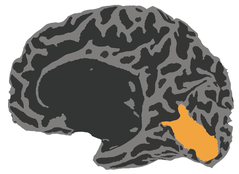
Hierarchical effects of contrast and motion coherence in early visual cortex

Dan Birman, Justin Gardner

Department of Psychology, Stanford University
danbirman@stanford.edu

1. Introduction

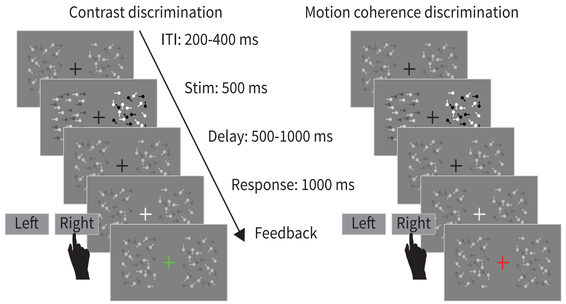
An existing model of contrast discrimination suggests early visual cortex is sufficient to explain behavioral performance[1].



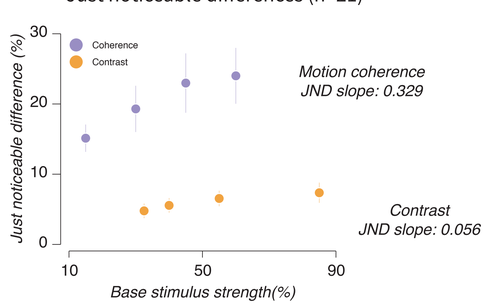
Can that approach be used to jointly explain motion coherence discrimination?

3. Discrimination task

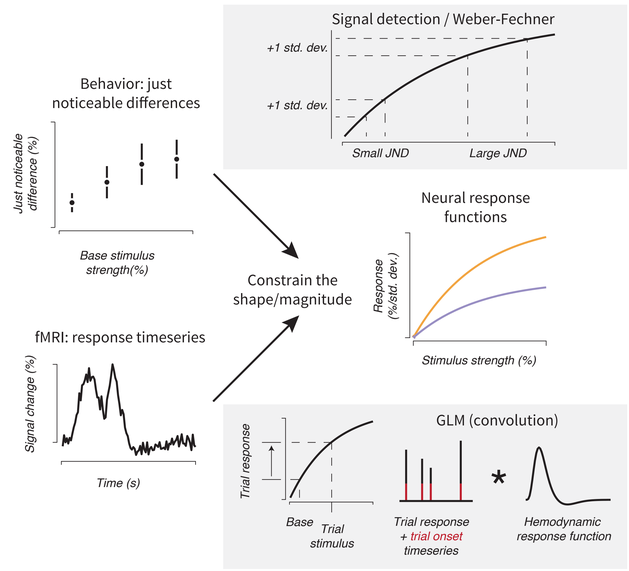
We collected data on how well participants could discriminate small increments in contrast and motion coherence.



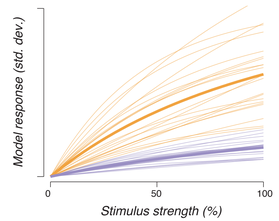
Just noticeable differences (n=21)



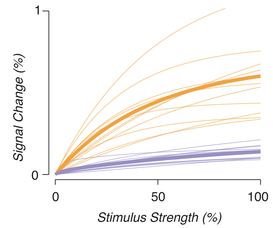
2. Model: neural responses



Contrast and motion coherence response functions constrained by behavior (n=21)

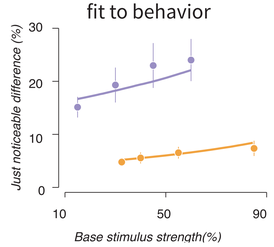


V1 contrast and MT motion coherence response functions constrained by fMRI (n=11)

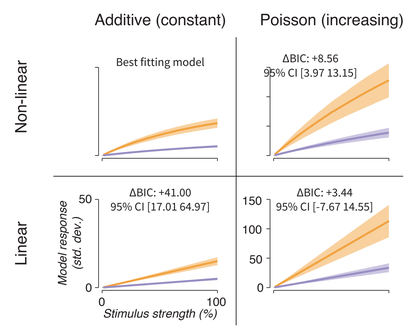


5. Response functions

Non-linear additive model fit to behavior

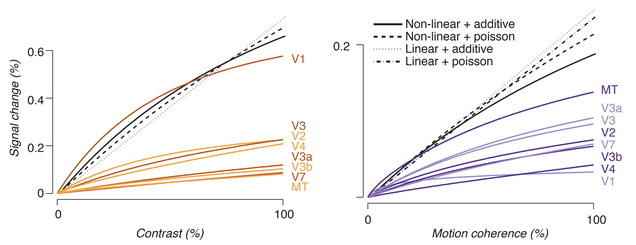


Neural response model variations[3,4]

