

# The Saliency of Lower-Order Features in Highly Self-Similar Wallpaper Groups

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## Introduction

- Symmetry detection may be a fundamental property of the human visual system; most prior research has focused on mirror symmetry.
- There are four fundamental symmetries in 2D – translation, reflection, glide reflection, and rotation. Their combination results in 17 distinct “wallpaper groups”.
- Clarke et al. (2011) used a sorting task to explore perceptual features observers detect in wallpapers.
- Five groups showed high self-similarity, implying an important role in perceptual space.
- We explored whether there are sub-categories within the five self-similar wallpaper groups.

## Methods

- Sample images normalized for contrast and spatial frequency were generated for each wallpaper group (Fig 1).
- Adult participants (n=11) sorted 20 exemplars from each wallpaper group into subgroups using self-chosen criteria.
- Calculated mean Jaccard index [0,1] for each exemplar to assess perceptual similarity between exemplar pairs.
- Higher mean Jaccard == more “typical” (Fig 1).
- Fit linear mixed effects models using *lme4* in R with random effects for exemplars and observers.

## Methods: Jaccard Index

$$J = \frac{c}{a + b + c}$$

- a = # subsets containing exemplar A
- b = # subsets containing exemplar B
- c = # subsets containing both exemplars

## Results: Representative Exemplars

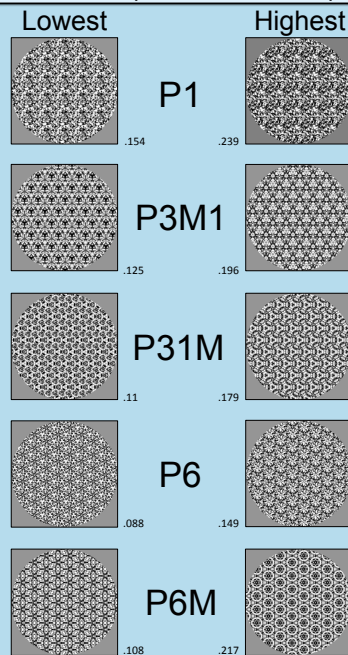


Figure 1. The exemplars from each wallpaper group with the lowest and highest calculated mean Jaccard index.

## Results: Numbers of Sets

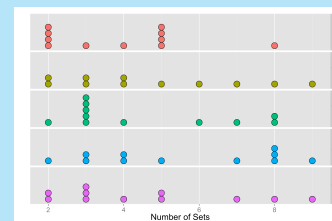


Figure 2. Observers sorted exemplars into different numbers of sets,  $\chi^2(4)=9.7$ ,  $p<.05$ ;  $P1 < P6$

## Results: Jaccard Indices

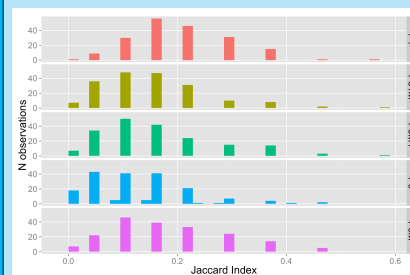


Figure 3. Mean Jaccard indices differ by group,  $\chi^2(4)=93.4$ ,  $p<.0001$ .  $P1 > P3M1$  and  $P6$ ;  $P6M > P6$ .

## Conclusions

- P1 exemplars more self-similar – fewer sets (Fig 2) and higher mean Jaccard indices (Fig 3) – than other groups.
- P6M more self-similar than P6 (Figs 2 & 3).
- Translational symmetry alone (P1) perceptually salient.
- Reflection symmetry increases perceived self-similarity ( $P6M > P6$ ).
- Increasing degree of rotation symmetry ( $P6^* \text{ vs. } P3^*$ ) does not increase perceived self-similarity.
- Detection of self-similarity influenced by emergent global geometric structures (e.g. large geometric forms, striations, grid patterns).
- Future studies could explore factors suggested to influence the saliency of characteristic geometric structures within wallpaper groups.

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