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BOUNDARY EXTENSION AS A NEW GESTALT PRINCIPLE

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Abstract

Gestalt principles of perceptual grouping have been suggested to reflect dynamic aspects of mental representation. Boundary extension, in which stimuli likely to have been present just beyond the boundaries of a previously viewed scene are remembered as having been included within that viewed scene, has also been suggested to reflect dynamic aspects of mental representation. Other similarities of Gestalt principles of perceptual grouping and boundary extension include (a) displacement in remembered location, (b) reflection of environmental regularities, (c) a basis in isomorphism, (d) decreases in amount of information processed, (e) dependence on surrounding context, (f) interpretation as a laboratory-based illusion or as a successful adaptation, (g) reflection of general rather than domain-specific principles, and (h) automatic application even in observers instructed about the phenomenon and asked to guard against it. It is suggested that boundary extension might be an example of a new class of Gestalt principle related to properties of scenes rather than to properties of objects.

Although examples of Gestalt principles of perceptual grouping found in textbooks usually involve static figures (see Figure 1), such principles actually reflect dynamic unfolding of perceptual space (Albertazzi, 2006). The Gestalt principles typically influence perception and memory for objects within a scene, but it is possible Gestalt-like principles might influence perception and memory for a scene itself. Boundary extension, in which a previously viewed scene is remembered as containing more information than was actually presented (for review, Hubbard et al., 2010), might be such a principle. For example, observers who draw the scene in a previously viewed target photograph include information in their drawing that was not within the viewed target but would likely have been present just beyond the edges of that photograph (see Figure 2); similarly, observers presented with a probe photograph are more likely to judge that probe to be the same as the previously viewed target if the probe has a wider-angle view (i.e., includes information from just beyond the boundaries of the original view). Inclusion of information from beyond the initial view of a target in boundary extension could reflect a dynamic unfolding of perceptual space that is similar to the dynamic unfolding of perceptual space within the initial view that is specified by Gestalt principles. Similarities of boundary extension and Gestalt principles are considered, and it is suggested that boundary extension is an example of a new class of Gestalt principle related to properties of scenes.

Similarities of Boundary Extension and Gestalt Principles

Displacement in Remembered Location

Both boundary extension and Gestalt principles of perceptual grouping result in displacement in remembered location. Coren and Girgus (1980) examined the "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 arrows, and the indicated lines in the top row are the same objective distance apart as the indicated lines in the bottom row. Because of the principle of proximity, 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 indicated lines, the reproduced distance for the lines in top row was larger than the reproduced distance for the lines in the bottom row. Coren and Girgus also provided analogous examples based on closure, good continuation, and other grouping principles. As shown in Figure 2, memory for the locations of boundaries of the scene are displaced outward such that the viewed scene is remembered as containing more than it actually contained (see also Intraub et al., 2006).

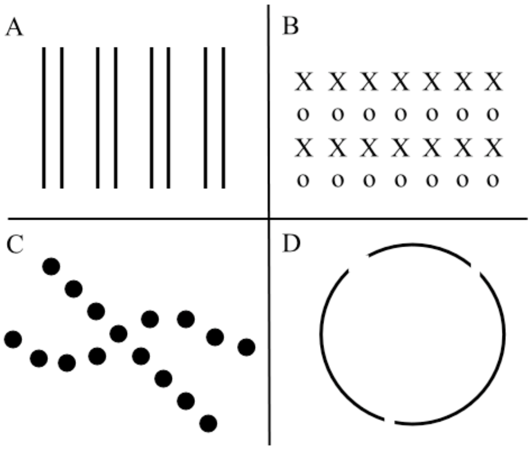

Figure 1. Gestalt principles of (A) proximity, (B) similarity, (C) good continuation, and (D) closure.

Reflection of Environmental Regularities

Both boundary extension and Gestalt principles of perceptual grouping reflect environmental regularities. 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 smooth and continuous paths rather than abruptly changing direction (good continuation), and portions of an object continue to exist even if occluded or in shadow (closure). Intraub (2002, 2004; Intraub et al., 1998) suggested boundary extension results from interpretation of a scene as a partial view of a larger scene that extends beyond the boundaries of the observed view and that space in a scene is perceived to continue beyond the edge of the target view (e.g., a landscape viewed through a window is perceived as continuing beyond the edge of the window and behind the occluding wall).

