The Influence of Familiarity on Symmetry Perception

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Background

Symmetry is an important cue for visual perception and object detection[1]. Symmetrical regions are more likely to be perceived as a figure rather than background[2].

Object familiarity also influences perceptual organization: Regions resembling familiar objects are more likely to be perceived as figure[2]. This familiarity effect is reduced or disappears when stimuli are inverted.

Both symmetry and familiarity influence perception at very short stimulus durations[2].

Previous work combining Steady-State Visual Evoked Potentials (SSVEPs) and psychophysics shows a strong correspondence between neural and behavioural measures of symmetry perception, with more complex symmetries producing stronger neural responses and being easier to detect[3].

Building on the same framework, this study uses SSVEPs and a complementary psychophysical experiment to test whether symmetry responses are influenced by object familiarity.

Research Question:
Are symmetry responses influenced by object familiarity?

Stimuli

Three shape classes

Intact:
- Natural animal silhouettes
- Familiar[4]

Frankenstein:
- Rearranged parts
- Moderately familiar[4]

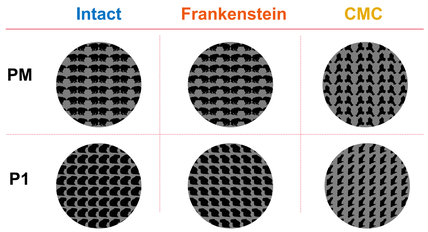
Curvature-Matched Controls (CMC):
- No recognizable global structure
- Highly unfamiliar[5]

Wallpaper groups

P1:
- Translation symmetry only
- Control condition[6]

PM:
- Reflection symmetry
- Test condition[6]

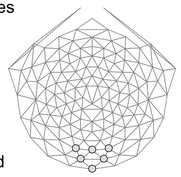
Generated Stimuli



EEG Data Analysis

Data were collected using a 128-electrode Magstim EGI Geodesic Sensor Net. Our analysis focuses on six electrodes over the occipital cortex.

In the SSVEPs paradigm, periodic visual stimulation produces brain responses at the stimulation frequency and its multiples (harmonics). Harmonic response amplitudes were examined using frequency-domain analyses.



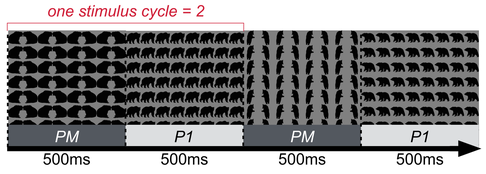
Even harmonics:
- General image update responses
- Reflect low-level image update

Odd harmonics:
- Capture differential responses between symmetry and control images
- Isolate symmetry-related brain responses[6].

Study 1: SSVEPs

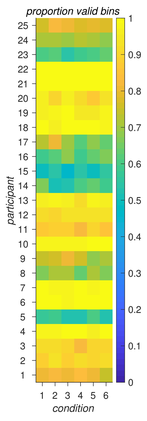
Experiment Design

We used a steady-state visual evoked potentials (SSVEP) paradigm in which participants (N = 25) passively viewed sequences of wallpaper patterns from the three shape classes. Each cycle presented two different exemplars to avoid apparent motion, while a stimulus- irrelevant size change task was used to control attention.



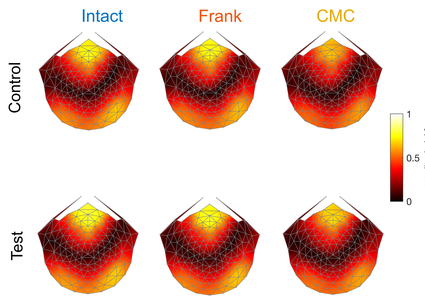
Results

Data Quality

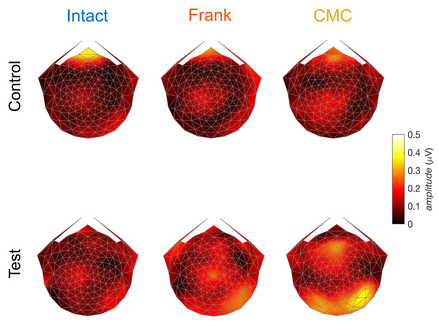


Most participants showed high data quality across conditions, with small variability.

