestalt principles of perceptual grouping and consequences of representational momentum are highly similar, and that representational momentum reflects a new class of Gestalt principle.

Similarities of Representational Momentum and Gestalt Principles

Displacement in Remembered Location

Both representational momentum and Gestalt principles of perceptual grouping result in displacement in remembered location. Coren and Girgus (1980) examined "Gestalt Illusions," and an example is shown in Figure 3. The principle of proximity results in the vertical lines in the top row being grouped as four pairs and the vertical lines in the bottom row being grouped as three pairs. Two lines in each row are indicated by the arrows, and the two lines in the top row are the same distance apart as the two lines in the bottom row. However, the indicated lines in the top row are parts of different pairs, and the indicated lines in the bottom row are parts of the same pair. When participants reproduced the distance between the lines, the reproduced distance for the lines in the top row was larger than the reproduced distance for the lines in the bottom row. Remembered location was biased so that the distance for lines grouped together was decreased relative to the distance for lines in different groups. Coren and Girgus also provided examples of similar illusions based on closure, good continuation,

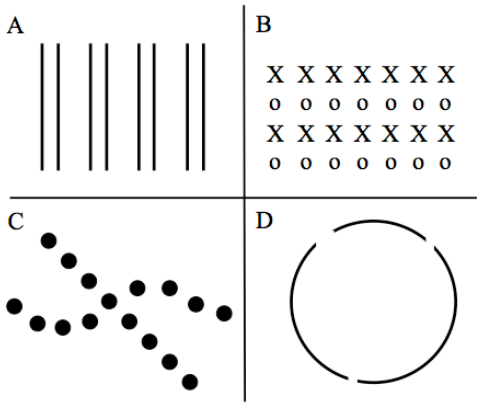

Figure 1. Gestalt principles of (A) proximity, (B) similarity, (C) good continuation, and (D) closure.

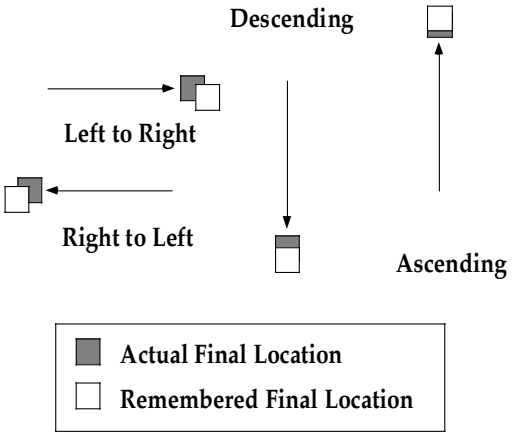

Figure 2. Representational momentum, a forward displacement in the remembered location of a target. Adapted from Hubbard (2005).

and other grouping principles. As noted above, representational momentum involves displacement in remembered location in the direction of target motion.

Reflection of Environmental Regularities

Both representational momentum and Gestalt Principles of perceptual grouping reflect environmental regularities. Regularities reflected by Gestalt principles involve object and form recognition (e.g., Goldstein, 1999; Lowe, 1985). Objects tend to be homogenous in lightness and texture (similarity), parts of a object tend to be closer to parts of the same object than to parts of other objects (proximity), objects follow along smooth and continuous paths rather than abruptly changing direction (good continuation), and portions of an object can be occluded or in shadow (closure).

Regularities reflected by representational momentum involve dynamics involved in object motion and localization (Hubbard, 2005, 2006). In Figure 4, an observer initially perceives a moving object at position P1. This starts a cascade of sensory, perceptual, cognitive, and perhaps motor processing. This processing is fast, but it requires a minimum amount of time. While this processing occurs, the object continues to move. By the time processing is complete, the object has moved to position P2. If the response is to be optimal, it should be calibrated to where that object would be when the response would reach it (i.e., at P2), not where the object was when the processing was initiated (i.e., at P1). Representational momentum bridges the gap between perception and action by reflecting dynamics of or on an object.

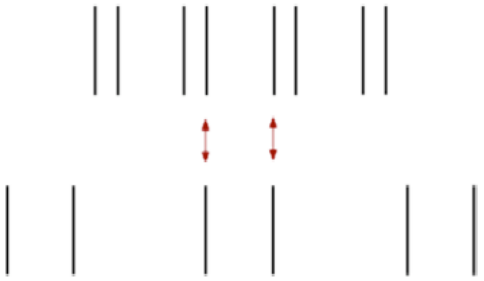

Figure 3. A Gestalt Illusion based on proximity. The lines indicated by arrows are the same distance apart in the top and bottom rows, but the distance is remembered as larger in the top row. Adapted from Coren and Girgus (1980).

