Symmetry Benefits Working Memory Representations of Object Orientation

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Background

Symmetry has long been considered an important cue to visual perception[1].

The literature has focused on symmetry in the image plane[2], however, the role of symmetry in perception is complicated by perspective distortion, as symmetry in the world rarely produces symmetry on the retina.

Distorted symmetry is known to produce weaker detection of rotation[3], and weaker brain responses[4], especially when observers are not engaged in a symmetry-related task[5].

Motivation

The current study aims to investigate if symmetry can facilitate working memory.
If so, are the effects of symmetry specific to symmetry in the image plane, or do they persist when symmetries are distorted due to perspective?

To test this, we presented participants with images of symmetrical and asymmetrical 3D objects generated procedurally in Blender 3D graphics software.

Methods

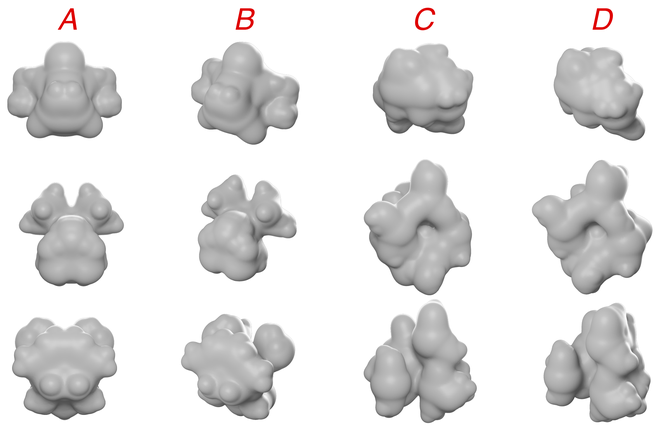
We recruited participants with normal or corrected-to-normal vision for two studies, one conducted online (N = 120) and one in-person (N = 60).

In both studies, participants were divided equally into two groups, the image-level group and the perceptive-distorted group.

In the image-level group, symmetrical objects were shown such that the reflection symmetry over the object was orthogonal to viewing direction, resulting in symmetry in the image plane (A).

In the perspective-distorted group, the object was rotated relative to viewing direction, leading to perspective distortion of the reflection symmetry over the object (B).

In both groups, the symmetrical object condition were paired with an asymmetrical object condition for which the set of object images were chosen such that image-level similarity between symmetrical and asymmetrical images were the same for both groups (C and D).

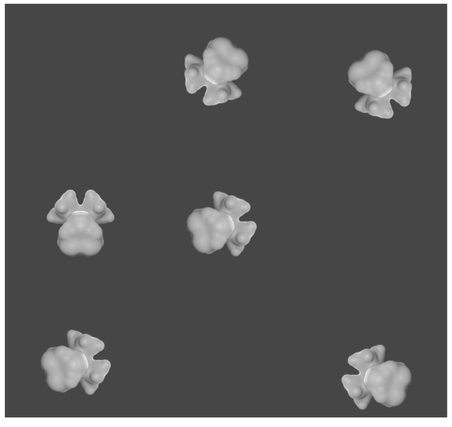


Rotation Detection Task

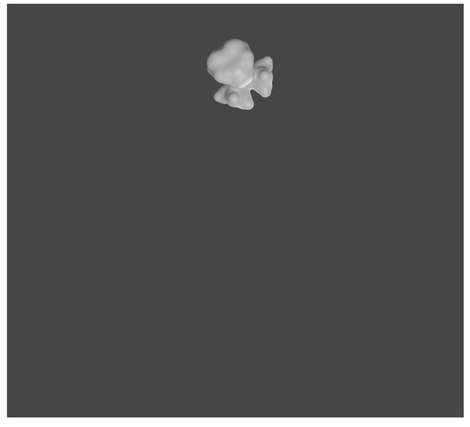
We showed 1-6 objects at different locations on the screen, at different pseudo-randomly chosen orientations. Objects appeared for 4000 ms.

