An Image-Computable Model of Orientation-Tuned Normalization

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Background

Divisive normalization:

A canonical neural computation that describes how cortical neurons mutually inhibit one another[1].

It remains uncertain what comprises the normalization pool of a given neuron.

Recent studies suggest that normalization depends on feature similarity[2,3]:

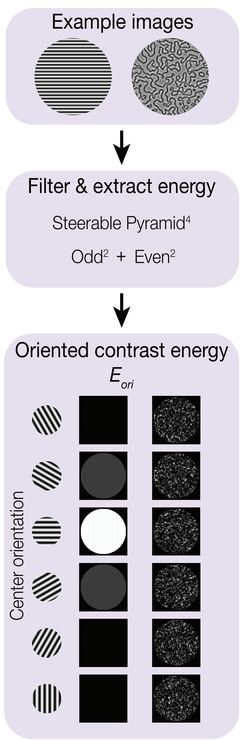
Opposite features Similar features:

Behavioral signature:
Perceived contrast is influenced by feature similarity[2]

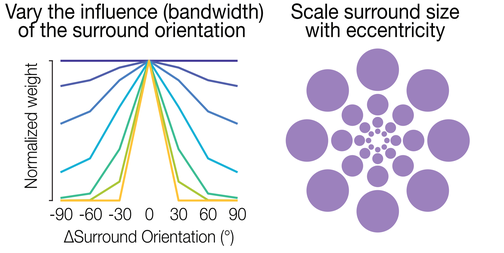
Does normalization depend on all nearby neurons, or are similar features weighted more strongly?

Image Computable Model

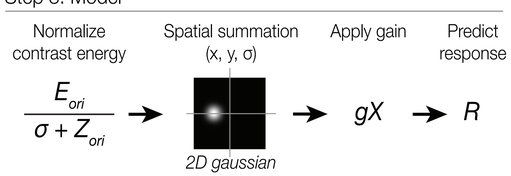
Step 1: Extract contrast energy (E_{ori})



Step 2: Compute normalization pool (Z_{ori})