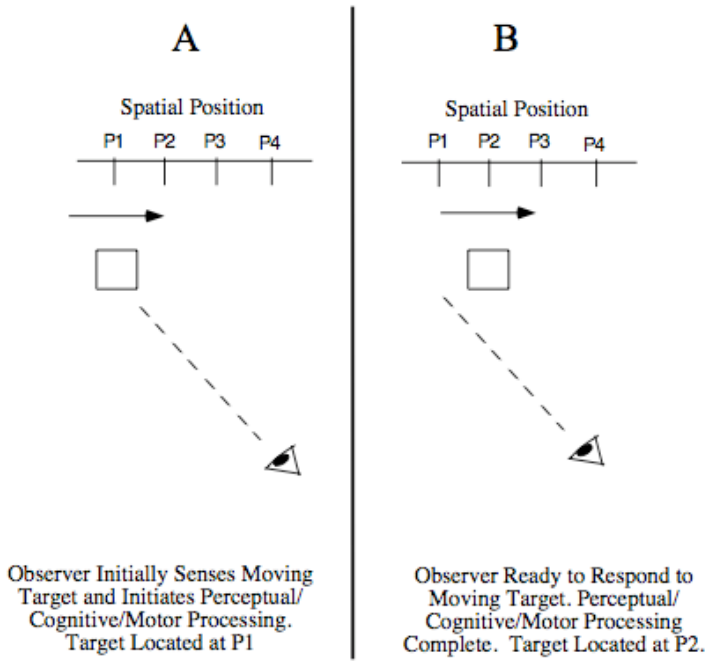

Figure 4. How representational momentum aids spatial localization. Panel A shows the target's position when initially sensed, and Panel B shows the target's position when a response from the observer would reach the target. Representational momentum bridges the gap between P1 and P2. Adapted from Hubbard (2005).

Decreases in the Amount of Information Processed

Both representational momentum and Gestalt principles of perceptual grouping decrease the amount of information to be processed. When shown shapes such as those in Figure 5, observers agree the leftmost shape is lowest in figural goodness and the rightmost shape is highest in figural goodness. The leftmost shape requires the most information to specify (64 bits), and the rightmost shape requires the least information to specify (16 bits, plus vertical and horizontal reflections). Thus, shapes higher in figural goodness require less total information to be processed.

Consider a moving target. In the absence of sensitivity to momentum, the search space for a subsequent location of that target is a circle centered on the target. However, in the presence of sensitivity to momentum, the search space is decreased in total size and is centered in front of the target (i.e., shifted in the direction of motion). Thus, sensitivity to dynamics of momentum requires less total information to be processed.

Bases in Isomorphism

Both representational momentum and Gestalt principles of perceptual grouping are based in isomorphism. Gestalt theories speculated on the correspondence between structures in the nervous system and structures of perceived objects, and referred to this as *isomorphism* (e.g., Kohler, 1969). The Gestalt notion did not involve a picture-in-the-head structural similarity as suggested by critics (see Henle, 1984), but instead involved a functional resemblance.

Shepard's theory of mental imagery involved a similar functional resemblance referred to as *second-order isomorphism* (see Figure 6). Just as a distal object rotating from orientation A to orientation C must pass through an intermediate orientation B, so too

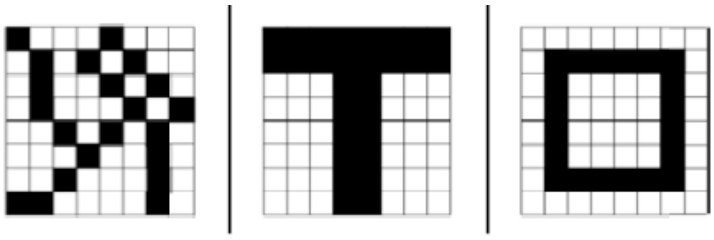

Figure 5. The relationship between figural goodness and the amount of information to specify a figure. As figural goodness increases, the amount of information to specify that figure decreases. Adapted from Coren, Ward, and Enns (2004).

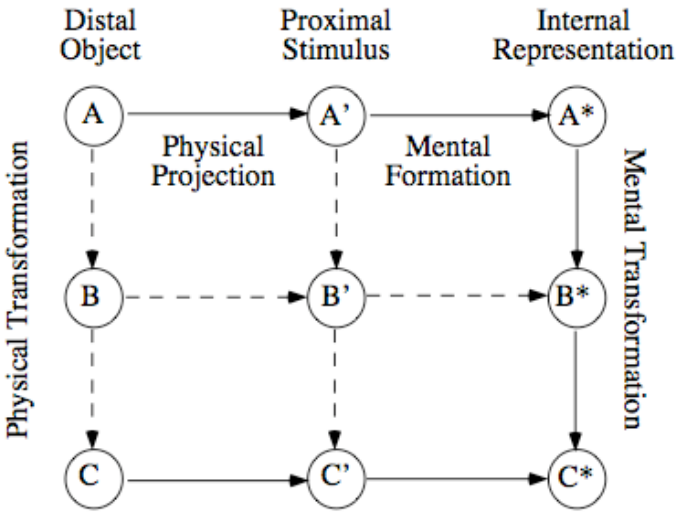

Figure 6. The correspondence between physical and mental transformations. Adapted from Shepard and Cooper (1982).

the mental image of an object rotating from orientation A* to orientation C* must pass through orientation B*. This second-order isomorphism can be adapted for representational momentum: Just as a distal object rotating from orientation A to orientation C must exhibit momentum, so too must the internal representation of an object rotating from orientation A* to orientation C* exhibit momentum.