120 trials per participant:
60 symmetrical
60 asymmetrical

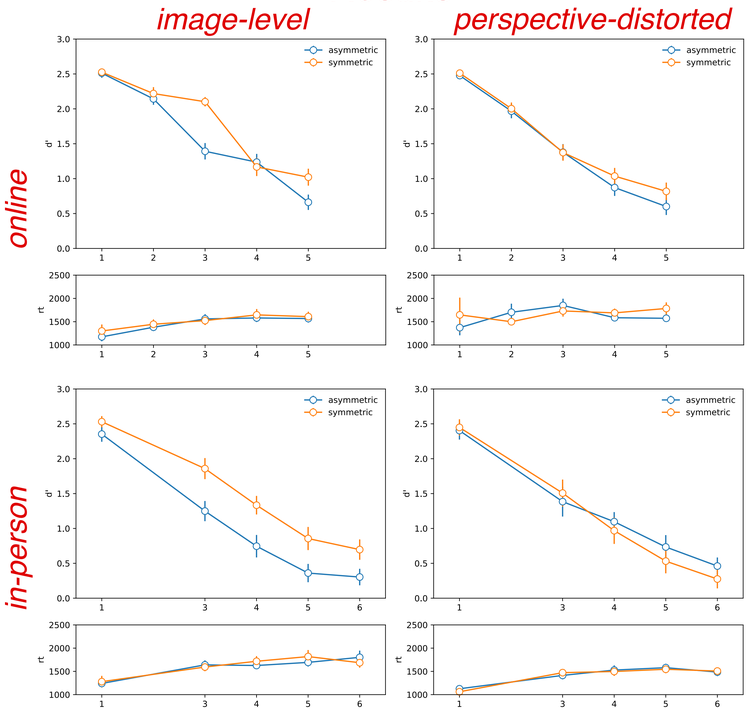
Participants were instructed to determine whether there was a rotation in the reappeared object. This was true in 50% of trials, and false in 50%.



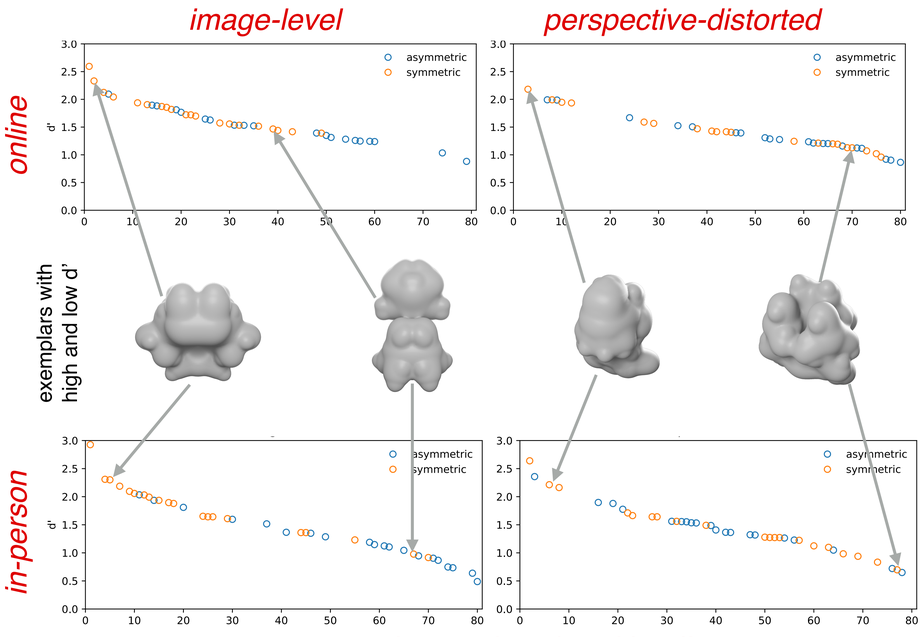
1000 ms retention interval



Results



Results by exemplar



Both studies found increased sensitivity for symmetrical objects in the image-level symmetry conditions.

There was no significant difference between symmetrical and asymmetrical objects in perspective-distorted conditions.

We also did an exemplar-specific analysis to identify exemplars from both the image-level and perspective-distorted groups that consistently produced low or high *d'* scores. Future research may investigate what makes symmetrical objects more or less memorable.

Discussion

Findings suggests that image-level symmetry facilitates representations of object orientation in working memory. This effect did not generalize to perspective-distorted symmetry.

It has been proposed that symmetrical objects may facilitate more efficient representations[5]. Our results provide evidence that the advantage of symmetry may extend beyond identifying object identity and features.

Our orientation differences were fairly large (minimum 72°) so while our results may be related to increased perceptual sensitivity to the orientation of symmetrical objects, they are unlikely to be driven by perceptual effects.

References

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