Discriminability of Neural Patterns within the Magnocellular and Parvocellular Visual Pathways

Daniel B. Elbich[1], Reginald B. Adams, Jr.[1], Kestutis Kveraga[2], & Nancy A. Dennis[1*]
[1]The Pennsylvania State University, [2]Harvard Medical School
*Corresponding author: nad12@psu.edu

Introduction

- The magnocellular and parvocellular pathways are two key visual pathways, integral to detecting gross differences in luminance as well as low contrast differences and color-sensitivity, respectively (Tootell et al., 1998; Kveraga et al., 2007).
- Previous findings in social perception show threat cues differentially activate the right and left amygdalae when biased towards the magnocellular and parvocellular pathway, respectively (Adams et al., 2012; Im et al., 2017; Cushing et al., 2018).
- Some aging work has suggested both pathways become less sensitive as we age (McKendrick et al., 2007), with signs of aging beginning at around age 50 particularly for the magnocelluar pathway (Benedek et al., 2017).
- Importantly, there is no work examining how the neural patterns within these pathways may differ in older adults, despite a body of knowledge describing dedifferentiation of neural specialization with age.

Goal

The goal of this study was to bridge this gap by evaluating the extent of dedifferentiation in the specialization of the magnocellular and parvocellular pathways using a large sample of adults

Participants

- Participants were 70 adults, ages 19-71.

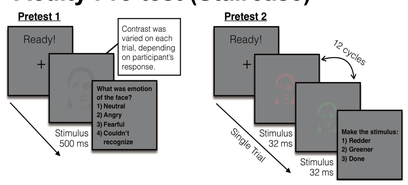
		Age		
	N	Range	*M*	*SD*
Young Adult (YA)	38	19-30	25.66	2.74
Older Adult (OA)	32	41-71	57.69	8.52

- All had normal or corrected-to-normal visual acuity and normal color vision
- Vision verified by the Snellen chart, the Mars letter contrast sensitivity test, and the Ishihara color plates.

Visual Bias Detection Task

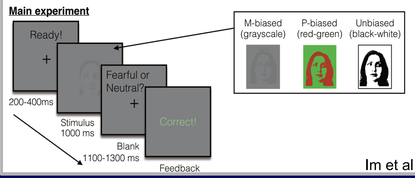
- Acuity pre-test was used to determine subject-specific thresholds for magno/parvo biasing
- Thresholds were used in subsequent fMRI task to ensure maximum stimulus visibility
- Pre-tests were performed immediately prior to scanning

Acuity Pre-test (Staircase)



- Subjects were shown visually biased stimuli and had to report the face emotion
- Visual feedback was given after each trial
- ¼ of trials were catch/null trials
- 4 runs; 96 trials per condition