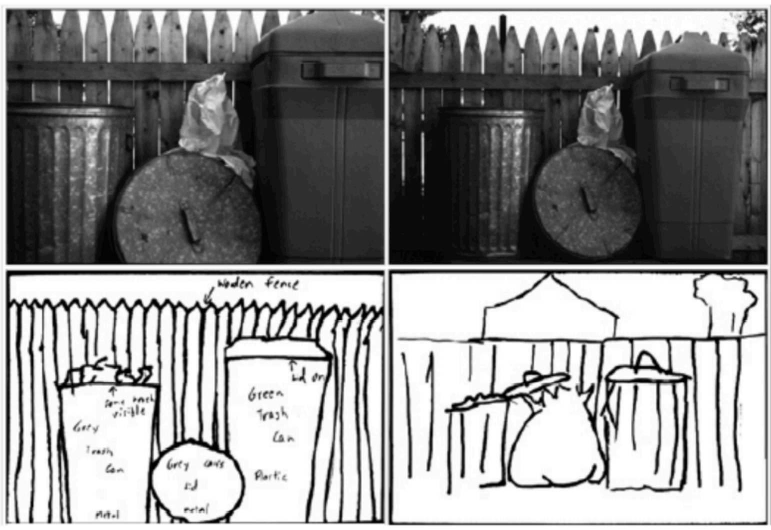

Figure 2. An example of boundary extension. Participants who viewed the scenes in the upper left and upper right produced the drawings in the lower left and lower right, respectively. Adapted from Intraub and Richardson (1989).

Basis in Isomorphism

Both boundary extension and Gestalt principles of perceptual grouping are based on the notion of isomorphism. Gestalt theories speculated on potential correspondences of structures in the nervous system with structures of perceived objects, and these correspondences were usually referred to as an *isomorphism* (Henle, 1984). Shepard's model of second-order isomorphism offers a useful framework (Shepard & Cooper, 1982; see Figure 4): A

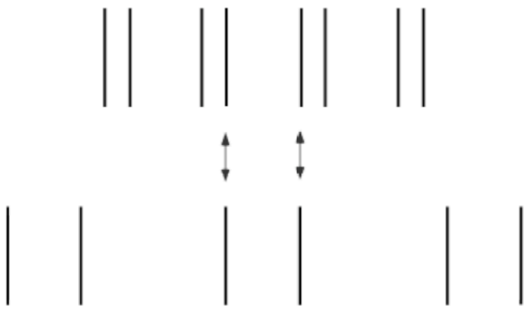

Figure 3. A Gestalt Illusion based on proximity. Lines indicated by arrows are the same distance apart in the top row and in the bottom row, but the remembered distance is larger in the top row (i.e., if the lines are not grouped together). Adapted from Coren and Girgus (1980).

physical object that is transformed (e.g., rotated) passes through intermediate states (e.g., orientations) in space, and the internal representation of an object that is transformed (e.g., mentally rotated) passes through intermediate states in functional space. Thus, space and the representation of space are both continuous. Gestalt principles of closure and good continuation involve "filling in" information between locations within a scene, and boundary extension involves "filling in" information beyond the boundaries of a scene. Gestalt principles of perceptual grouping and boundary extension involve similar correspondences between the continuity of an object or scene and the continuity of the mental representation of that object or scene.

Decreases in Amount of Information Processed

Both boundary extension and Gestalt principles of perceptual grouping decrease the amount of information to be processed. If shown the shapes in Figure 5, observers usually 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). Shapes higher in figural goodness (i.e., better "gestalts") require less information processing. By automatically extrapolating information regarding what might be outside the edge of the viewed scene, boundary extension facilitates processing of information that is most likely to be encountered in the next fixation. This facilitation results in a decrease in the amount of information that might need to be processed in the next fixation (Dickinson & Intraub, 2008), and so decreases the total or average amount of information processing that would otherwise occur in exploring or navigating a scene. Stimuli that are better "scenes" might provide more information about what is likely to be encountered in the region beyond the area currently fixated, and so would thereby decrease the amount of information processing required in the next fixation; this is consistent with findings that boundary extension does not occur if a scene is not present (Gottesman & Intraub, 2002).

