Role of MT disparity tuning biases in figure-ground segregation

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In natural vision, figure-ground segregation serves to parse salient objects from the surround

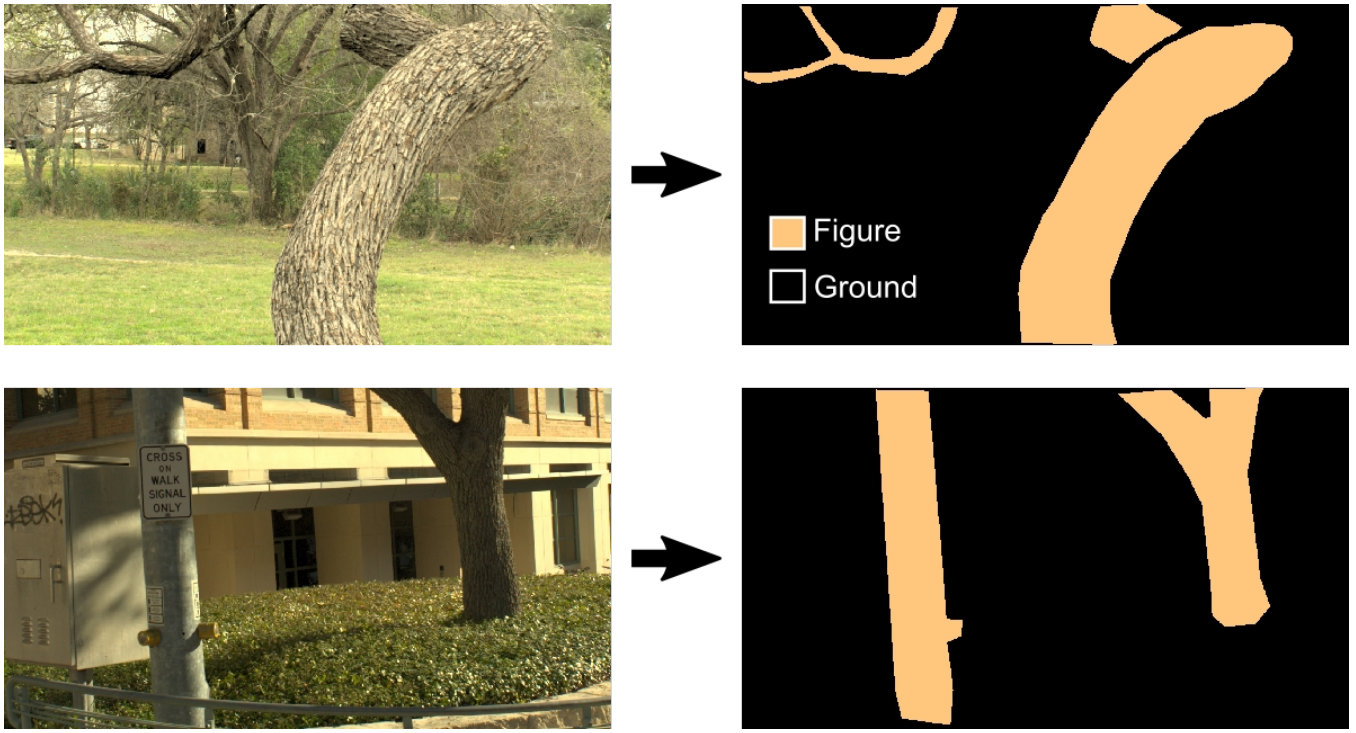
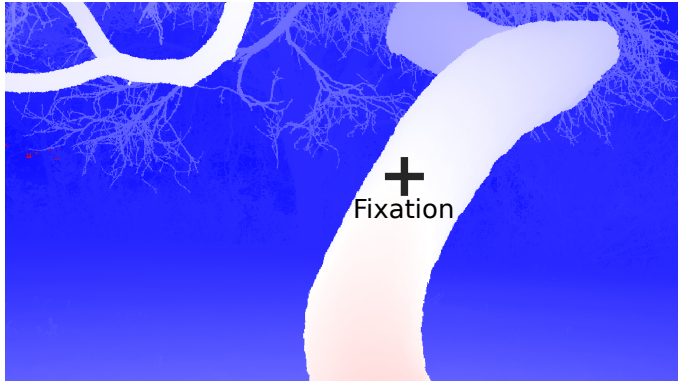


