Perceptual grouping reduces perceived speed but does not change uncertainty

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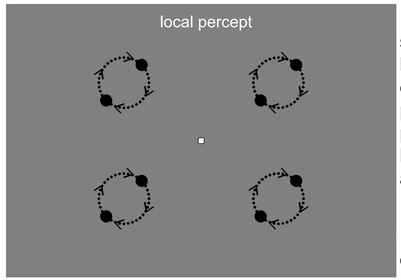
Background & Motivation

Four dot pairs independently rotating about the vertices of an implied square (local percept) are perceptually grouped over time, forming the illusion of two overlapping squares[1] (global percept). We perceive the global percept to move slower than the local percept, a phenomenon known as the "global slowdown effect".

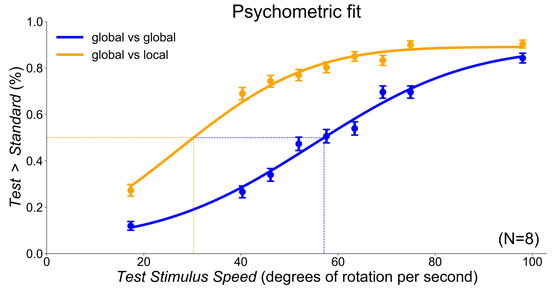


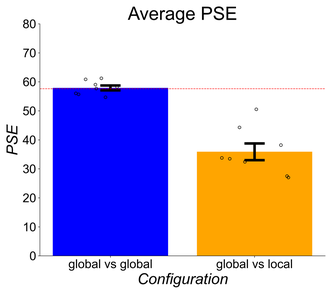
Research has shown that the global slowdown effect cannot be explained by differences in perceived size, emergent rotation, or the number of perceived moving elements between percepts[2]. Here, we test two additional hypotheses for why the slowdown arises from perceptual grouping.

First, we test if the effect depends on depth cues introduced by having two elements per vertex of rotation. If so, removing one element per axis should reduce or eliminate the effect.

Second, we test whether the slowdown reflects a systematic difference in sensory uncertainty between global and local percepts. If the global percept is more uncertain than the local perception, it may be explained by a Bayesian prior for slow motion[3].

Results: Experiment 1

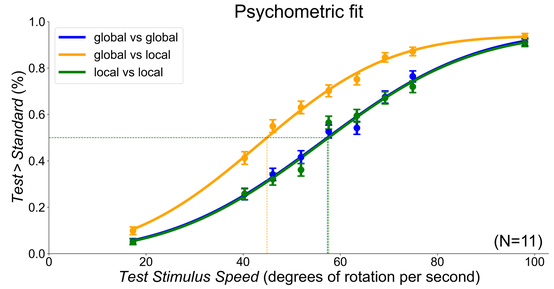


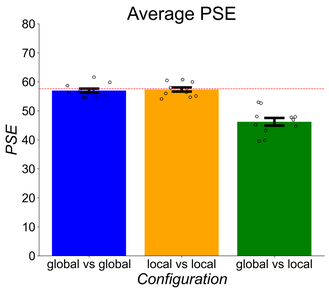


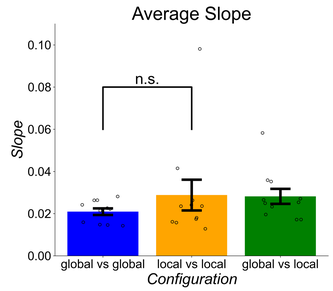
6 participants removed due to poor psychometric function fits ($R^2 < 0.8$ for either condition).

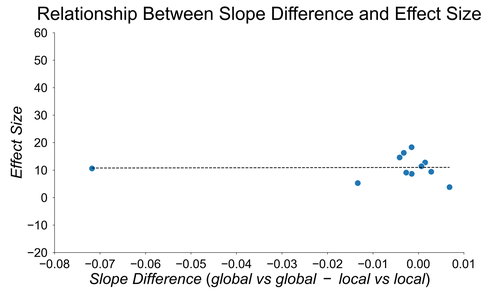
Slowdown effect persisted even with only one L per axis of rotation.

