Infant brain responses differentiate between optic flow patterns and motion speeds

Alyssa Pandos *(aap5371@psu.edu)*, Rick O. Gilmore, and Andrea R. Seisler

Background

Optic flow informs infants' perception of the geometry, speed, and motion of objects in their environment and their own movements through space. Prior research suggests that infants show larger amplitude electroencephalographic (EEG) responses to direction-reversing linear patterns of optic flow [1] than to radial or rotational patterns. Infants also show larger EEG responses to coherence-modulating rotational flow patterns when motion speeds are faster [2]. Moreover, children 4-8 years old show larger amplitude EEG responses to fast radial and rotational optic flow [3], suggesting that the motion processing network undergoes prolonged development throughout childhood.

Methods

To provide a direct comparison with prior child neural data, high density (128 channel) EEG responses were recorded from (n=23; 13 female) 17- to 38-week-old infants who viewed two different patterns (radial and linear) of optic flow presented at two different speeds (2 and 8 deg/s). Flow patterns were generated from white dots moving on a black background, with the degree of motion coherence varying from 100 percent (coherent) to 0 percent (incoherent/random) every 833 ms, resulting in a first harmonic (1F1) of 1.2 Hz. EEG data were cleaned and filtered before being subjected to a frequency domain analysis using a discrete Fourier transform. This analysis provided data about complex domain responses to the optic flow stimulus at low-order integer harmonics of the coherence modulating frequency (e.g., 1F1, 2F1, 3F1).

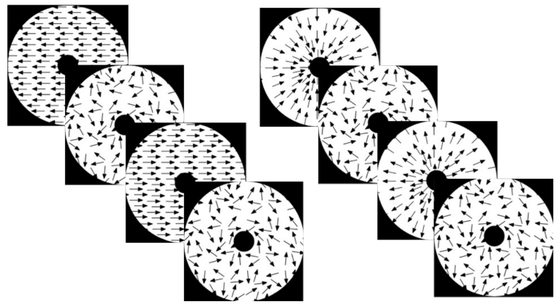
References

[1] R. O. Gilmore, C. Hou, M. W. Pettet, and A. M. Norcia, "Development of cortical responses to optic flow," *Visual neuroscience*, vol. 24, no. 06, pp. 845–856, Nov. 2007. [Online]. Available: http://journals.cambridge.org/article_S0952523807070769

[2] C. Hou, R. O. Gilmore, M. W. Pettet, and A. M. Norcia, "Spatio-temporal tuning of coherent motion evoked responses in 4–6 month old infants and adults," *Vision research*, vol. 49, no. 20, pp. 2509–2517, Oct. 2009. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0042698909003666

[3] R. O. Gilmore, A. L. Thomas, and J. Fesi, "Children's brain responses to optic flow vary by pattern type and motion speed," *PloS one*, vol. 11, no. 6, p. e0157911, Jun. 2016. [Online]. Available: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0157911

