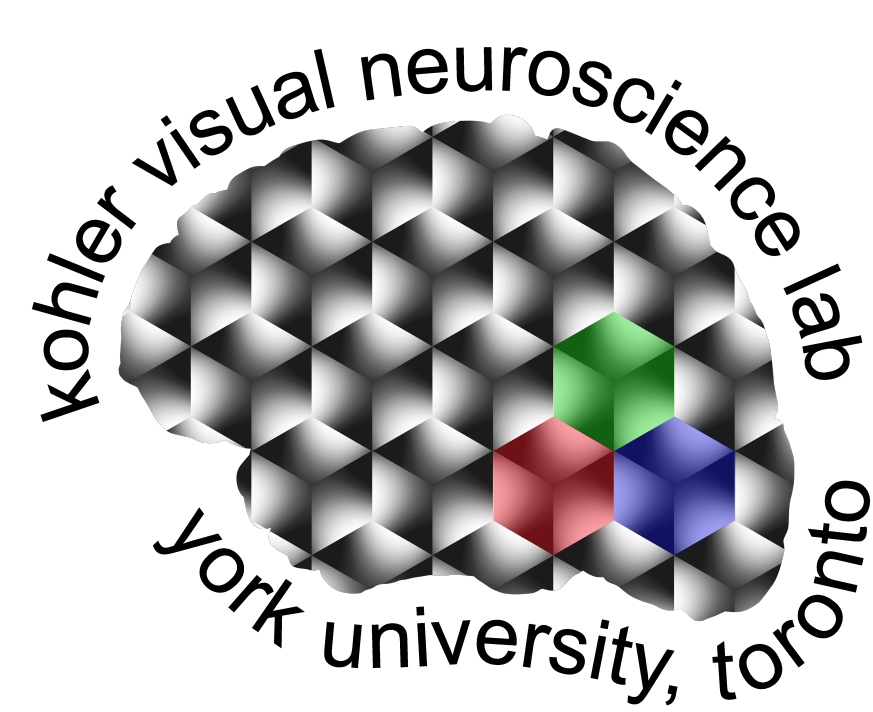


Brain Responses to Visual Symmetry in Early Infancy

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Background

Humans and other animals are highly sensitive to symmetries in their environment, and vision research has demonstrated that symmetry is an important cue to perception of objects and scenes.

Is sensitivity to symmetry innate or does it arise over early development due to exposure to symmetries in the visual environment? Preferential-looking paradigms have provided some behavioural evidence for reflection symmetry sensitivity in infants¹. Here we build on this work by using high-density EEG to measure symmetry responses in infants between 2 and 9 months of age.

We use stimuli from a class of regular textures known as wallpaper groups – a set of 17 unique combinations of symmetry types. The visual cortex of adult humans² and macaques³ responds strongly to reflection and rotation symmetries in wallpaper group textures. We focus on two groups that prominently feature reflection and rotation symmetries, respectively.

Research Questions: (1) Do infant brains respond to symmetry? If so, (2) Do they respond to both reflection and rotation symmetry? (3) Do their responses have similar temporal dynamics as adults? (4) Do their responses change over early visual development?