Results: Experiment 2









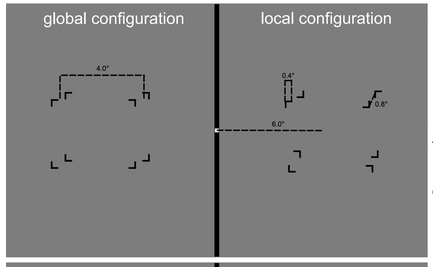
5 participants removed due to poor psychometric function fits ($R^2 < 0.8$ for any condition).

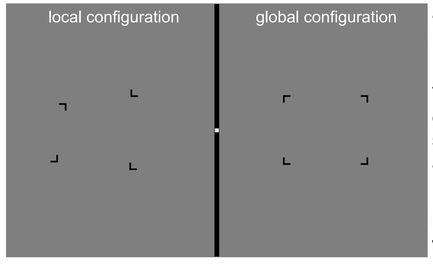
The slowdown effect was replicated.

No significant difference between the average slope of the global vs global control condition and the local vs local control condition, showing that participants were equally sensitive to changes in speed under both conditions.

No significant relationship between effect size and slope difference. A difference in uncertainty would result in a correlation between slope difference and effect size.

Methods





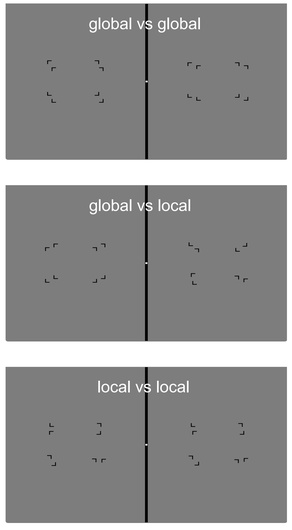
Dots were replaced with "L"-shapes to bias perception toward either global or local motion.

In the global configuration, Ls formed the vertices of an illusory square, producing the percept of two overlapping squares moving in phase.

In the local configuration, Ls along each axis were assigned random phases, making perceptual grouping unlikely.

To test the first hypothesis, one L from each pair was omitted, producing a single illusory square translating along a circular path.

Eye tracking ensured gaze stayed within 2° of fixation.



We ran a 2AFC task where participants compared the speed of two configurations on either side of fixation. The reference rotated at 57.6°/s, while the test varied around 57.6°/s.

We measured the slowdown effect using the Point of Subjective Equality (PSE), focusing on trials with a global reference and local test.

Our first hypothesis consisted of two conditions: global vs global and global vs local. Our second hypothesis introduced local vs local.

Sensitivity was measured using psychometric slope, and uncertainty was assessed by comparing slopes across conditions.

Conclusions

In Experiment 1, the slowdown effect persisted with the stimulus being simplified to only one L per axis of rotation, suggesting that the effect is not caused by depth-like cues that may arise from the grouped percept.

In Experiment 2, the slowdown effect was replicated, but psychometric slopes did not differ significantly between global and local configurations. Additionally there was no relationship between effect size and the difference in slope between control conditions, suggesting global motion is not associated with greater sensory uncertainty.

We find no evidence to support that the slowdown effect is a result of depth-like cues and no evidence to support that the effect is driven by a Bayesian prior for slow motion.

References

[1] Anstis, S. (2003). Levels of motion perception. In L. Harris & M. Jenkin (Eds.), Levels of perception (pp. 75-99). New York: Springer.

[2] Kohler PJ, Caplovitz GP, Tse PU. The global slowdown effect: why does perceptual grouping reduce perceived speed? Atten Percept Psychophys. 2014 Apr;76(3):780-92. doi: 10.3758/s13414-013-0607-x. PMID: 24448695.

[3] Weiss, Y., Simoncelli, E., & Adelson, E. H. (2002). Motion illusions as optimal percepts. Nature Neuroscience, 5(6), 598–604.