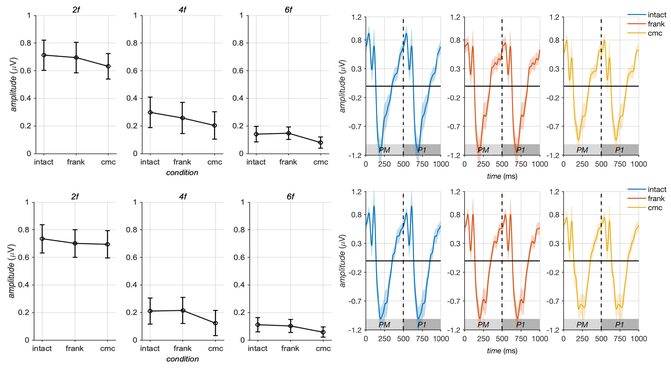
Topographies: 2nd Harmonic



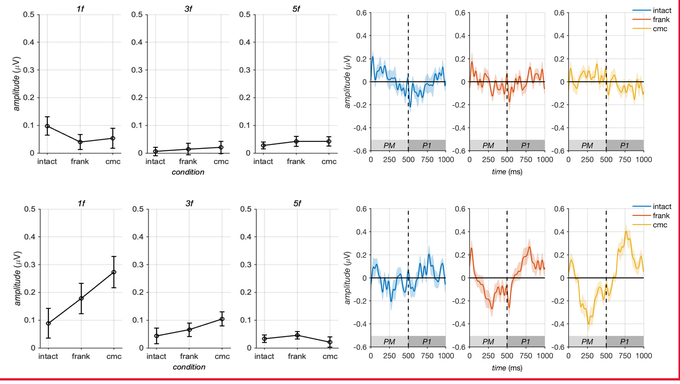
Topographies: 1st Harmonic



Even Harmonics



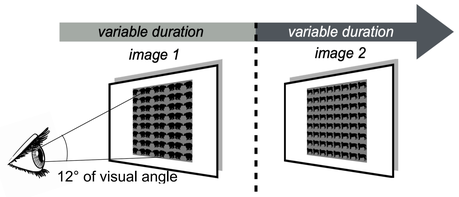
Odd Harmonics



Study 2 : Psychophysics

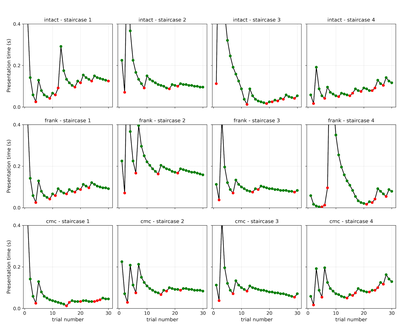
Experiment Design

Participants (N = 20) completed a two-interval forced-choice task. On each trial, two wallpaper patterns were presented sequentially in one of two orders, with each image followed by a noise mask. Stimulus duration was varied using an adaptive staircase (QUEST) to estimate symmetry dection threshold across three shape conditions.

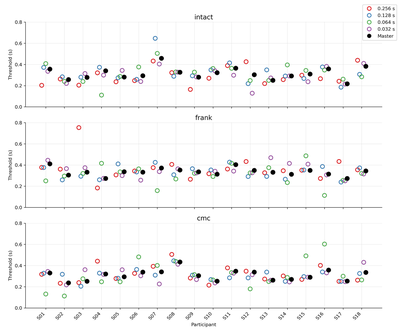


Results

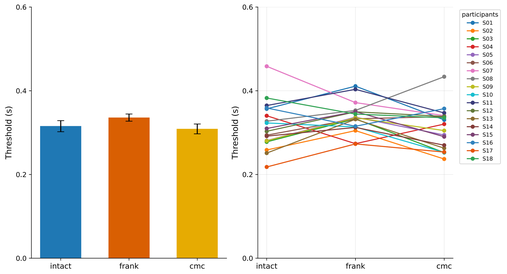
Cross-trial Performance from an example participant



Convergence of Staircase Thresholds Across Participants



Symmetry Detection Thresholds by Condition

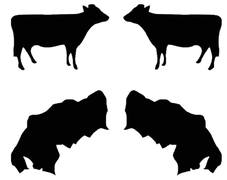


Symmetry detection thresholds were higher for Frankenstein shapes, but the three conditions did not differ significantly (repeated-measuresANOVA: p =.056).

Conclusions

Symmetry responses measured with EEG are weaker for familiar objects. This effect fails to replicate in the psychophysical experiment.

- This pattern suggests a task-dependent effect of symmetry and familiarity cues
- Conflict between these cues may down-regulate symmetry processing when attention is directed away from symmetry



References

1.Machilsen, B., Pauwels, M. & Wagemans, J. The Role of Vertical Mirror Symmetry in Visual Shape Detection. *Journal of Vision* 9, 11.1–11.11 (2009).
2.Peterson, M A & Gibson, B S (1994). Must figure–ground organization precede object recognition? An assumption in peril. Psychological Science 5(5):253–259.
3. Kohler, P. J., & Clarke, A. D. F. (2021). The human visual system preserves the hierarchy of two-dimensional pattern regularity. *Proceedings of the Royal Society B: Biological Sciences*, *288*, 20211142.
4.Baker, N & Elder, JH (2022). Deep learning models fail to capture the configural nature of human shape perception. IScience 25(9):104913.
5. Elder, J. H., Oleskiw, T. & Fründ, I. The Role of Global Cues in the Perceptual Grouping of Natural Shapes. Journal of Vision 18, 1–21(2018).
6. Kohler, P. J., Clarke, A., Yakovleva, A., Liu, Y., & Norcia, A. M. (2016). Representation of Maximally Regular Textures in Human Visual Cortex. *The Journal of Neuroscience*, *36*(3), 714–729.