Stimuli

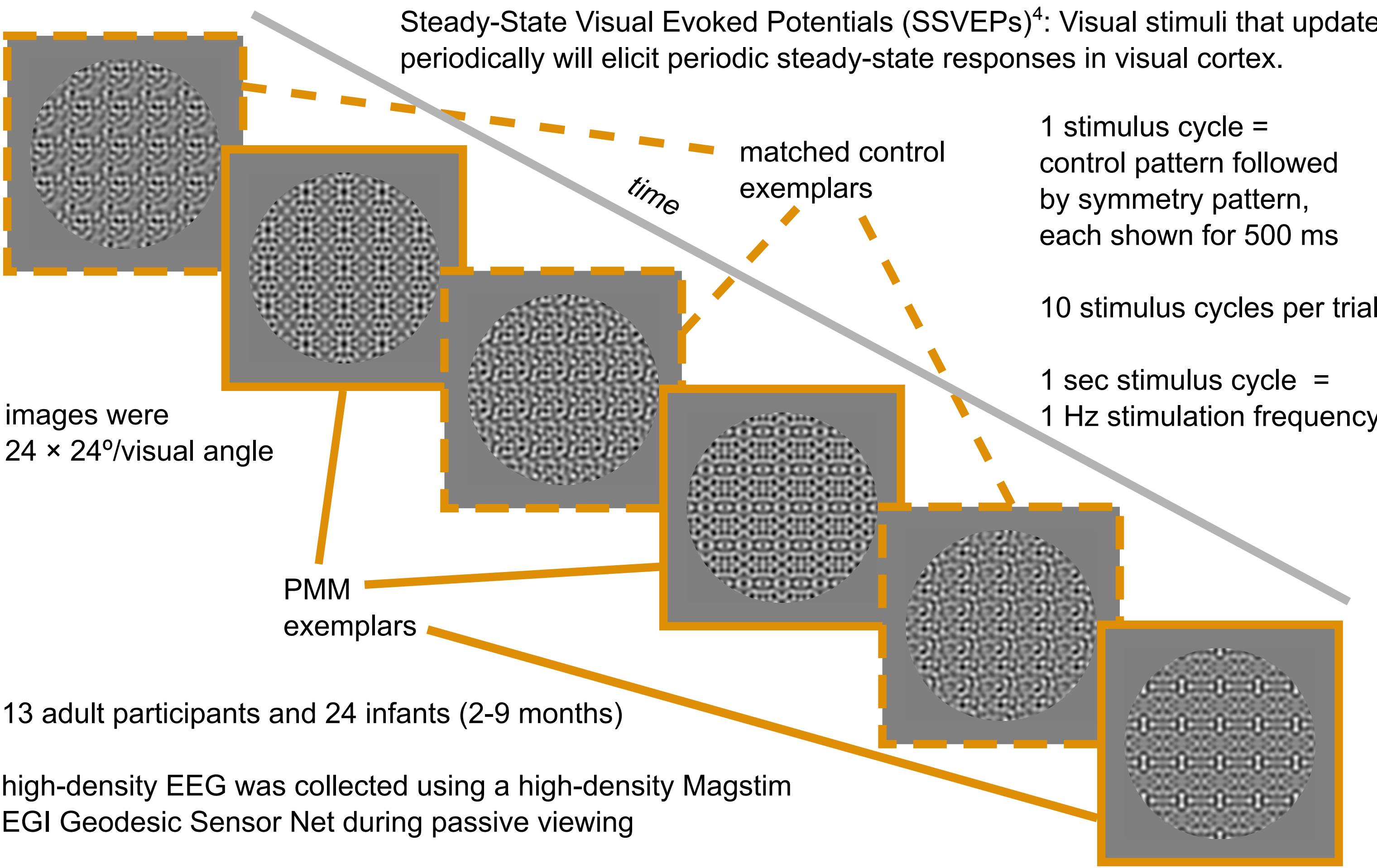
Multiple distinct exemplars from each wallpaper group were generated based on varying random-noise seed regions that enable rich variability across exemplars.

Each wallpaper group consists of a lattice that is repeated to tile the plane. We controlled the ratio of the lattice area to the overall wallpaper (1/25) and the spatial frequency content (1 cpd).

We generated control patterns for each PMM and P4 exemplar that were matched in terms of low-level visual features.

We used 10 distinct control-exemplar pairs for each of the two wallpaper groups.

