Table 1. Conductance-Based Model Parameters

	Parameters
Leak Conductance	g_L = 6 nS; R_L = −50 mV
Excitatory Synaptic Conductance	σ = 45 deg; g_{max} = 5 nS; g_{min} = 3 nS; R_E = 0 mV (see Figure 5)
Inhibitory Synaptic Conductance	σ = 70 deg; g_{max} = 7 nS; g_{min} 6 nS; R_I = −65 mV (see Figure 5)

silencing Pyr responses. So in mice where we did not record from PV cells we used this range of light intensity, i.e., light intensity was set to 0.05–0.1 mW/mm^2, and increased until change in the activity Pyr cells was observed. The population response of the visual cortex to visual stimuli was monitored using local field potential recordings during this process. Light intensities never exceeded 1 mW/mm^2.

When recording from PV cells while photo stimulating Arch or ChR2 (Figure 2) cortical illumination started before the visual stimulus (to monitor the effect on spontaneous activity) and ended before the end of the visual stimulus (to determine the kinetics of recovery to visually evoked firing rates).

Data Analysis

Spontaneous spike rate was calculated as the average firing rate during a 0.5 s period before the presentation of the stimulus. The visual response to a given stimulus was the average rate over the stimulus duration or over the period when both cortical illumination and visual stimulus occurred (1–2 s). Orientation selectivity index (OSI) was calculated as 1 − circular variance (Ringach et al., 1997). Responses to the 12 grating directions were fit with orientation tuning curves i.e., a sum-of-Gaussians (Figures 1, 3, and 4). The Gaussians are forced to peak 180 degrees apart, and to have the same tuning sharpness (σ) but can have unequal height (A_{pref} and A_{null}, to account for direction selectivity), and a constant baseline B. The tuning sharpness was measured as σ $(2 \ln(2))^{1/2}$, i.e., the half-width at half height (HWHH). Direction selectivity index (DSI) was calculated as $(R_{pref} - R_{null}) / (R_{pref} + R_{null})$, where R_{pref} is the response at the preferred direction and R_{null} is the response 180 degrees away from the preferred direction. Contrast-response curves were fit with the hyperbolic ratio equation (Albrecht and Hamilton, 1982): $R(C) = R_{max}\, c^n / (C_{50}{}^n + c^n) + R_{offset}$, where c is contrast, C_{50} is the semisaturation contrast, and n is a fitting exponent that describes the shape of the curve, R_{max} determines the gain, and R_{offset} is the baseline response.

To obtain the threshold-linear fit, we first computed a summary of Pyr cell responses in layer 2/3. The tuning curves of all cells were aligned to the same preferred orientation, a nominal value of 0 degrees and the maximal response was scaled to a nominal value of 100% (Figure 4A). We then plotted the median Pyr cell response measured during the suppression or activation of PV cells against the median response measured in the control condition (Figure 4B). The bootstrapped distribution of median responses was used to calculate errors bars in OSI, DSI, and HWHH. Please see Supplemental Experimental Procedures for more details.

Conductance-Based Model

The membrane potential tuning, or net depolarization, as a function of orientation, θ, was modeled as:

$$\Delta V(\theta) = \frac{g_L R_L + g_E(\theta) R_E + g_I(\theta) R_I}{g_L + g_E(\theta) + g_I(\theta)} - V_r$$

$$g_x = g_{min} + (g_{min} - g_{max})\ e\,\frac{-\theta^2}{2\sigma^2}.$$

Where x is either E (excitation) or I (inhibition); σ is the tuning sharpness; g_{max} and g_{min} are the conductances at preferred and nonpreferred orientation (see Table 1). R is the reversal potential of the respective conductance. V_r (−50mV) is the cell's resting potential.

The firing rate was computed as $[\Delta V(\theta) - V_{thres}]^n{}_+$, where V_{thres}, the spike threshold, was 4mV (relative to rest) and exponent n was 3 (Priebe et al., 2004). The subscript "+" indicates rectification, i.e., that values below zero were set to zero.

The tuning properties of excitatory and inhibitory synaptic conductances (i.e., σ, g_{min}, g_{max}) in layer 2/3 Pyr cells were determined using whole-cell recordings voltage-clamp configuration where cells were held at the reversal potential for inhibition and excitation, respectively. The average visually evoked conductance was then determined for each of the six orientation of drifting gratings presented (Figure 5C). The result was fit with a Gaussian, g_X.

Statistical significance was determined using the Wilcoxon sign rank, and rank sum tests where appropriate.

SUPPLEMENTAL INFORMATION

Supplemental Information includes Supplemental Experimental Procedures and five figures and can be found with this article online at doi:10.1016/j.neuron.2011.12.013.

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