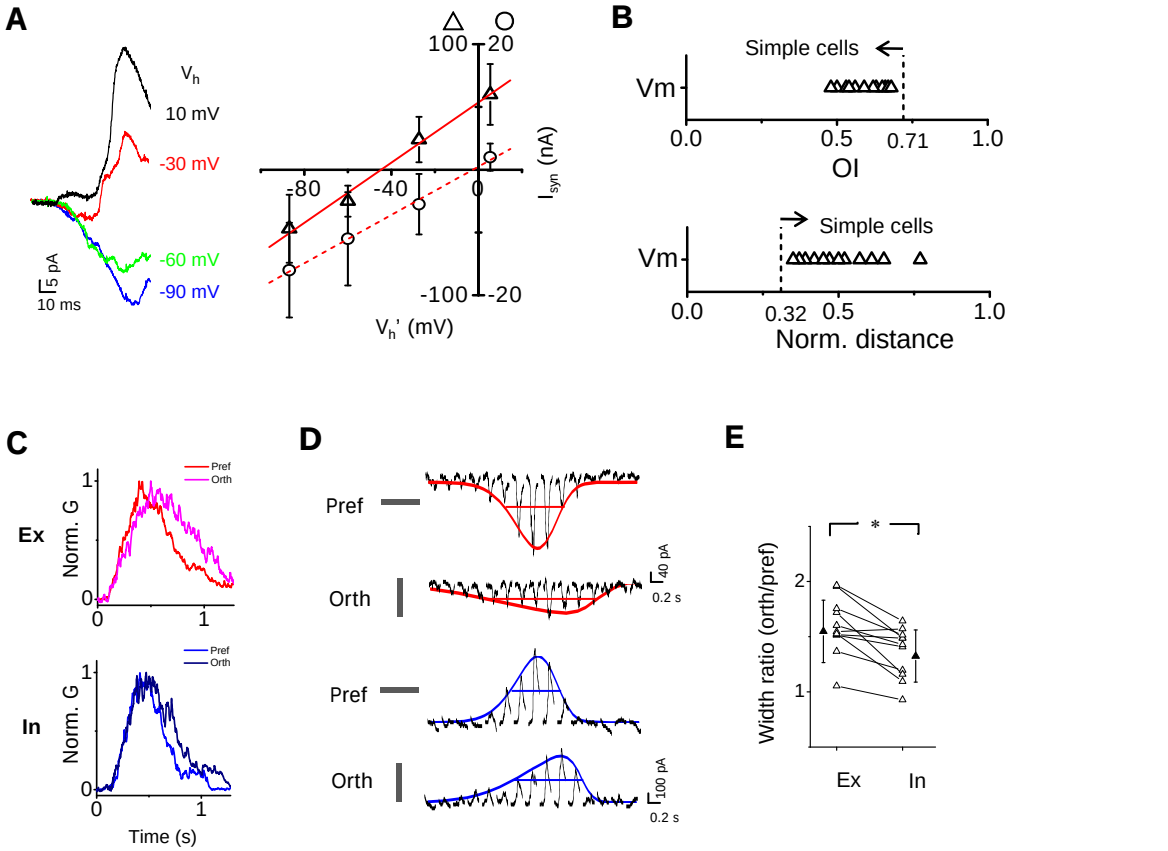

Figure S1: (**A**) Left, average synaptic currents measured with noise stimulation and recorded under various holding potentials (V_h) in an example cell. Right, I-V curves for synaptic currents measured at 15ms (circle) and 55ms (triangle) after the onset of excitatory synaptic response. V_h' is the corrected holding potential. Error bar = SD. (**B**) Distribution of overlap indices (OI, top) and normalized distances (bottom) for On and Off subfields of membrane depolarization responses (Vm) of 12 recorded simple cells, measured with flashing bars at preferred orientation. The criteria of OI<0.71 and normalized distance>0.32, marked by dash lines, were used to identify simple cells according to Liu et al, 2010. (**C**) Superimposed normalized excitatory (top) and inhibitory (bottom) conductances evoked by drifting bars at preferred and orthogonal orientations. (**D**) Excitatory (top) and inhibitory (bottom) responses to bright flashing bars at preferred orientation and orthogonal orientations in the same cell as shown in Figure 2. Each pixel represents 3.5º. The envelop of peak response amplitudes was fitted with a skew-normal distribution (red and blue curves). Red and blue lines mark the bandwidths at half-height. (**E**) The ratio between the bandwidths at half-height of the spatial tuning curves measured with bars at orthogonal and preferred orientations (orth/pref). *, $p < 0.005$, paired t-test, n=11. (Associated with **Figure 2**)

