Similarity Sorting of Novel 2-D and 3-D Objects

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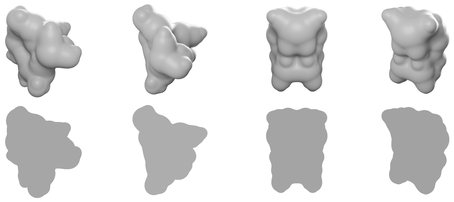
Background

Similarity judgments of natural objects can be described by several core dimensions[1].

Symmetry has also been understood to be an important feature that is assessed to perceive objects and scenes[2, 3].

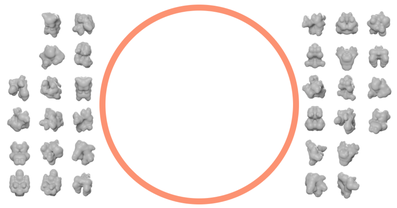
What role does symmetry play in object similarity judgments?

Methods



Novel 2D and 3D objects were generated - 2D objects were generated by removing shading cues from 3D object images. Two viewpoints were used such that symmetrical objects either gave rise to **image-level or perspective-distorted symmetry.**

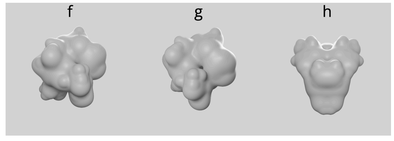
Free Sort Task



16 objects (8 symmetrical, 8 asymmetrical) were shown from **two viewpoints** for a **total of 32 images.**

Participants (n = 31) **sorted the objects by placing more similar objects closer together** in a circular arena. Similarity was operationalized according to the pairwise Euclidean distances between objects.

Triplets Odd-One-Out Task

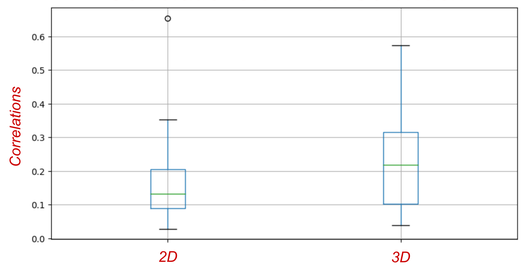


8 objects (4 symmetrical, 4 asymmetrical) were shown from **two viewpoints** for a **total of 16 images.**

Participants (n = 105) **selected the odd object** presented out of the three objects by pressing the respective key. Similarity was operationalized according to the number of times two objects were paired together over the number of object pair occurrences.

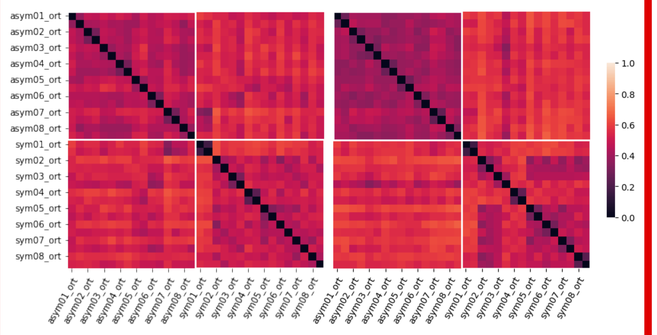
Results

Correlations of Free-Sort Task



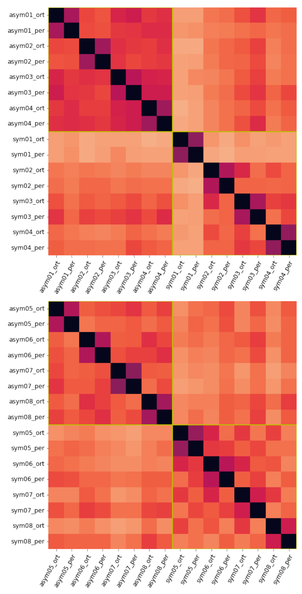
Test re-test reliability was computed between the trials of the 2D (M = 0.17, SD = 0.12) and 3D (M = 0.22, SD = 0.14) settings of the free-sort task.