Displays

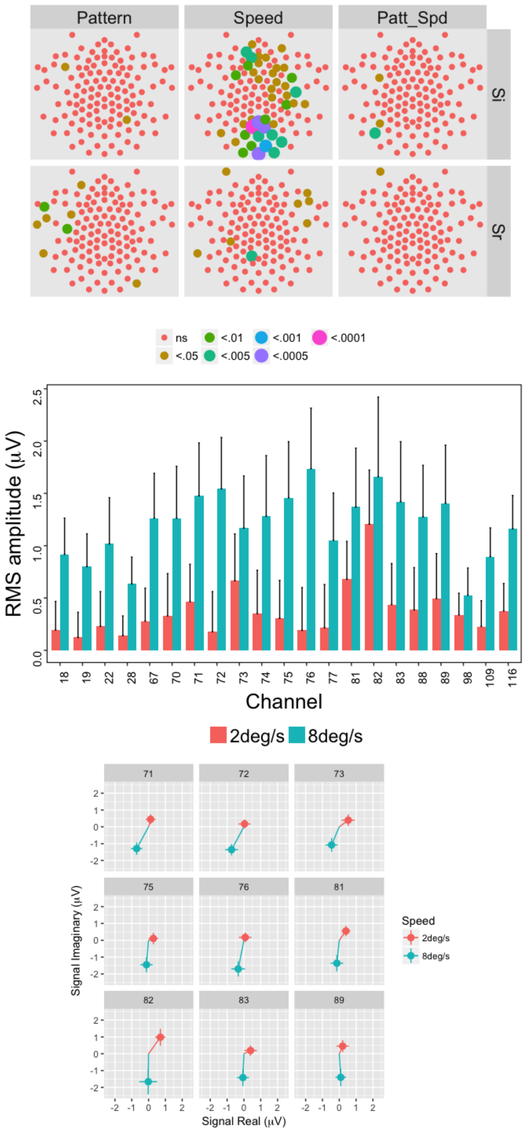


Results and Discussion

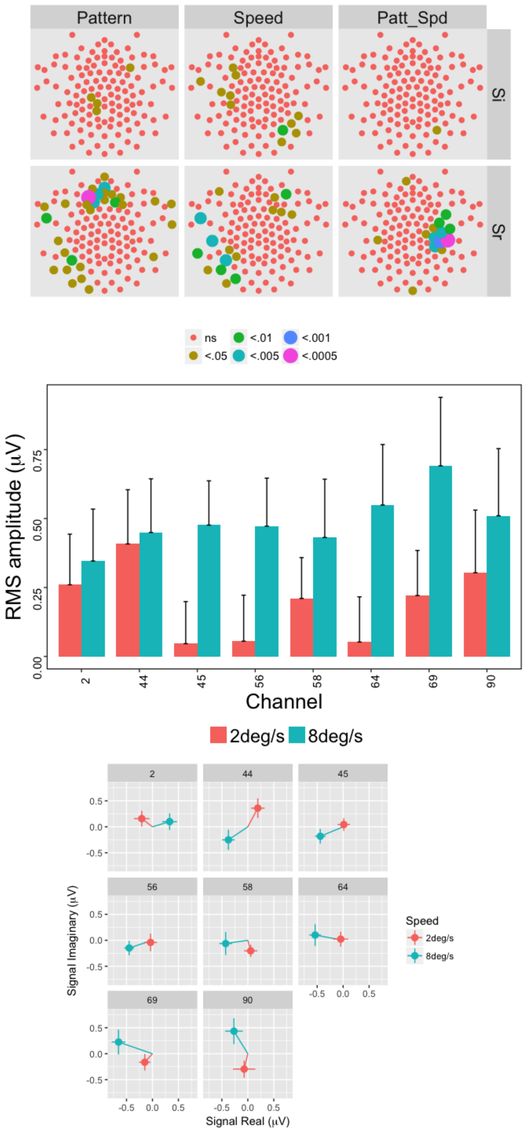
At the first harmonic, infants showed a small cluster of left frontal channels that showed higher amplitude responses to translational patterns and a larger cluster over the posterior midline that showed higher amplitude and distinct phase responses to faster speeds. At the second harmonic (2F1; 2.4 Hz), there was a cluster of left frontal channels that showed higher amplitudes to radial motion, a group of left lateral channels that showed higher amplitudes to faster speeds, and a right lateral cluster that showed a pattern by speed interaction. Results from the third harmonic (not shown) showed a small left frontal cluster of channels with higher responses to radial motion and two left and right central clusters where EEG phases, amplitudes, or both distinguished between the two speed conditions.

Taken together, the results show that infant brain responses to coherence-modulating optic flow differ both from prior EEG results using direction-changing optic flows [1] and from those recorded in older children using identical displays [3]. Faster (8 deg/s vs. 2 deg/s) speeds tend to evoke larger amplitude EEG responses, consistent with predictions, but radial flows activated larger amplitude responses than linear flows, in contrast with predictions. Moreover, the spatial pattern of channels showing speed or pattern sensitivity differs between infants, children, and adults. The network of brain systems that detect and respond to optic flow may undergo patterns of development that are more idiosyncratic or individual-specific than indicated by previous findings.

Results: 1F1



Results: 2F1



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Data Sharing

Movies of the displays, metadata about the participants, and raw data files are available at: `http://databrary.org/volume/218`. Full reports of our data analysis workflows are available at: `http://github.com/gilmore-lab/moco-psychophysics/child-laminar-radial`