Symmetry Benefits Working Memory Representations of Object Orientation

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Background

Symmetry is known to be an important cue to visual perception[1].

The literature has focused on symmetry in the image plane[2], however, symmetries in objects and scenes are subject to perspective distortion, and therefore rarely produce symmetry on the retina during natural vision.

Distorted symmetries are more difficult to detect[3], and produce 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?

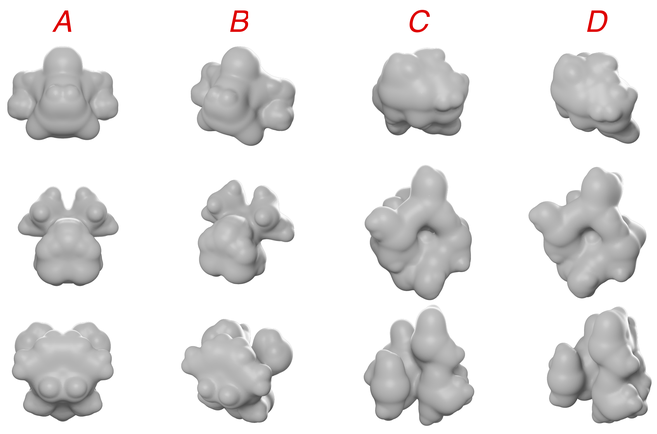
To test this, we presented participants with images of symmetrical and asymmetrical 3D objects generated procedurally in Blender 3D graphics software.

Methods

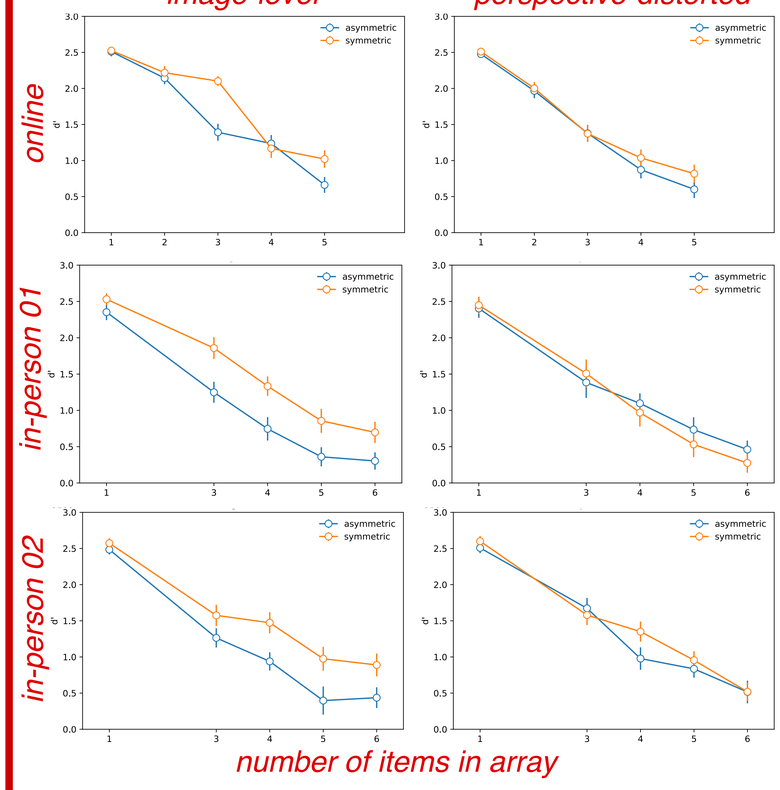
We recruited participants with normal or corrected-to-normal vision for three studies, one conducted online (N = 120) and two in-person (2 x N = 60). In all studies, participants were divided equally into two groups, the image-level group and the perceptive-distorted group.

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).

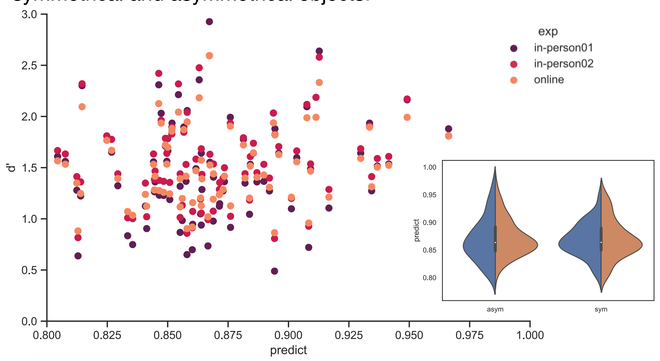


Results



We 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 passed our images through ResMem[6], a deep learning model that can predict the intrinsic memorability of an image: the likelihood of an image being remembered in subsequent viewings. There was a correlation of 0.15 between our data and the model predictions, but predictions did not vary systematically between symmetrical and asymmetrical objects.