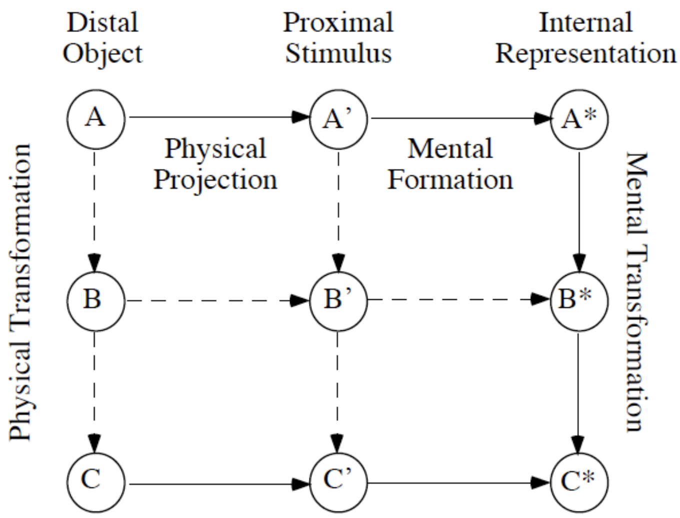

Figure 4. The correspondence between physical and mental transformations. Adapted from Shepard and Cooper (1982).

Dependence on Context

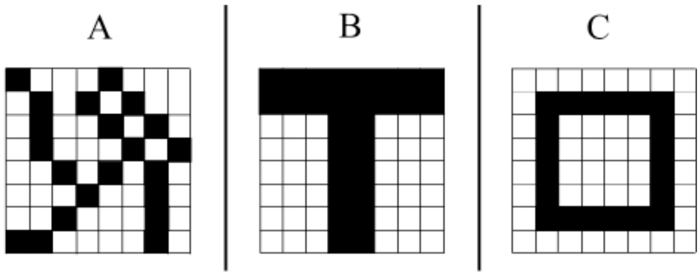

Figure 5. The relationship between figural goodness and the amount of information necessary to specify a figure. As figural goodness increases, the amount of information necessary in order to specify that figure decreases. Adapted from Coren, Ward, and Enns (2004).

Both boundary extension and Gestalt principles of perceptual grouping are highly dependent upon context. The strength of illusory contours in a Kanizsa-type figure is greater if there is more context suggesting that such contours should be present (see Figure 6). If targets are presented in isolation on a blank background, then boundary extension does not occur (Intraub et al., 1998), but if a background scene is perceived or even imaged, then boundary extension occurs (Gottesman & Intraub, 2002). Similarly, the direction in which a triangle is perceived to point depends upon the configuration in which that triangle is embedded (see Figure 7), and boundary extension is larger in the direction that the primary object in the scene is expected to move (Courtney & Hubbard, 2008).

Laboratory-Based Illusion or Successful Adaptation

Both boundary extension and Gestalt principles of perceptual grouping result in laboratory-based illusions. Gestalt principles give rise to illusory contours (see Figure 6), and as noted earlier, the Gestalt Illusions give rise to illusions regarding distance or location (see Figure 3). Similarly, boundary extension gives rise to illusions regarding the location of the boundaries of the scene (see Figure 2). However, Gestalt illusions and boundary extension only appear to be illusions if the perceived stimulus is compared to the actual stimulus; alternatively, Gestalt illusions and boundary extension could both be viewed as adaptive strategies for object recognition and localization and for exploring and navigating through a scene.