Reference:

Liu, B. H., Li, P., Sun, Y. J., Li, Y. T., Zhang, L. I. & Tao, H. W. Intervening inhibition underlies simple-cell receptive field structure in visual cortex. *Nat. Neurosci.* **13**, 89-96 (2010).

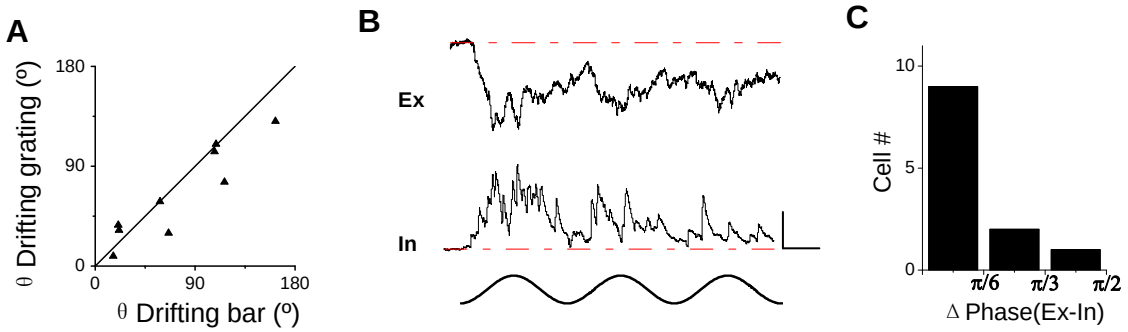

Figure S2: (**A**) The preferred orientation measured with drifting gratings vs. that with drifting bars. Black line is the identity line. (**B**) Traces of excitatory (top) and inhibitory (bottom) currents to a drifting sinusoidal grating at preferred orientation in an example simple cell. The sinusoidal wave marks the cycles of illumination. Scale: 0.11 (Ex)/0.3 (In) nA, 200ms. (**C**) Distribution of the difference in temporal phase between excitatory and inhibitory responses (Exc-Inh) in simple cells. The temporal phase was measured by performing Fourier transformation. In most of recorded simple cells excitation and inhibition are temporally in phase. Note that responses to gratings include those to both On and Off stimuli, thus are different from responses to single drifting bras. (Associated with **Figure 3**)