Free Sort 2D RDM

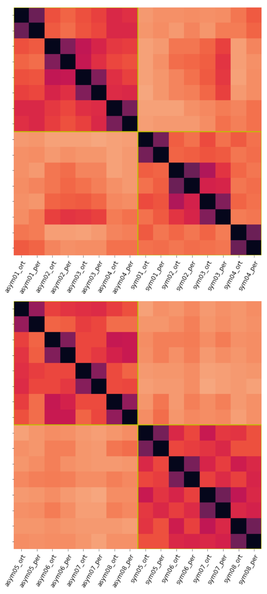


Free Sort 3D RDM

Triplets 2D RDM



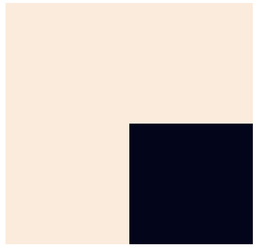
Triplets 3D RDM



Symmetry Models

Four symmetry models were proposed to predict participant object similarity sorting behaviours.

Symmetry

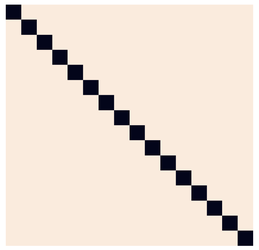


The **object symmetry model** indicates that **symmetrical objects are ranked as more similar to other symmetrical objects** than to non-symmetrical objects.

Asymmetry

The object asymmetry model indicates that **asymmetrical objects are ranked more similar to other asymmetrical objects** than to symmetrical objects.

Object Identity



The **object identity model** indicates that **objects are ranked more similar to the same object from a different viewpoint** than to other objects.

Viewpoint

The **viewpoint model** indicates that **images with image-level symmetry are ranked as more similar to other images with image-level symmetry** than to images without image-level symmetry.

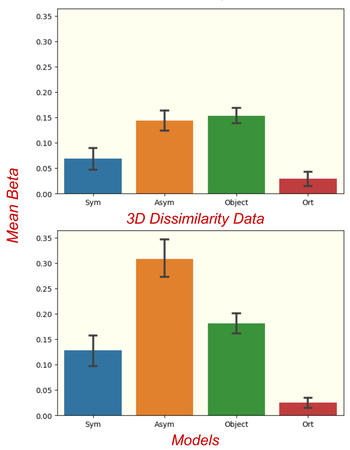
Multiple Linear Regression

$$Y = \beta_0 + \beta_1 x + \beta_2 x + \beta_3 x + \beta_4 x + \epsilon$$

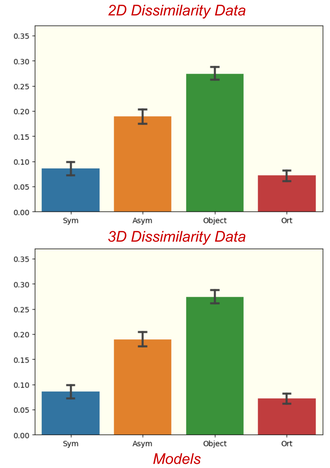
RDMs of symmetry models and participant data were vectorized and z-scored prior to model fitting. Symmetry models served as independent variables predicting participant data.

Task Results

Model Coefficients of Free Sort Data



Model Coefficients of Triplets Data



Results followed the same pattern for both tasks: Object identity and asymmetry play a large role in similarity judgments. Symmetry and asymmetry appear to explain more variance in the 3D Free Sort task possibly due to the availability of image-level and perspective-distorted symmetry.

In both tasks, symmetry at the image-level appears to explain equal variance in 2D and 3D images possibly due to the importance of object identify and object symmetry in similarity judgments.

Discussion

Our findings suggest that similarity sorting judgments of novel objects mainly rely on **the presence and absence of symmetry and object identity.**

Our findings also suggest that object viewpoint may only have marginal effects on object similarity judgments within the context of our experiments.

Extending the idea that core dimensions can help in identifying similar objects, our findings suggest that symmetry (or lack thereof) may also play a role.

Our study is the first of its kind investigating the role of symmetry on similarity judgments of novel 2-D and 3-D objects. Future research should aim to validate these findings with larger sets of objects and investigate the neural correlates that may be associated with perceived similarities of symmetrical and asymmetrical objects.

References

[1]Hebart, M. N., Zheng, C. Y., Pereira, F., & Baker, C. I. (2020). Revealing the multidimensional mental representations of natural objects underlying human similarity judgements. *Nature Human Behaviour, 4*(11), 1173–1185.

[2]Bertamini, M., Silvanto, J., Norcia, A. M., Makin, A. D. J., & Wagemans, J. (2018). The neural basis of visual symmetry and its role in mid- and high-level visual processing. *Annals of the New York Academy of Sciences, 1426*(1), 111–126.

[3]Treder, M. S. (2010). Behind the Looking-Glass: A Review on Human Symmetry Perception. *Symmetry, 2*(3).