Image set: Burge et al. 2016
Figure-ground data: Huang et al. 2019

Horizontal binocular disparity is an informative cue for figure-ground segregation



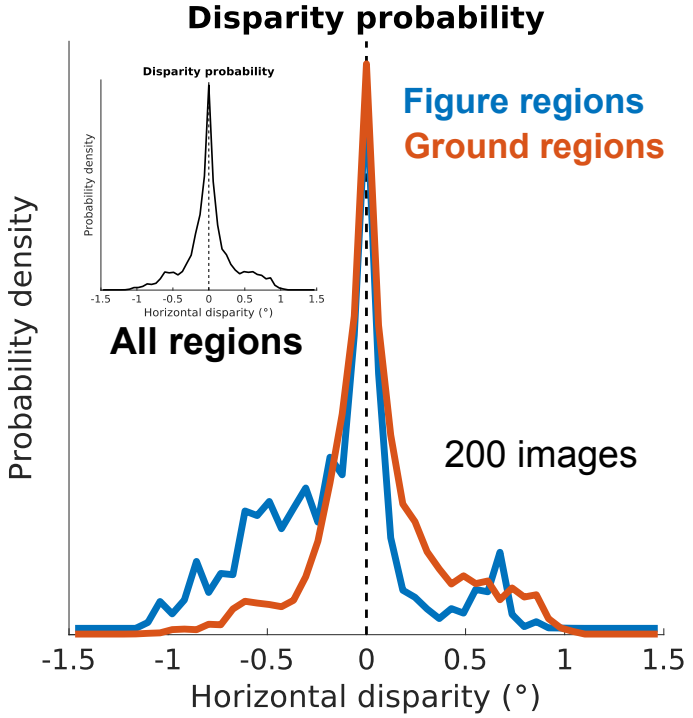
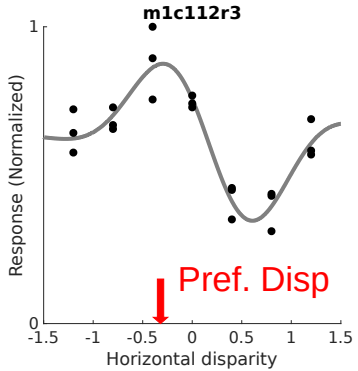
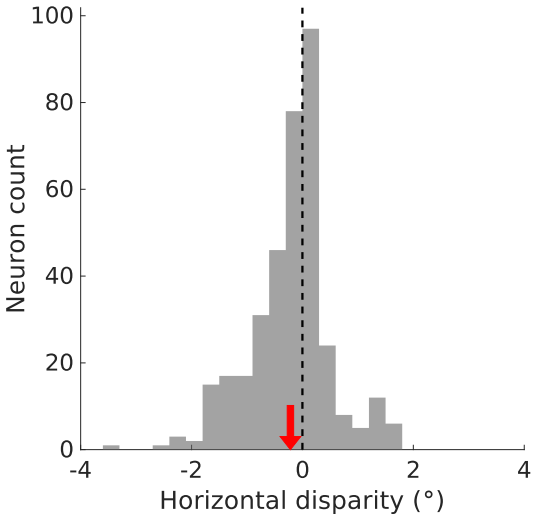
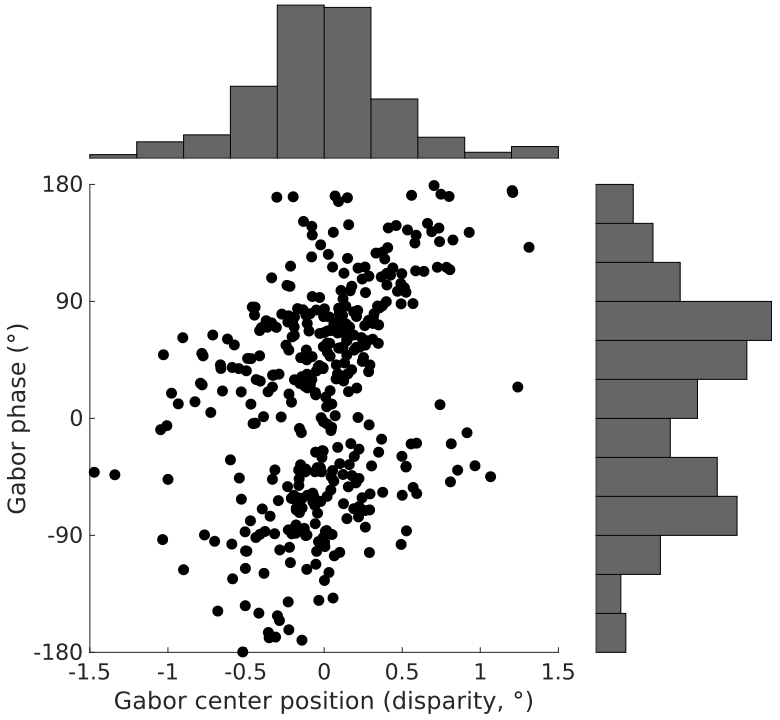