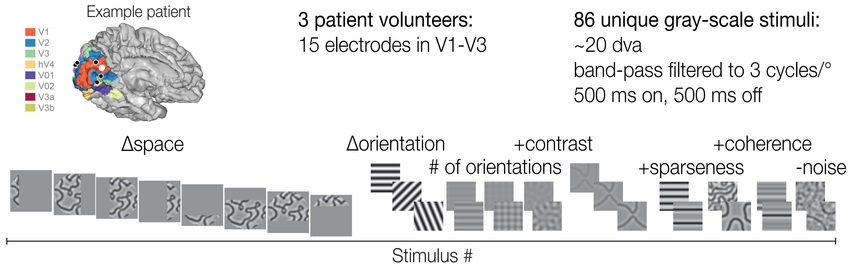


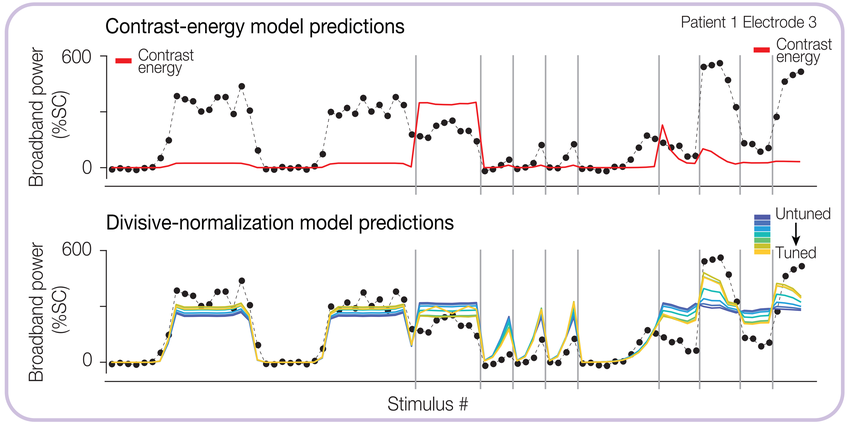
Step 3: Model

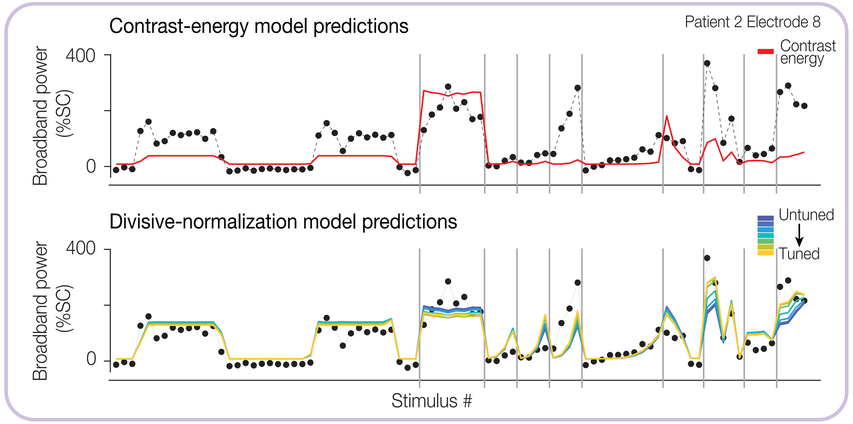


Dataset 1: Hermes et al. 2019[5]

Compute broadband power (50-200Hz) for various band-pass filtered, static images







References

[1]Carandini, & Heeger (2012). *Nat. Rev. Neuroscience*
[2]Bloem, Watanabe, Kibbe & Ling (2018). *Psych. Science*
[3]Fang, Bloem, Olssen, Ma, Winawer (2023). *BioRXiv*
[4]Portilla & Simoncelli (2000). *Int'l Journal of Computer Vision*
[5]Hermes, Petridou, Kay & Winawer (2019). *Elife*
[6]Groen et al. (2022). *J. Neuroscience*

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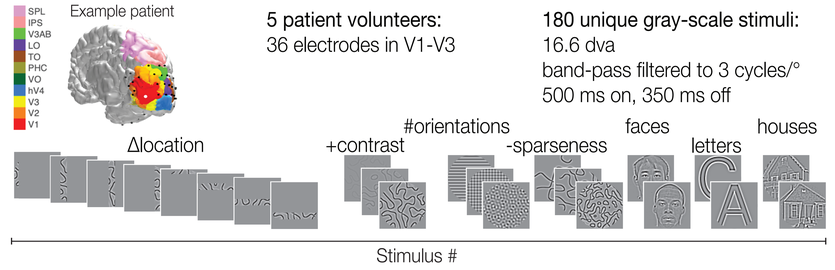
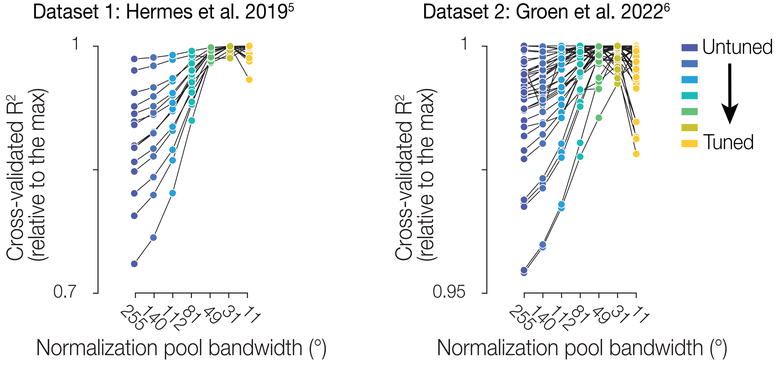
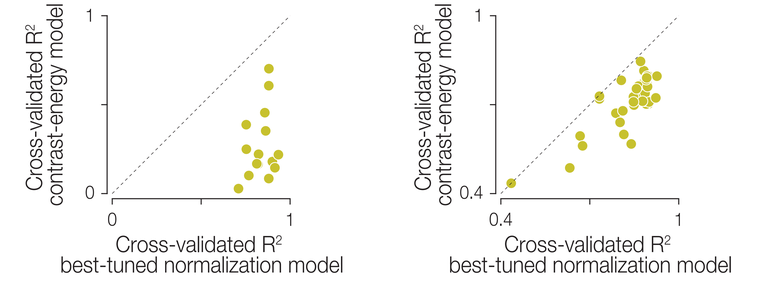
Dataset 2: Groen et al. 2022[6]

Compute broadband power (50-200Hz) for a different set of band-pass filtered, static images



Results: Model comparison for all electrodes across both datasets





Visual responses are best captured by a model that has a tuned normalization pool.

The bandwidth of the tuned normalization pool is ~30°.