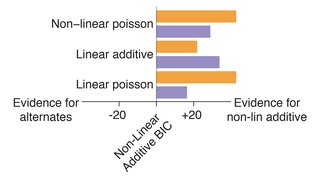


6. Behavior to fMRI

We fit a neural noise[5] parameter to scale response models into the same space. Based on previous work[1] we fit this parameter using the functions constrained on V1 and constrast discrimination.

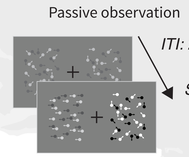


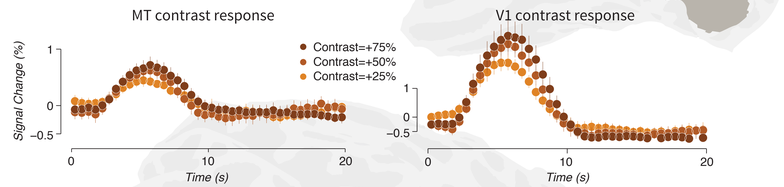
Model comparison of behavioral contrast and motion coherence response models to V1 and MT, respectively

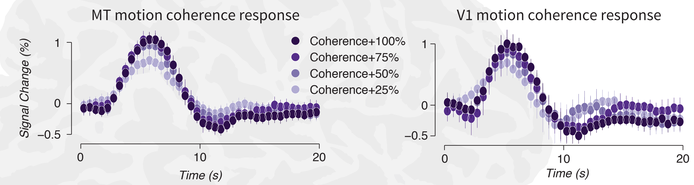


4. Cortical measurements (fMRI)

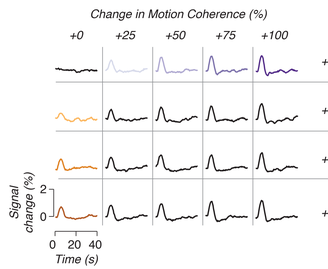
Cortical responses were measured during discrimination and passive observation while performing a fixation task.



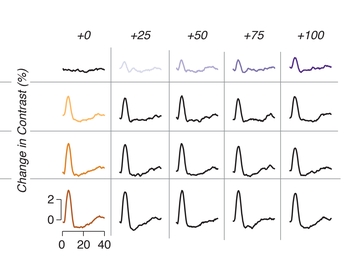




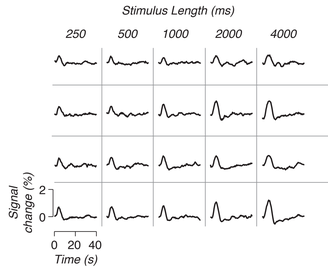
MT Contrast/Coherence Averages



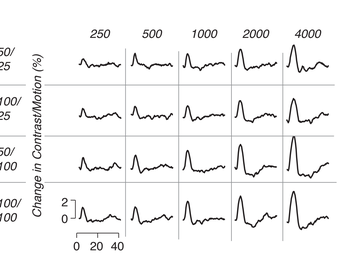
V1 Contrast/Coherence Averages



MT Timing Averages



V1 Timing Averages



All data shows mean ± 95% CI

1. Boynton, G. M., Demb, J. B., Glover, G. H., & Heeger, D. J. *Vision Research* (1999).
2. Non-linear response functions were modeled using an exponential: $Response(s) = \alpha - \alpha e^{-\kappa s}$
3. V5/MT is thought to respond linearly to increasing motion coherence (see also 4). Rees, G., Friston, K., & Koch, C. *Nature neuroscience* (2000).
4. Simoncelli, E. P., & Heeger, D. J. *Vision Research* (1998).
5. Previous reported values for neural noise in a similar model of contrast discrimination were 0.064% and 0.016% for distributed and focal attention. Pestilli, F., Carrasco, M., Heeger, D. J., & Gardner, J. L. *Neuron* (2011).

Stanford Psychology