Reference-Frame Selection in Motion Perception

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Motion is often perceived according to non-retinotopic reference-frames (e.g., Duncker's wheel; biological motion); however, how reference-frames are selected remains to be established.

The stimulus consisted of two concentric arcs undergoing circular motion, with the same average angular-velocity, around the center of the display. The outer arc's (target) velocity was modulated by a sine-wave whereas the inner arc (reference) moved at a constant velocity, except in Experiment 4. Observers' task was to report (yes/no) whether the target reversed its direction of rotation at any point during its motion. The minimum velocity of the target at "50% yes" gave the point of subjective stationarity (PSS). PSS=0 indicates a retinotopic/spatiotopic reference-frame while a PSS equal to the average velocity indicates a motion-based reference-frame with perfect vector-decomposition. In four experiments, we varied the radial and the angular contour distances between the two arcs, the relative radial size of the arcs and the velocity modulation of the reference arc.

The perception of motion was neither retinotopic/spatiotopic nor based on perfect vector-decomposition. The effect of the reference arc's motion on the perception of target arc's motion ("reference-frame effect") decreased with increasing radial and angular contour distances, while it was independent of the size-ratio and the absolute-level of velocity modulation. In assessing which metric would unify all of our findings, we considered (i) object-centered, (ii) object-nearest-contour, (iii) motion-centered, and (iv) motion-nearest-vector reference-frames. Our results reject the first three and strongly support the last one. In fact, when the data from all experiments were plotted against this metric, we found a simple linear relationship between the reference-frame effect and the distance defined by this metric.

The selection of a reference-frame for motion perception can be explained by a field whose strength decreases linearly as a function of the distance between the nearest motion vectors.