Inhibitory stabilization of the cortical network underlies visual surround suppression

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Lateral inhibition is thought to be a universal process that sharpens the tuning of sensory neurons and enhances apparent contrast. According to this principle, a stimulus lateral to a neuron’s preferred stimulus, either in physical space or in feature space, is expected to increase inhibition onto that neuron. In visual cortex, one form of lateral inhibition is surround suppression: stimuli in the receptive field surround suppress the response to stimuli in the receptive field center [1-6]. Unlike the classical examples of lateral inhibition, we find from in vivo intracellular recordings that suppressive stimuli evoke only a transient increase in synaptic inhibition, after which both inhibition and excitation decrease to below their initial levels. From theoretical considerations, these observations suggest that cortex forms an inhibition-stabilized network (ISN) [7], in which strong, recurrent excitatory connections are unstable on their own, and require inhibition for stabilization. The strong excitatory recurrence in ISNs allows the networks to perform complex computations, and yet remain stable enough to respond in a graded way to stimuli of different strengths [8]. Lateral inhibition may thus be implemented through a network mechanism that leads to a reduction in local recurrent excitation together with a paradoxical decrease in synaptic inhibition, rather than the expected increase in inhibition.

Acknowledgments
We thank N. Priebe, C.E. Boudreau, J. Yu, H. Sato, L.F. Abbott, M. Eisele and T. Toyoizumi for comments. This work was supported by grants from the National Institutes of Health (D.F. and K.D.M.). H.O. was partly supported by a JSPS postdoctoral fellowship.

References