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EFFECTS OF LONG-RANGE CONNECTIONS ON GAIN CONTROL IN AN EMERGENT MODEL OF VISUAL CORTICAL ORIENTATION SELECTIVITY.

D. Somers*, S.B. Nelson, and M. Sur, Dept. of Brain and Cognitive Sciences, MIT, Cambridge, MA 02139.

We previously constructed a model visual cortical circuit with short-range (< 300μ) intracortical excitatory and inhibitory connections which yielded emergently sharp orientation selectivity (Somers et al '93). The model predicts a small contribution to orientation tuning from direct inhibitory inputs to single cells, but a substantial contribution from the distributed inhibitory inputs to a cortical column. Intracortical excitation selectively amplifies responses to preferred stimuli, and inhibition primarily regulates the gain of excitatory feedback. Here we demonstrate that cortical gain also depends on stimulus contrast: the gain rises to boost mild suprathreshold stimuli and drops off as stimulus strength increases. This mechanism yields cortical contrast response functions that rise more rapidly and saturate more quickly than do their geniculate inputs.

We have added to our model two forms of longer range cortical connections: very sparse inhibitory inputs from oblique or cross orientations (300 – 600μ) and more extensive excitatory inputs from iso-orientations ($\geq$ 1mm). Long range inhibitory connections comprise less than 20% of inhibitory and less than 5% of all model synapses. Although long-range inhibitory connections are not required to achieve sharp orientation tuning, these connections permit the circuit to maintain sharp orientation selectivity and contrast gain control across the full range of suprathreshold stimulus contrasts (Skottun et al. '87). As in the short-range model, inhibition is strongest at the preferred orientation and has predominately distributed rather than direct effects on tuning. Adding long-range excitatory connections produces biphasic effects that depend on stimulus context. Strong iso-orientation surround stimuli can up- or down-modulate the responses to stimuli within the classical receptive field; responses to subthreshold or weak center stimuli are amplified, while those to strong center stimuli are reduced.

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