The First Second of Symmetry: Visual Search during Symmetry Verification

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Although symmetry judgment seems instantaneous, there is considerable evidence that it is a two-stage process. As proposed by Palmer & Hemenway (1978), symmetry judgment begins with a quick symmetry estimation taking 50-200 ms, followed by a 2000-4000 ms verification stage.

We are currently exploring the symmetry verification stage. This stage is important for two reasons. First, because it uses information from the axis detection phase, the pattern of verification may help us implicitly understand what axis detection initially omits. Second, the verification phase provides general clues on how visual regularity guides visual search.

Unlike the axis-detection phase, which happens too quickly for saccades, the verification stage can be examined by tracking patterns of eye-movements. These patterns help us understand the relationship between the two stages. A first step in this process is to model a baseline pattern of search so that we can detect changes to that search pattern for particular symmetry types or stimulus manipulations.

To find a baseline pattern, we have completed an analysis of over tracking data from over 19,000 symmetry judgments from two previous experiments (Mappus et al., 2005). These experiments involved symmetry judgments for symmetric, near-symmetric, and nonsymmetric polygons. Polygons had 10, 18, or 26 sides and varied in average radius from 5 to 15 visual degrees.

Analysis of the first 1000 ms of tracking data shows a "treble-clef-shaped" search pattern that appears to be used to maximize proximate feature inspection and cross-axis comparisons (Fig. 2). In this pattern, participants initially fixate at the center of the figure, and then move up. They then descend while moving from the left to the right. This pattern is unique in that is contains extended initial fixation, upward movement to the tip of the vertical axis, and oscillating downward movement.

To test the predictive value of the Treble Clef search pattern, we compared it against three alternative search strategies: Random, Greedy, and the Area Activation Model (Pomplun et al., 2000). To do this, we built a stochastic eye-movement model, based on known psychological results, to serve as the engine for the four search strategies. Results from the simulations show that the treble clef accounts for the experimental data better than the alternative strategies (Fig. 2).

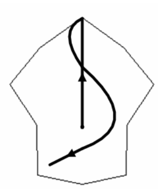

Fig. 2: The Treble Clef search pattern

Overall, the Treble Clef search pattern provides insight into symmetry verification during symmetry judgments. In addition, it provides a baseline pattern to which we can compare search patterns for particular symmetry types. For example, our previous work shows that whether near-symmetric figures have qualitative or quantitative differences and an impact on judgment accuracy, number of fixations, response time, and scan paths (Mappus et al 2005). Similarly, our eye-tracking data shows minor differences between these two symmetry types with respect to their mean vertical and horizontal positions, especially after 500 ms.

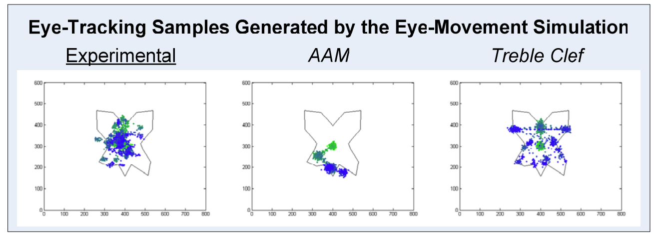

Fig. 1: Comparison of Treble Clef with competing models

The search patterns, like accuracy and response time, are affected by the symmetry type. This suggests that studying perturbations of the Treble Clef search pattern may show how the processing of various symmetry types differs. It also suggests that one could determine when a symmetry type begins to influence the visual system by determining when the eye-movement patterns begin to diverge.

Acknowledgments

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