Contributions to Aesthetics and Artistic Expression

Both representational momentum and Gestalt principles of perceptual grouping are related to aesthetics and artistic expression. Arnheim (1966, 1974) proposed a Gestalt theory of art in which traces of forces that acted on a stimulus could be seen in the shape and structure of that stimulus (see also Leyton, 1992); indeed, Arnheim (1966, p. 62) suggested artistic expression is "the psychological counterpart of the dynamic processes that result in the organization of the perceptual stimuli."

Studies of representational momentum examine effects of dynamic information acting on or contained within a stimulus. One method used in the study of representational momentum is to present a "frozen action photograph" drawn from a larger motion sequence (e.g., a dancer in mid-leap); observers are more likely to accept a subsequently presented probe as being the same as the original photograph if that probe was drawn from later in the motion sequence than from earlier. An aesthetic work of art often appears as if it were a frozen action photograph drawn from a larger motion sequence (see Figure 7), and so dynamics assessed by studies of representational momentum and specified by Arnheim's Gestalt theory of art might be related or even identical (see Hubbard & Courtney, 2006).

Effects of Context

Both representational momentum and Gestalt principles of perceptual grouping are influenced by context. It is a truism in Gestalt psychology that the whole is greater than the sum of the parts. For example, the strength of illusory contours in a Kanizsa-figure is greater when there is more context suggesting such a contour should be present (see Figure 8). Similarly, the direction in which a triangle is perceived to

Figure 7. Examples of aesthetic works of art that contain dynamic information. Adapted from Hubbard and Courtney (2006).

point depends upon the configuration within which that triangle is embedded (see Figure 9).

Context can influence representational momentum: Motion of a surrounding frame (Hubbard, 1993; Whitney & Cavanagh, 2002), and whether a target moves toward or away from a landmark (Hubbard & Ruppel, 1999), influence representational momentum. If target motion oscillates, then displacement at the moment of an anticipated reversal is in the direction of the expected reversal and not the direction of prior motion (Johnston & Jones, 2006; Verfaillie & d'Ydewalle, 1991).

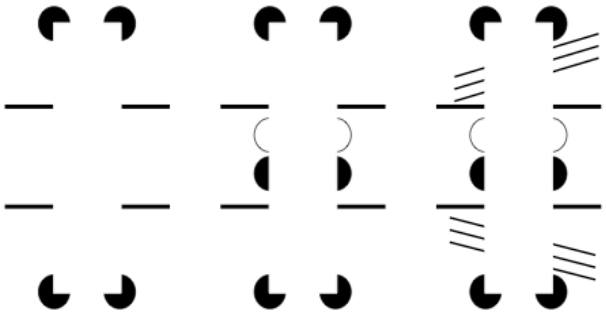

Figure 8. The strength of illusory contours increases when the amount of context suggesting such contours should be present increases. Adapted from Schiffman (2001).

Production of Laboratory-Based Illusions

Both representational momentum and Gestalt principles of perceptual grouping result in illusions. As noted earlier, the Gestalt Illusions give rise to illusions regarding distance (e.g., Figure 3), and Gestalt principles give rise to illusory contours (e.g., Figure 8). Similarly, representational momentum gives rise to illusions regarding location (cf. Roediger, 1996). However, it should be noted Gestalt illusions and representational momentum only appear to be illusions if the perceived stimulus is compared to the actual stimulus; alternatively, such influences could be viewed as adaptive strategies for object recognition and localization.

Automaticity of Application

Both representational momentum and Gestalt principles of perceptual grouping result from automatic processes. Emergence of illusory contours resulting from application of Gestalt grouping principles in Figure 8 is automatic; even when observers know the contours are not physically present in the stimulus, the perception of such contours is nonetheless strong. Similarly, participants given feedback about performance in target localization (Ruppel, Fleming, & Hubbard, in press) or information about representational momentum prior to an experiment (Courtney & Hubbard, in press) still exhibit significant representational momentum (even so, displacement is partially cognitively penetrable; Hubbard, 2005, 2006).

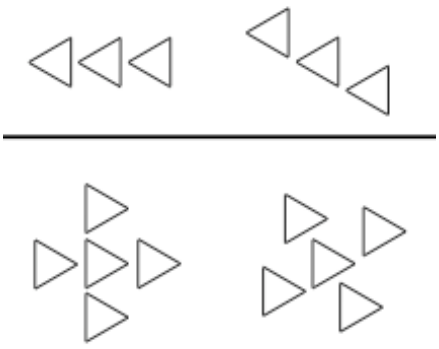

Figure 9. Effects of context on direction of perceived pointing. Adapted from Palmer (1980).

Conclusions

Both Gestalt principles of perceptual grouping and representational momentum result from dynamic processes. Furthermore, consequences of Gestalt principles of perceptual grouping are similar to consequences of representational momentum. Similar to Gestalt principles, representational momentum provides an adaptive strategy for rapid and effective online processing of sensory

material. Whereas traditional Gestalt principles focus on objects, representational momentum represents a new class of Gestalt principle that focuses on forces that operate on those objects.

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