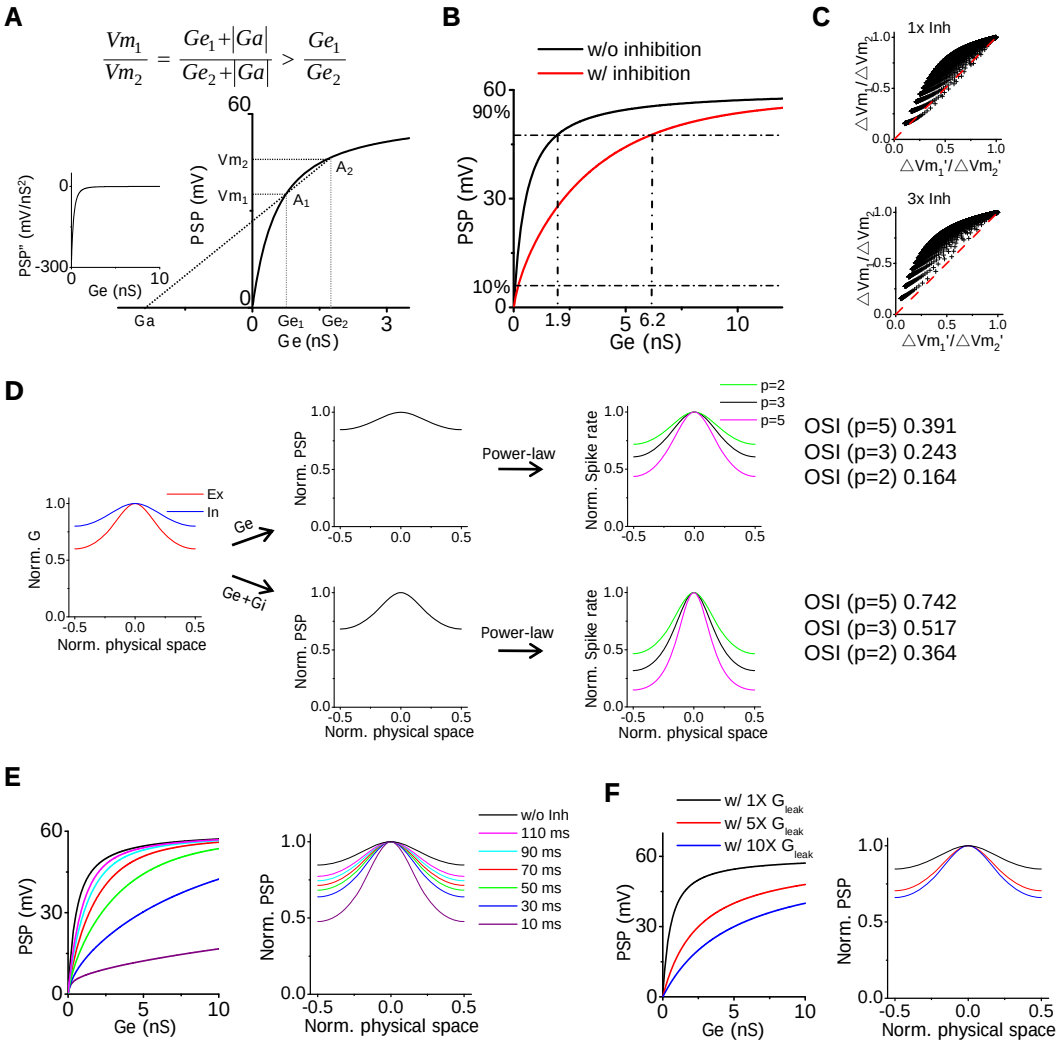

Figure S3: (**A**) Geometry determines that $Vm_1/Vm_2 > Ge_1/Ge_2$ (with $Ge_1 < Ge_2$) always holds true for the Vm-Ge relation in the absence of inhibition. The fist-order and second-order derivatives (Inset) of the Vm-Ge relation indicate that it is a convex curve. Thus, the x-intercept of the line connecting A_1 and A_2, Ga, will always be negative. (**B**) Inhibition expands the dynamic range of excitatory inputs by about 3 folds. Here, the dynamic range was defined as the range of excitatory conductance that corresponds to PSP response from 10% to 80% of maximum, as marked by dash lines. (**C**) 1X and 3X inhibition ameliorates the attenuation of selectivity, as shown by plot of ratio between membrane potential responses to optimal and orthogonal orientations in the absence of inhibition versus that in the presence of inhibition. (**D**) Transformation under power law spike thresholding schemes. Left, tuning curves of exciation and inhibition. Middle, tuning curves of PSP responses in the absence (top) and presence (bottom) of inhibition. Right, tuning curves of spike responses in the absence (top) and presence (bottom) of inhibition. Three exponents (p) were used. Note that the spike tuning is sharper with inhibition compared to without inhibition. (**E**) The dependence of input-output relation (left) and orientation tuning (right) on the relative onset latency of inhibition. The tunings of excitation and inhibition are the same as in (**C**). (**F**) The effect of increasing leakage conductance only (without synaptic inhibition). Left, input-output curve. Right, orientation tuning curve. (Associated with **Figure 4**)