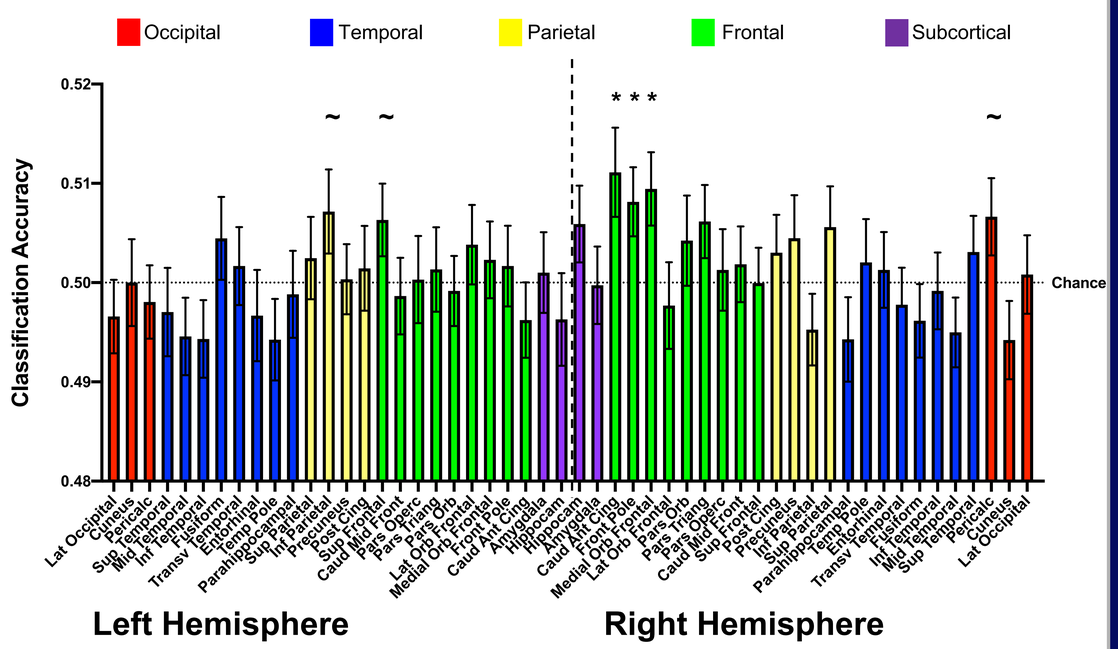
fMRI Task



Im et al., 2017; Im et al., 2018; Adams et al., 2019

First to show age-related differences in discriminability of neural patterns within magnocellular & parvocellular pathways.

Successful Classification for Magno/Parvo-biased Stimuli in Dorsal Pathway Regions

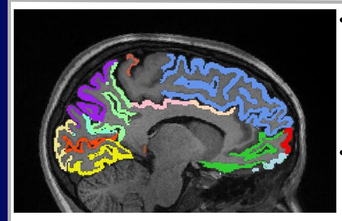


- Significantly above chance classification for magno-biased and parvo-biased stimuli was found in the right caudal anterior cingulate, frontal pole, and medial orbitofrontal cortex ($p < 0.05$).
- Anterior frontal regions serve as the endpoint for the magnocellular pathway.
- Trending effects were found in throughout the brain in the superior frontal gyrus, inferior parietal sulcus, and pericalcarine sulcus ($p < 0.10$).

Conclusions

- Right frontal areas show above chance classification for the entire group, including the frontal pole, caudal anterior cingulate, and medial orbitofrontal gyrus
- In terms of age, we found multiple bilateral regions with greater classification for younger adult participants compared to older adults
- There is a trend in the same direction for the right amygdala, where univariate findings show an effect of threat for magno-biased stimuli
- Overall, results show that regions along both the magnocellular and parvocellular pathways exhibit some level of neural discriminability for the conditions, with little evidence for dedifferentiation in the pathways.

Data Processing

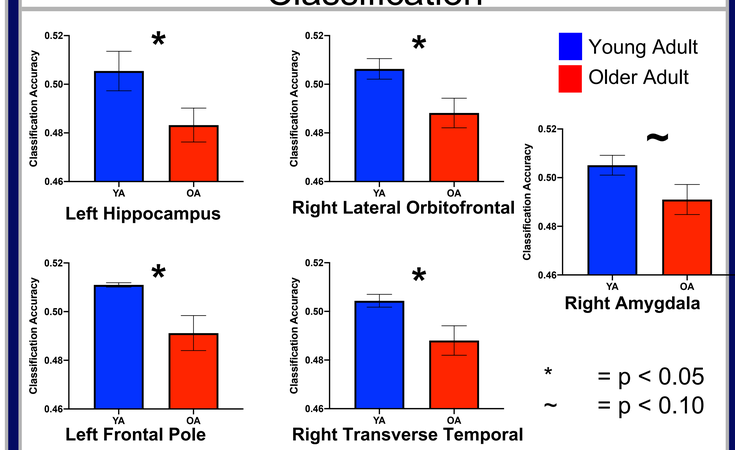


- Functional data collected using 1.5T Siemens Avanto (TR/TE = 2500, 33.83ms; voxel size = 3x3x2 mm, Flip angle = 90°, 58 Interleaved Slices).
- Data was preprocessed in native space using SPM12. Slice scan time and motion correction performed only.
- High resolution T1 images were reconstructed, preprocessed, and parcellated using Freesurfer (version 6.0).
- Selected subcortical & cortical regions were extracted using Freesurfer (total 54; see above).

Multivariate Analysis

- Analysis performed using CoSMoMVPA toolbox (http://www.cosmomvpa.org)
- Employed multivariate pattern classification using a linear support vector machine (SVM) to quantify the neural discriminability between biased stimuli throughout the brain.
- Classification performed in all regions in all subjects for magno/parvo biased stimuli
- Statistical tests were performed in SPSS

Age-Related Differences in Pattern Classification



Acknowledgements

Thank you to Dr. Hee Yeon Im for collecting the data, and to Jordan Chamberlain and Courtney Gerver for their council with the data analysis pipeline. This research was funded by the National Institute of Mental Health (NIMH) Grant R01 MH101194 to K. K. and R. B. A.