Image set: Burge et al. 2016
Figure-ground data: Huang et al. 2019

MT neurons are selective for disparity and exhibit tuning biases



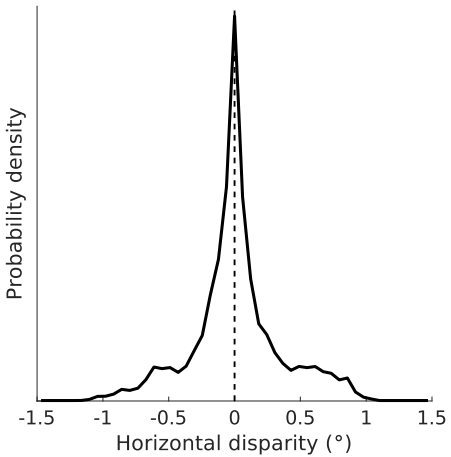




Data from DeAngelis & Uka 2003

Do tuning biases reflect an optimization for disparity **information transmission**?

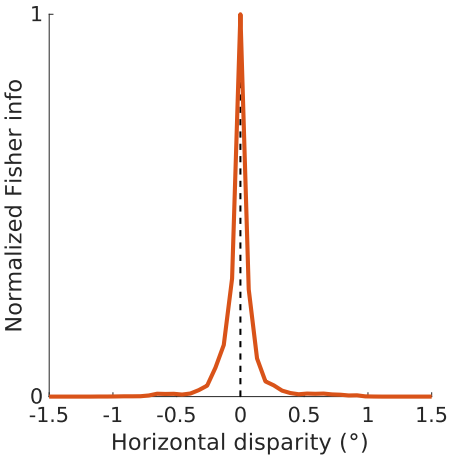
Scene Statistics



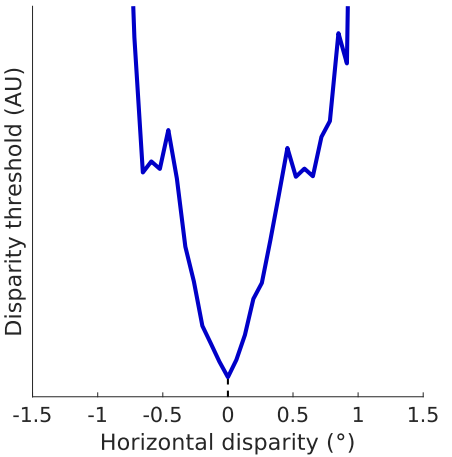
$p(disp)$

Infomax optimization: for a **set number of spikes in population, A,** shape tuning curves to **maximize mutual information** between stimulus and response

