Mapping Spatial Frequency Preferences in the Human Visual Cortex

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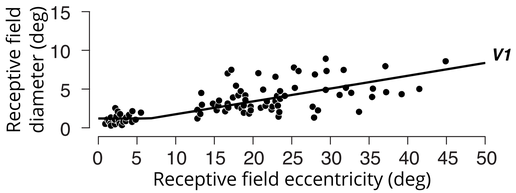
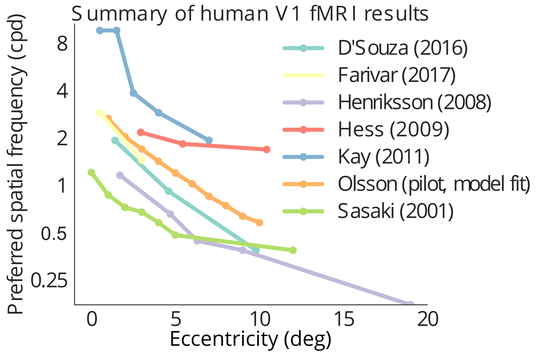
Background

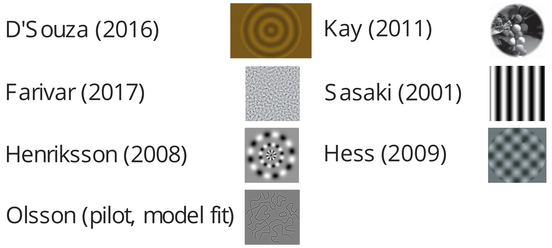
- V1 receptive field size scales linearly with eccentricity[3]



- How do spatial frequency preferences change across the visual map?
- Previous results show peak spatial frequency decrease with eccentricity, but actual numbers vary by two to three octaves!



- Variability perhaps due to inconsistent stimuli



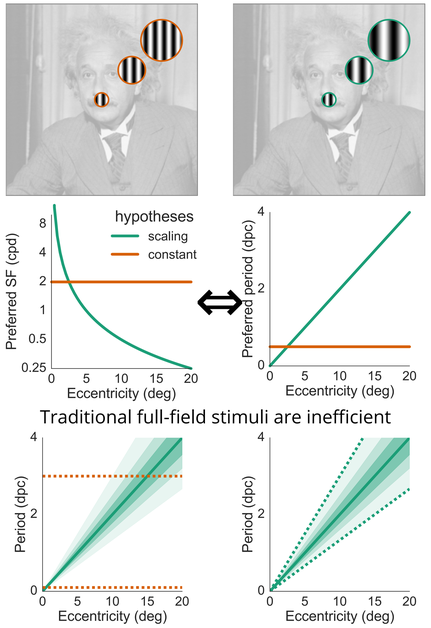
References

1. Kay, K. N., Rokem, A., Winawer, J., Dougherty, R. F., & Wandell, B. A. (2013). GLmdenoise: a fast, automated technique for denoising task-based fmri data. Frontiers in Neuroscience, 7(). http://dx.doi.org/10.3389/fnins.2013.00247
2. Benson NC, Winawer J (2018). The relationship between structure and function in early visual cortex can be quantified by Bayesian analysis of retinotopic organization. In Preparation.
3. Replotted from Freeman, J., & Simoncelli, E. P. (2011). Metamers of the ventral stream. Nature Neuroscience, 14(9), 1195–1201. http://dx.doi.org/10.1038/nn.2889

Extreme Possibilities

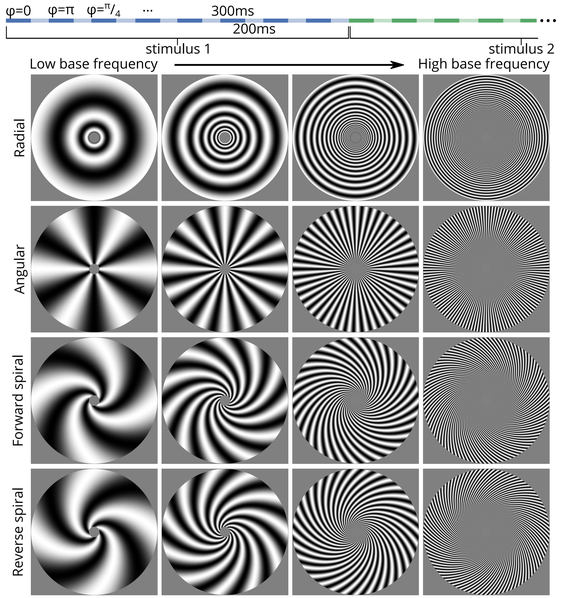
SF preferences constant across visual field

