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A large-scale realistic model of V1 exhibiting orientation selectivity diversity and laminar dependence

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Background

An important question regarding orientation selectivity (OS) in the primary visual cortex (V1) is to know how OS varies among different V1 neural populations and throughout V1 layers [1,2]. In this work we present a large-scale model highly constrained by physiology and anatomy and use it to address these questions.

Methods

The model corresponds to 4 mm² of cortical area in a 10:1 scale. It is composed of 59,821 cells arranged into six layers (L1, L2/3, L4B, L4C$_{\alpha}$, L5 and L6) representing the M pathway. Six different HH-type neuron models were constructed to simulate six different cell classes: late spiking, non-late spiking, fast spiking, regular spiking, chattering,

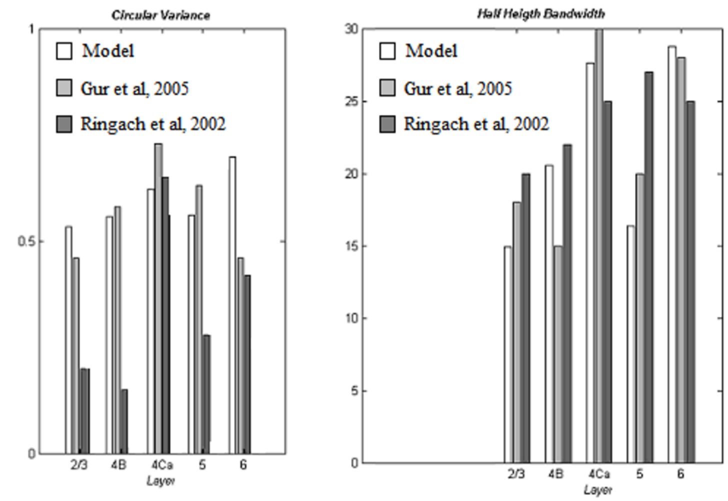

Figure 1
Comparison of the OS profile shown by the model with experimental results.

and bursting neurons. These neurons were distributed in the six layers in a realistic way with short- and long-range intra-laminar connections as well as inter-laminar connections. Thalamic inputs are delivered to all excitatory cells in layers $4C_{\alpha}$ and 6. Activation of a cortical cell is modeled by a convolution of a sinusoidal drifting grating with a Gabor function. Neural OS profile was determined via circular variance and half-height bandwidth of its tuning curve.

Results

Neurons in the model show a diversity of OS consistent with experimental data (see Figure 1).

Conclusion

Results suggest that the diversity in OS observed across cortical layers is at least partially due to heterogeneity in cellular electrophysiology and circuitry properties.

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