Neural Encoding



Encoding Precision



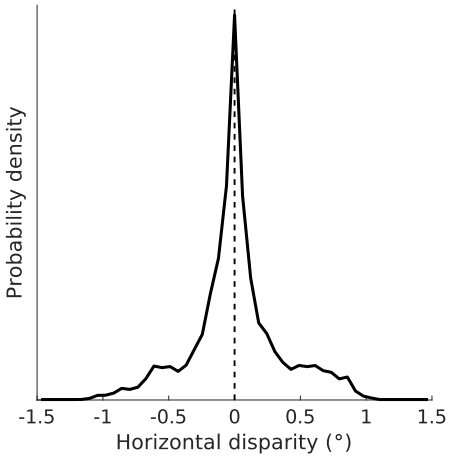
$$FI(disp) \propto Ap^2(disp) \quad thresh(disp) \geq \frac{disp_{min}}{\sqrt{FI(disp)}}$$

Fisher information (*FI*): related to neural population precision and provides lower bound for mutual information

Brunel & Nadal 1998;
Ganguli & Simoncelli 2014;
Wang, Stocker, Lee 2012

Do tuning biases reflect an optimization for disparity **discriminability**?

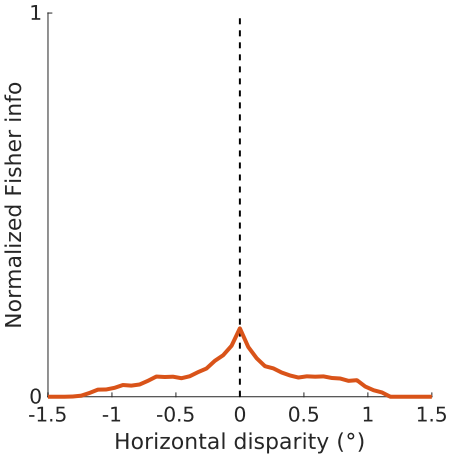
Scene Statistics



$p(disp)$

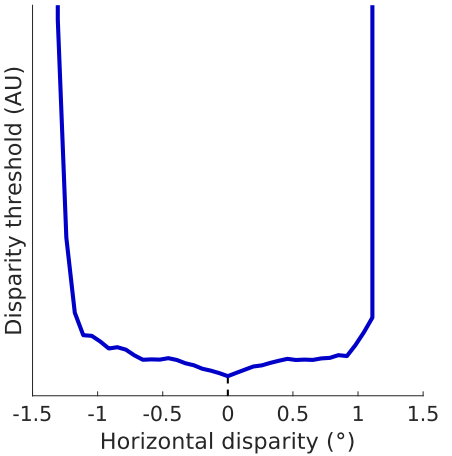
Discrimax optimization:
for a **set number of spikes in population, A,** shape tuning curves to **maximize stimulus discriminability**