SF preferences scale with eccentricity / receptive field size



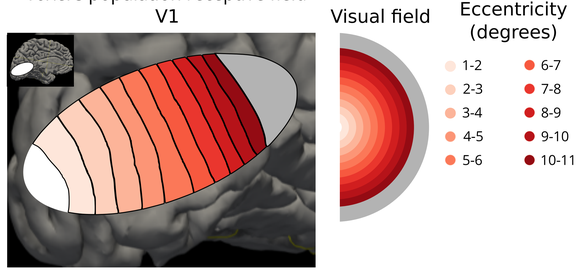
Experiment

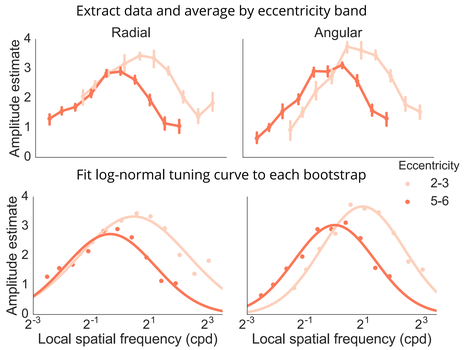
- Showed 5 subjects 40 log-polar gratings (8 phases each) spanning 1 to 12 degrees from 4 classes with 10 base frequencies in 12 runs
- Each stimulus presented once per run, in random order, during a 4 second trial, in which all 8 phases were presented in random order.
- Subjects performed 1-back task on digit stream at fixation



Methods

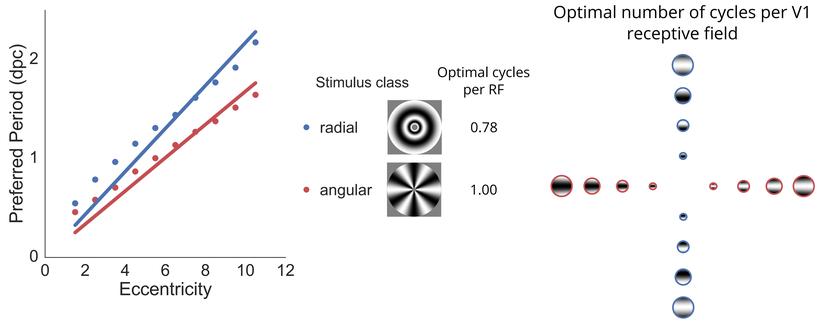
- GLMdenoise[1] to estimate a (bootstrapped) response amplitude per voxel per stimulus
- Bayesian retinotopy[2] to estimate an eccentricity and angle for each voxel's population receptive field



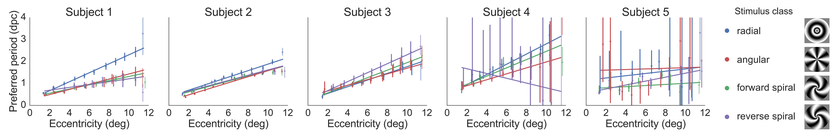


Results

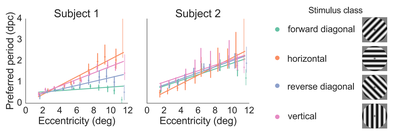
- Extract preferred period from tuning curves, then take median across bootstraps and average across subjects (weighted by precision), fit line (with intercept=0) as function of eccentricity

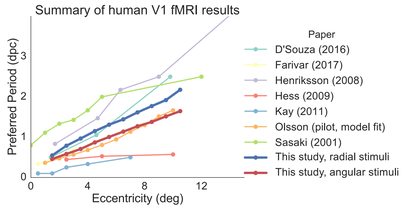


Trends are broadly similar across subjects, though two are **way** noisier



Conventional stimuli give similar, but noisier results





Conclusions & Future Directions

- Because their spatial frequency scales with eccentricity, log-polar gratings allow for a more efficient estimation of spatial frequency tuning
- V1 spatial frequency preferences scale as the inverse of eccentricity, at approximately the same rate as V1 receptive field size
- Subjects all show approximately this pattern, though data quality varies greatly

- Model response in each voxel as an anisotropic 2d Gaussian over ω_x and ω_y, allowing us to predict response to additional stimuli (intermediate log-polar stimuli and constant gratings)
- Investigate whether individual differences in noise are due to subjects falling asleep
- Investigate if spatial frequency preferences vary with population receptive field polar angle
- Look into other visual areas