General Rather Than Domain-Specific

Both boundary extension and Gestalt principles of perceptual grouping reflect general principles of spatial cognition rather than domain-specific principles. Although the majority of research on Gestalt principles of perceptual grouping and on boundary extension involved visual stimuli, there is evidence that Gestalt principles of perceptual grouping and boundary extension occur with nonvisual stimuli. Grouping principles influence auditory streaming (Bregman, 1990; Deutsch, 1999), and boundary extension has been found for haptically explored scenes with a congenitally blind participant and with normally-sighted but blindfolded participants (Intraub, 2004).

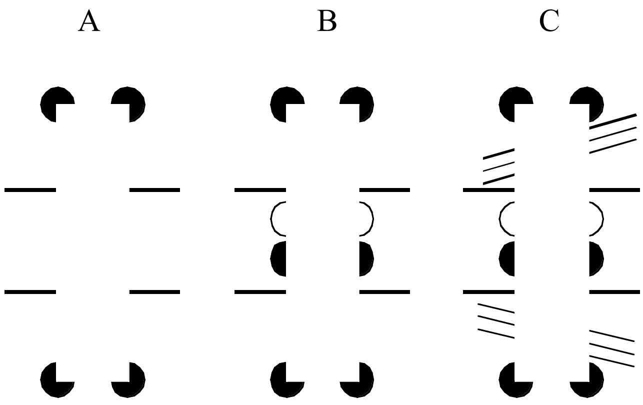

Figure 6. The strength of illusory contours increases if the amount of context suggesting such contours should be present increases. Adapted from Schiffman (2001).

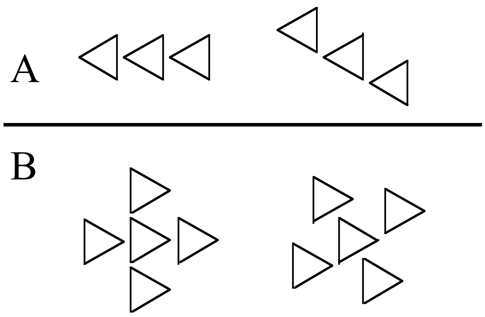

Figure 7. Effects of context on the direction of perceived pointing. Adapted from Palmer (1980).

Automatic Application

Both boundary extension and Gestalt principles of perceptual grouping result from automatic processes. Emergence of illusory contours resulting from application of Gestalt principles of perceptual grouping in Figure 6 is automatic; even if observers know the contours are not physically present in the stimulus, the perception of such contours is still quite strong. Similarly, participants exhibit significant boundary extension even if they are instructed about boundary extension prior to data collection and asked to guard against it in their responses (Intraub & Bodamer, 1993). Relatedly, boundary extension and Gestalt principles of perceptual grouping involve rapid responses, as Gestalt principles (e.g., Herrmann & Bosch, 2001) and boundary extension (Dickinson & Intraub, 2008) influence perception within a few hundred milliseconds of stimulus presentation. Indeed, application of Gestalt principles of perceptual grouping has been speculated to involve pre-attentive (automatic) processes (e.g., Moore & Egeth, 1997), and this is consistent with increases in boundary extension under conditions of divided attention (Intraub et al., 2008).

Conclusions

Several properties of boundary extension are similar to properties of Gestalt principles of perceptual grouping, and this is consistent with the hypothesis that boundary extension reflects a new class of Gestalt principle that involves properties of scenes. Gestalt principles of perceptual grouping influence perception and memory of objects, and boundary extension influences perception and memory of scenes within which those objects appear. The suggestion that boundary extension reflects a new class of Gestalt principle is consistent with a recent suggestion that representational momentum (a dynamic aspect of mental representation in which memory for the final location of a moving target is displaced in the direction of motion; for review, Hubbard, 2005) reflects a new class of Gestalt principle (Hubbard, 2011), as representational momentum and boundary extension share numerous properties (for discussion, Hubbard et al., 2010). Indeed, similarity of properties of boundary extension and of representational momentum to properties of Gestalt principles of perceptual grouping suggests there might be closer relationships between findings in contemporary studies on dynamic aspects of mental representation and historical notions of Gestalt perceptual theory than have been previously acknowledged.

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