Neural Encoding

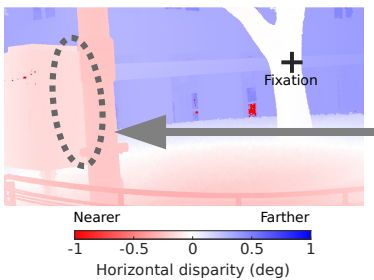


$$FI(disp) \propto A p^{1/2}(disp)$$

Encoding Precision



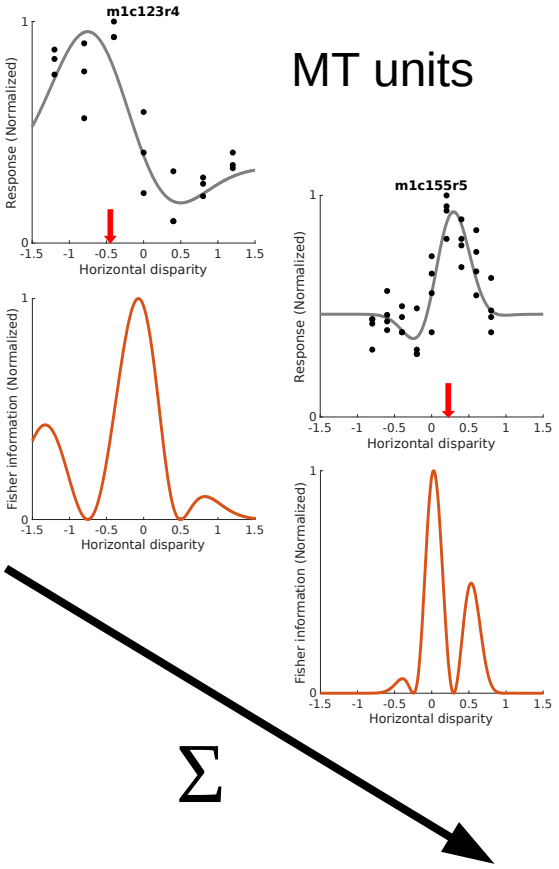
$$thresh(disp) \geq \frac{disp_{min}}{\sqrt{FI(disp)}}$$

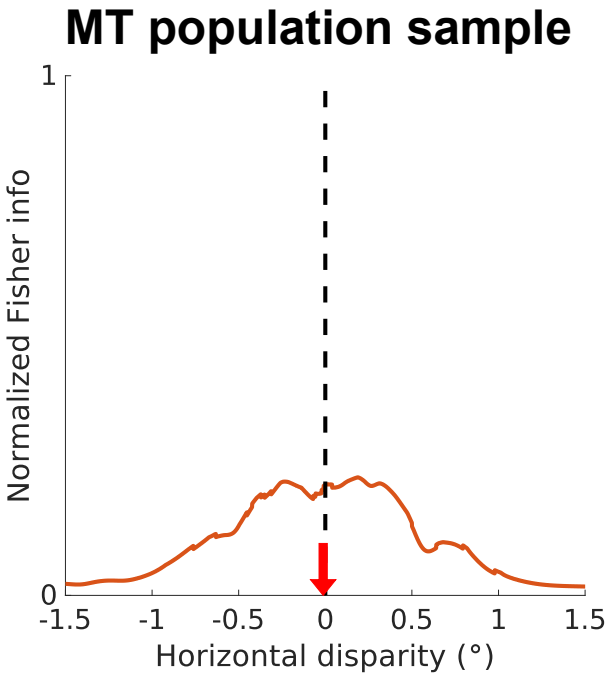


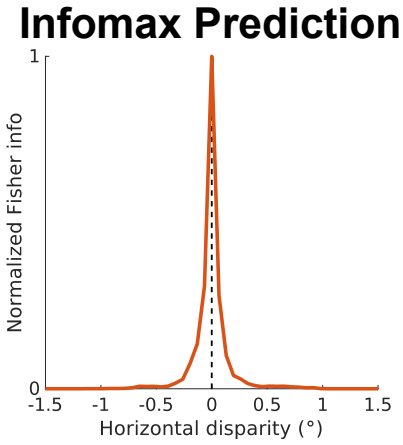
Some figure-ground boundaries occur at large disparity pedestals

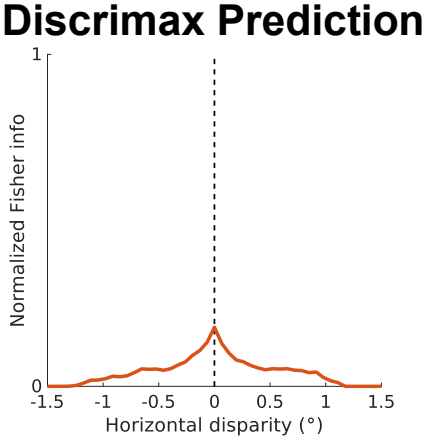
Brunel & Nadal 1998;
Ganguli & Simoncelli 2014;
Wang, Stocker, Lee 2012