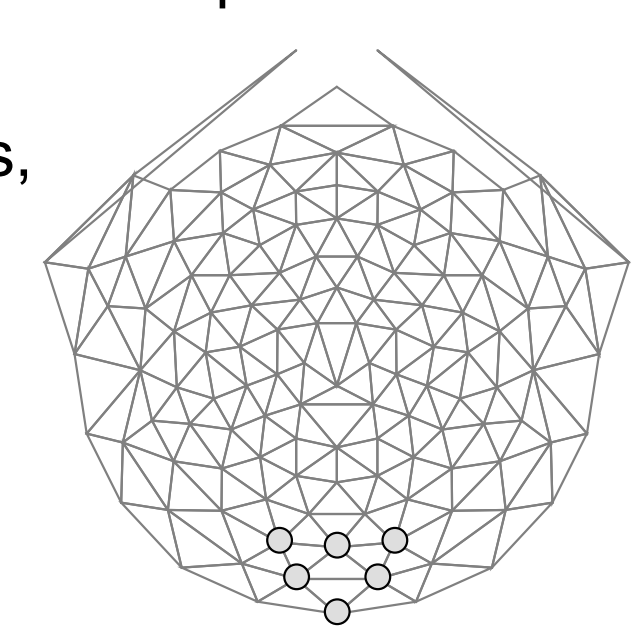
Experiment Design



Data Analysis



- preprocessing was done using HAPPE⁵ and in-house software
- 1 infant was excluded due to having <10 trials of surviving data
- after removing the first and last cycles of each trial, the data were folded and averaged, and DFT was used to obtain 0.5 Hz resolution spectra
- harmonics are narrow-band peaks in the response spectrum at integer multiples of the stimulation frequency
- even harmonics: The part of the SSVEP that is the same for symmetry and control images, relatively low-level image-update responses
- odd harmonics: The part of the SSVEP that differs between symmetry and control images, isolating symmetry-specific brain responses²
- spectral data were projected back into the time domain to generate single-cycle waveforms
- our analyses focused on six electrodes over occipital cortex



Conclusions

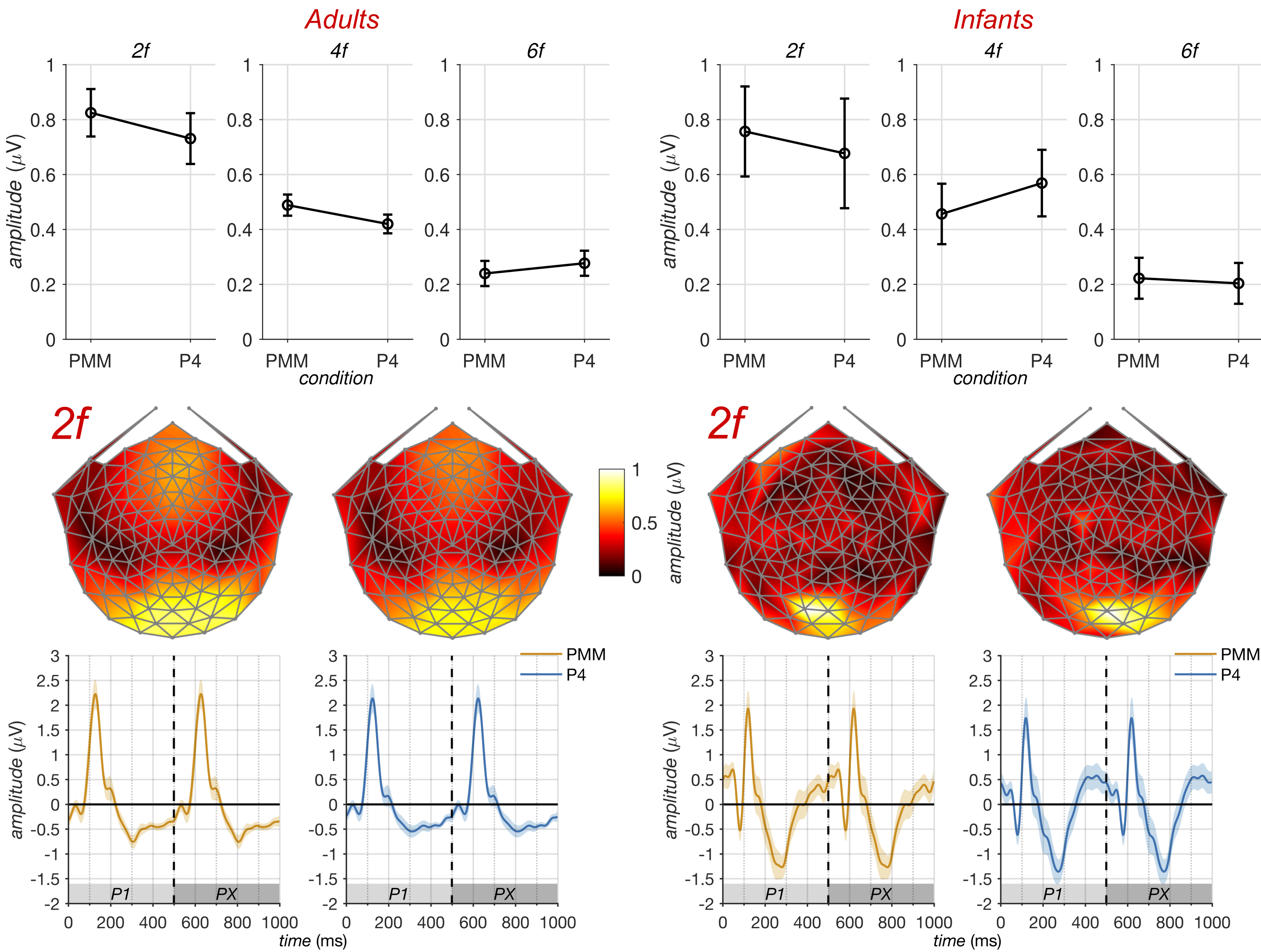
Results revealed robust image-update responses for PMM and P4, demonstrating that infants were equally willing to look at the screen for both conditions.

