

# **Macular Degeneration and Plasticity:**

a Newly Shared Dataset Available as Part of the NIH Connectomes in Human Diseases Project



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Full test Battery: 18 hours data collection per participant.

Participants with Macular Degeneration have at least 2 years of vision loss.

HUMAN Connectome National

NATIONAL INSTITUTES OF HEALT

Selected Results

Eve

Institute



# Introduction

### Large, shared datasets are beneficial for neuroscience

•Datasets like the Human Connectome Project HCP 1200, for example, have had enormous benefit for the field because they allow many investigators to examine independent hypotheses in well curated datasets.

• Much of the work using these large shared datasets has examined the typical brain: this limits the range of questions that can be addressed in these datasets. To examine more detailed questions, for example questions about plasticity in the human brain, detailed knowledge about individuals' experiences is needed.

## Vision as a model for plasticity

•The visual system has proven to be a superb model for examining neural plasticity. It has precise retinotopic mapping, meaning that the cortical locations of hypothesized changes can be accurately localized.

· Plasticity manifests differently in the developing brain vs. the adult brain vs. the older adult brain. For example, ocular dominance plasticity, as observed in primary visual cortex, V1, occurs only in the developing brain.

· Understanding what types of plasticity are available to the older brain is essential to developing effective cognitive remediation strategies.

### Macular Degeneration

 Patients who have macular degeneration (MD) experience profound changes in the way they use vision, starting in adulthood.

· MD is one of the most common causes of blindness in the industrialized world (Owen, et al., 2003). It results from the death of retinal tissue in the macula, as seen in the lower image on the right. This leads to the

loss of central vision. • People with MD learn to use their spared peripheral vision for everyday activities, including reading and recognizing faces.

• Often, they develop a "Preferred retinal Locus" (PRL), which they use similarly to a fovea.

# Macular degeneration as a model for plasticity.

·Because exposure to the change in vision is 24 hours a

day, seven days a week, over multiple years, and Macular because many important daily activities use vision, (central) motivation is high, and the strength of the experience is Vision very high.

·Because this is a selective vision impairment, we can MD patients use compare precise retinotopic locations, affording within- Peripheral vision more in daily life subject controls.

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Owen, C. G. How big is the burden of visual loss caused by age related macular degeneration in the United Kingdom? British Journal of Ophthalmology 87, 312-317 (2003)

Visual Field

"Central "Peripheral

V1"

Standard Human Connectome Project MRI protocol, plus extras

#### ·Field maps Diffusion

Anatomy

- 4 scans, 1.5 mm isotropic b= 0 and 3000
- · 98 directions AP. 98 directions PA. · 99 directions AP, 99 directions PA

MRI (5 sessions):





# Eye (1 session):

- Retinal imaging:
- Fundus photography images of retina
- · Optical Coherence Tomography fine scale retinal anatomy. measures retinal layers
- Macular Integrity Assessment (MAIA) measures areas of functional retina, and
- fixation stability Vision testing:
- Acuity, contrast sensitivity, Farnsworth color test, Visual functioning questionnaire (VFQ)

			All	
Retinal Imaging	MD	H	C Sul	bjects
OCT		34	27	61
MAIA		36	26	62
Fundus				
Photography		37	27	64
All 3 Image Types		33	25	58

#### Functional MRI:

Controls are matched 1-to-1 on age, sex, and education level. Age 23-93 y/o, median = 68 y/o

Dataset

- Dataset includes over 150 hours of curated, cleaned BOLD data
- Functional BOLD, 2mm isotropic resolution, multiband acceleration factor of 8, TR = 800 ms. Eye tracking collected during all BOLD scans.
- · Rest, eyes open (8 scans, 336 s duration each, half AP, half PA) · Emotion (1 scan, 140.8 s duration, AP)
  - · Gambling (1 scan, 202.4 s duration, AP)

Age 22-93 y/o, median = 77 y/o

- Social Cognition (1 scan, 133.6 s duration, AP)
- Working Memory (1 scan, 155.2 s duration, AP)

#### Additional Vision-related Functional MRI scans

- · Dark rest, with eyes open, in order to control for participants' visual experience (8 scans, 336 s duration each, half AP, half PA)
- · Retinotopy with unpredictable bar stimuli (4 scans, 336 s, half AP, half PA)
- · Pixar Movie viewing (4 scans, 336 s, half AP, half PA)
- · Full field visual stimulation (1 scan, 336 s, half AP, half PA) Stimulation of the PRL (1 scan, 336 s, half AP, half PA)

# Behavior (5 sessions):

- Motor
- Penn computerized neuropsychological testing

  - · emotion recognition
  - delay discounting
- Quality of life: SF-36
- · Detailed demographic information

# Selections of results from published manuscripts: Right and Left Retina, mergeo



A method for mapping retinal images in early visual cortical areas. Defenderfer, Demiravak, Visscher, (2021), Neuroimage 245, 118737.



Right Retin

# Connectivity of spared regions of V1 to MT is strong. Fleming, Defenderfer, Demirayak, Stewart, DeCarlo, & Visscher (2023). Preprint under review:

doi.org/10.2139/ssrn.4473801

experience, dependent on age. Defenderfer, M. K., Demirayak, P., Fleming, L. L., DeCarlo, D. K., Stewart, P., & Visscher, K. M. (2023). Cortical plasticity in central vision loss: Cortical thickness and neurite structure. Human Brain Mapping, 44(10),4120-4135

Examine how neurite density changes with

4'3 6'8 9'3 15'7 26'6 45'4 V1 ROI (° Eccentricity)

Neurite density across visual eccentricity

# Conclusions

- MDP dataset is a well-curated, openly accessible resource for examining large-scale plasticity in a human model.
  - · Within-subject controls (lesion vs. PRL vs. control portions of retinal space)
  - Deep phenotyping
- · As part of the Human Connectome Project, this dataset is now available for download. See information and download the dataset at the QR code above or go.uab.edu/MDP

Contact Kristina Visscher, kmv@uab.edu with guestions.

- Full HCP behavioral workup: NIH toolbox: Cognition
  - Emotion
  - Sensory
    - Line orientation
      - continuous performance test
      - · word memory test
    - · Personality: NEO-five factor
    - Daily functioning: Achenbach self report



•T1 MPRAGE 0.8 mm isotropic •T2 SPACE 0.8 mm isotropic