Method: calculate population Fisher information

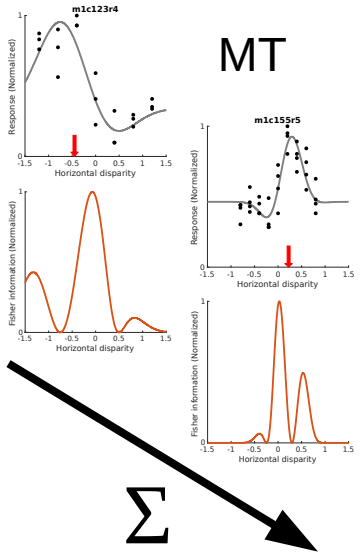


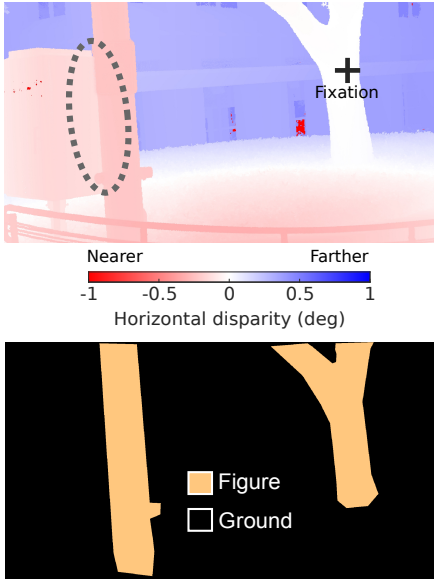






Summary: MT population disparity sensitivity may facilitate discrimination at Figure-Ground borders





- Disparity is a helpful cue for Figure-Ground segregation
- Disparity tuning biases in MT potentially explained as an optimization for disparity statistics at Figure-Ground borders

Acknowledgments

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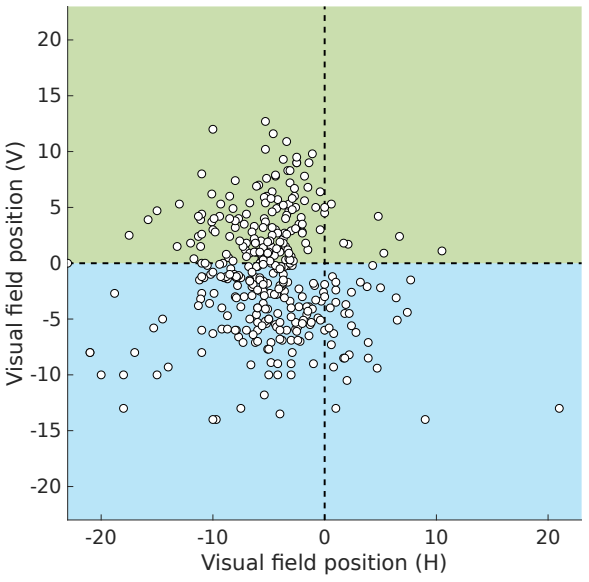
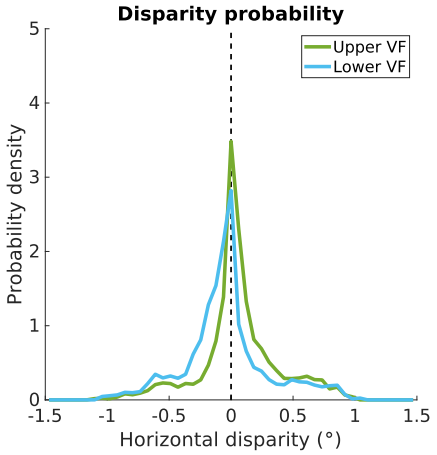
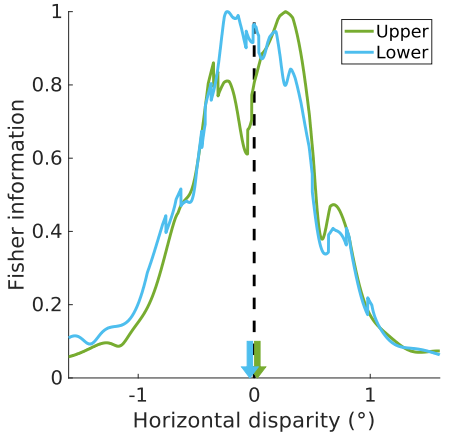
Fisher information distribution matches disparity statistics in visual field subregions