Infants had measurable responses to both reflection and rotation symmetry, and like adults responded more strongly to reflection than rotation. The temporal dynamics were less clearly sustained for infants. To our knowledge, these are the first measurements of brain responses to symmetry in early infancy.

There was a promising correlation between age and rotation symmetry response strength, but no such relationship for reflection response strength or image-update response strength. If the correlation holds, it would suggest that sensitivity to rotation symmetry emerges over the age range tested here, while sensitivity to reflection is fully developed in early infancy.

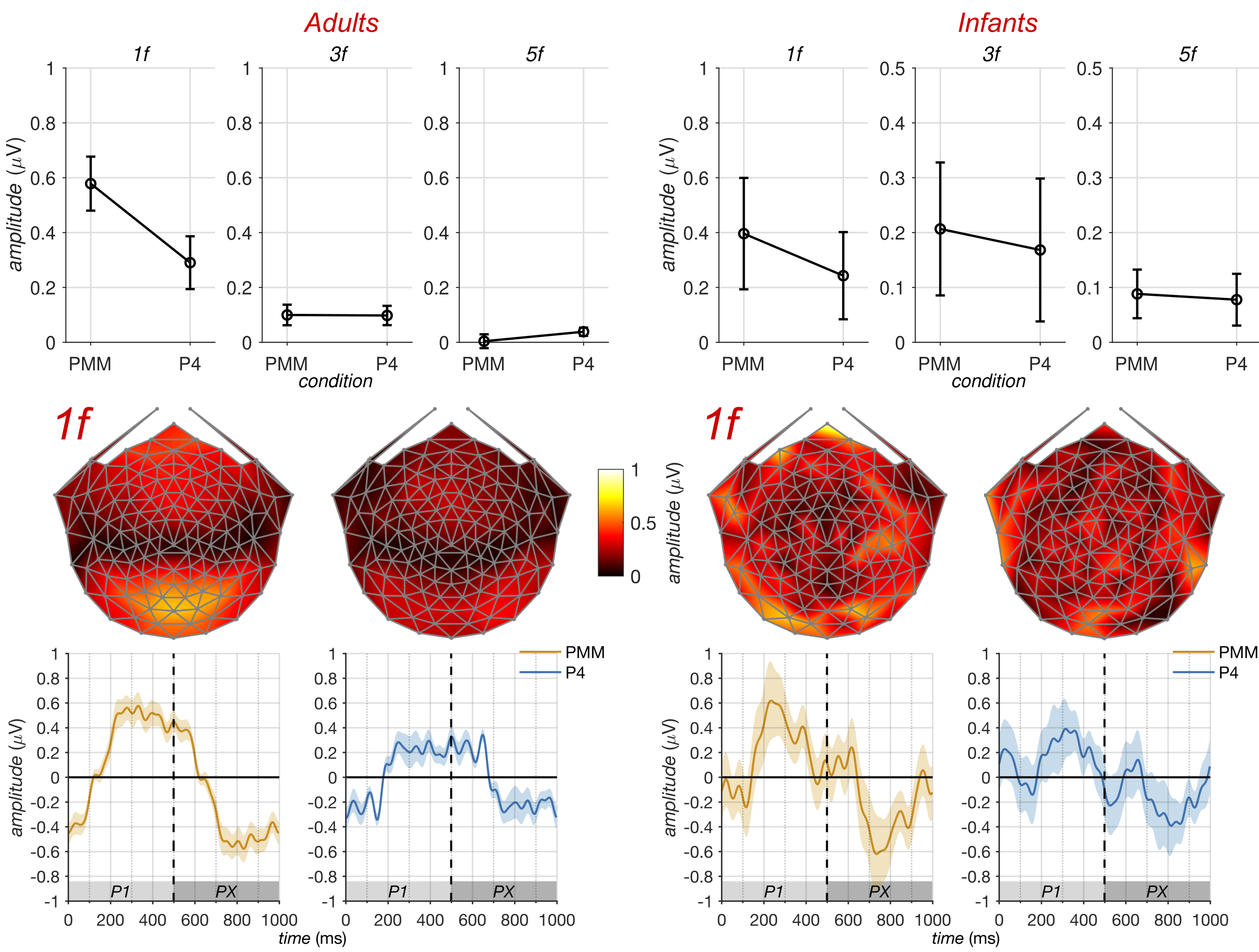
Results: Even Harmonics

Robust image-update responses for both infants and adults. No systematic differences between PMM and P4.