Discussion

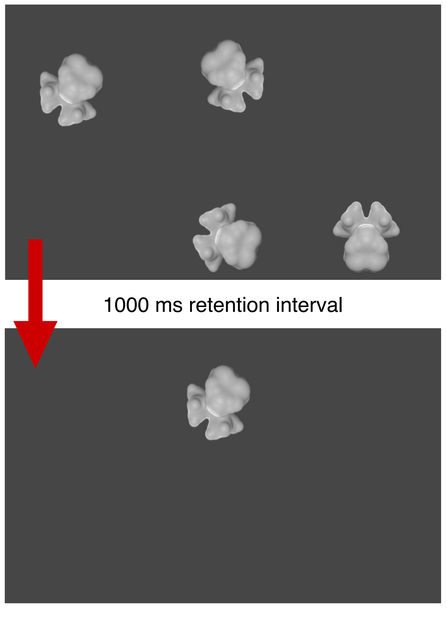
We find that image-level symmetry facilitates representations of object orientation in working memory. This effect did not generalize to perspective-distorted symmetry.

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.

Rotation Detection Task

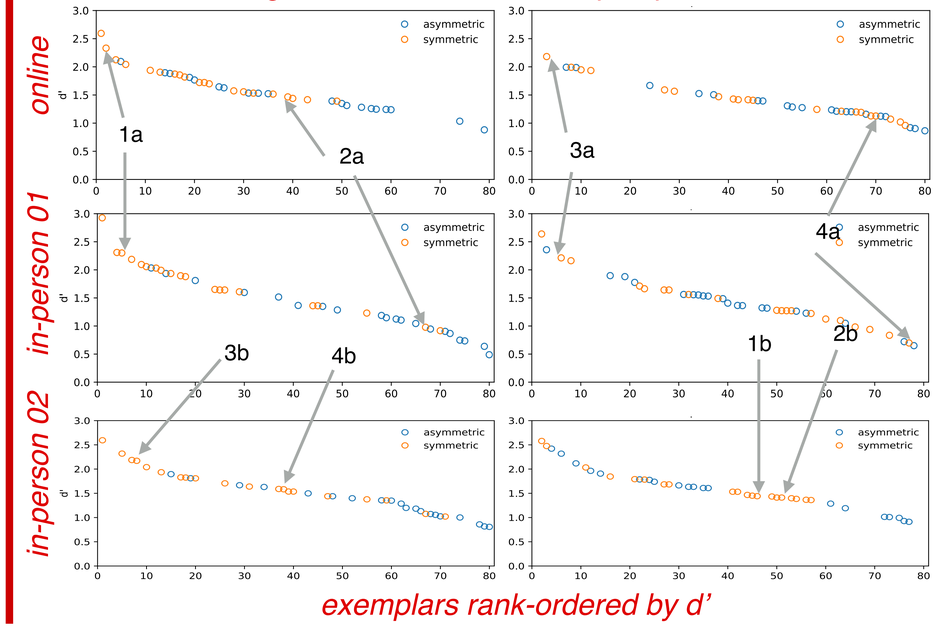
120 trials: 60 symmetrical 60 asymmetrical



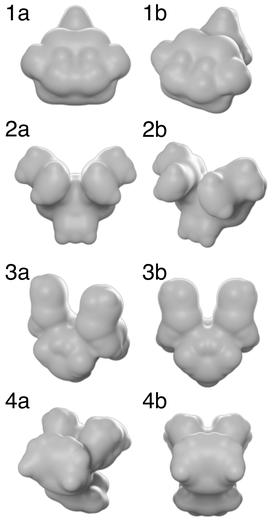
Study phase:
1-6 objects were shown at different screen locations, each at a different pseudo-randomly chosen orientation. Objects appeared for 4000 ms.

1000 ms retention interval

Test phase:
A single object was shown either at the same or a different 2D image orientation. Participants were asked to decide whether the orientation had changed.



We identified exemplars from both image-level and perspective-distorted groups that consistently produced low or high *d'* scores.



References

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