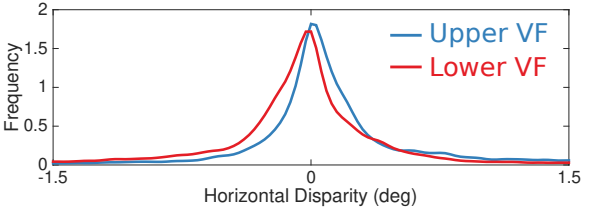
Neuron RF center







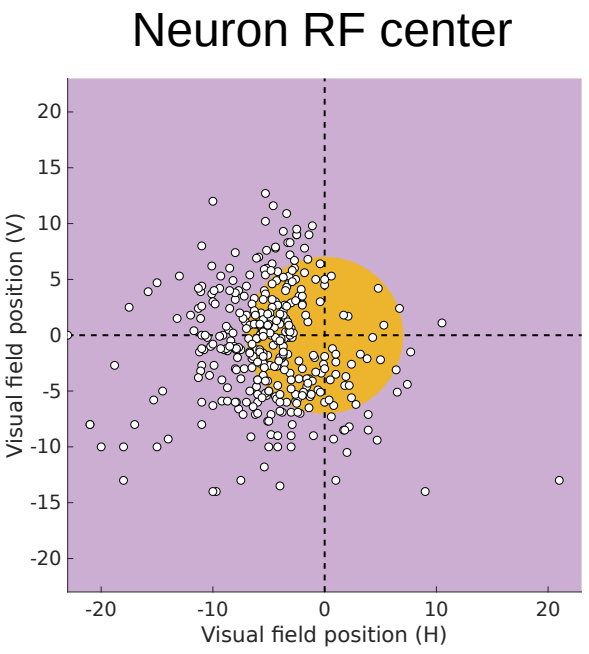
Collected from the Burge et al image set

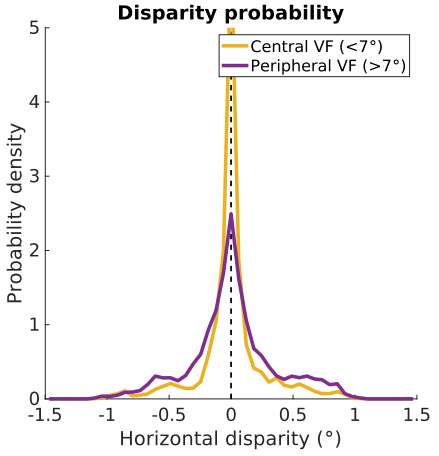


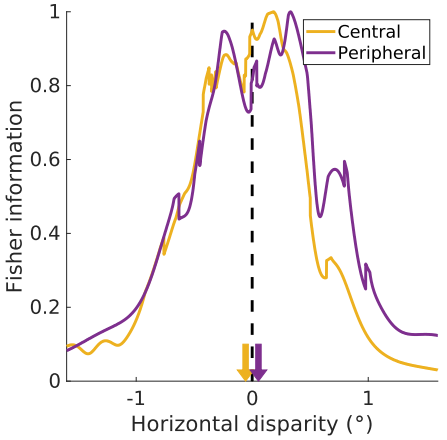
Collected during naturalistic behavior:

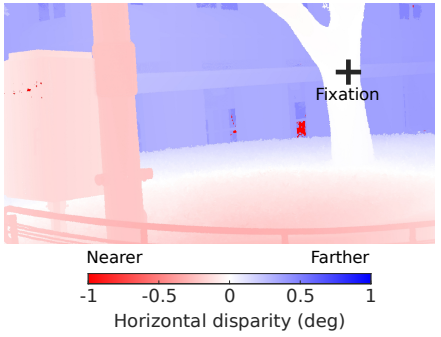
Sprague, Cooper et al (2015)

Fisher information distribution matches disparity statistics in visual field subregions









Disparities cluster around zero near fixation; in periphery, they are more variable