Results: Odd Harmonics

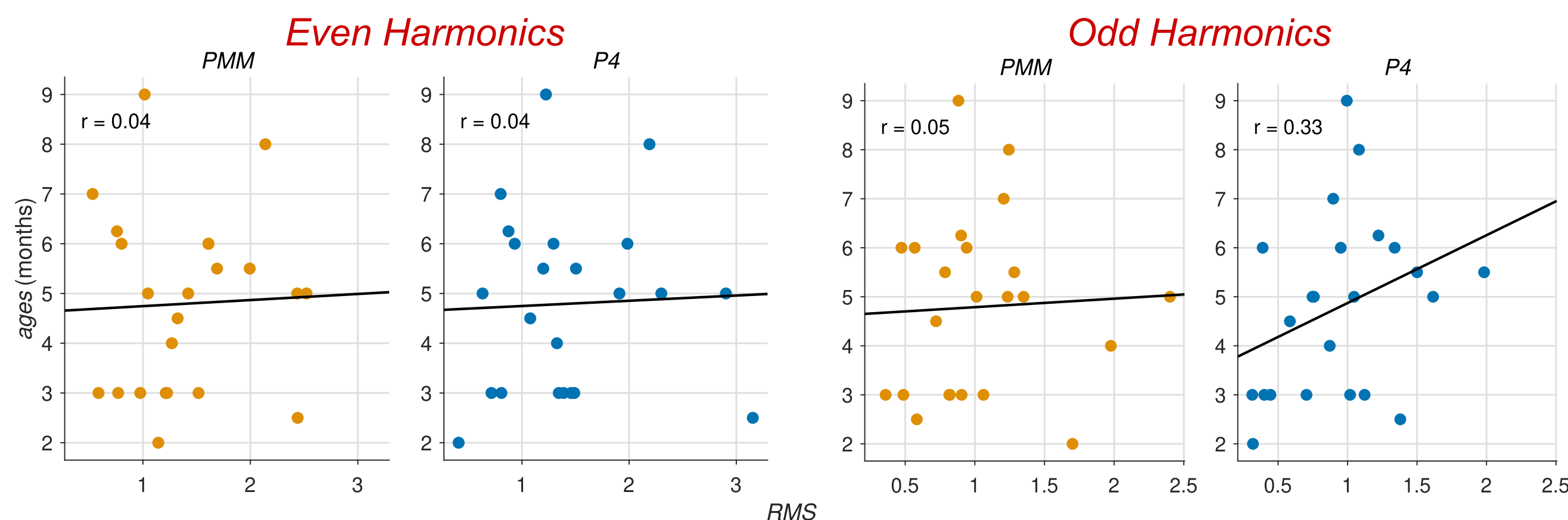
Adults had sustained symmetry responses that were stronger for PMM than P4, consistent with prior work. Infants had measurable symmetry responses, stronger for PMM than P4, but less clearly sustained.



Relationship Between Age and Response Strength

To test whether symmetry responses change over early visual development, we computed the root-mean-square over the back-projected waveforms for each individual participant. We then correlated the RMS values with the age of each infant, separately for each of our four measures.

We found a positive correlation for P4 Odd Harmonics, but not for any of the other measures, indicating that responses to rotation symmetry grow stronger over early visual development.



References

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