Supplementary Figure 1. The component mean predicts responses to multiple orientations across a range of spatial frequencies. (a) PRPs for one animal derived from the standard stationary stimulus, with each grating composed of 0.25° lines separated by 3°. Responses to single gratings at 70° and 110° are shown in black and gray, respectively; responses to the superimposed pair are shown in red, while the component mean is shown in blue. (b) PRPs from the same animal evoked by gratings composed of 0.25° lines separated by 1.5°. (c) PRPs evoked by 1.5° lines separated by 3°.
Supplementary Figure 2. The component governs response to multiple orientations only where both orientation are locally “visible”. (a,b) Responses evoked in one animal by single lines 0.25° wide, oriented at 70° and 110°, respectively. Temporal parameters of the stimulus were identical to gratings. (c) Response evoked by simultaneous presentation of both lines. (d) Response evoked by a Gabor patch 3° wide at the screen location of the crossing point between the the lines in c. (e) To assess the spatial scale over which the component mean predicted responses to two simultaneous orientations, we computed a statistic that related the response of each pixel to the paired lines $R_{\text{Pair}}$, to the responses evoked by each single line, $R_{70}$ and $R_{110}$. The Normalized Departure from the Mean (NDM) was calculated as $[(R_{\text{Pair}} - (R_{70}+R_{110})/2) / |R_{70} - R_{110}|]$. An NDM value of 0 means a pixel’s response to the paired lines was exactly equal to the average of the responses to each single line. Values of 0.5 and -0.5 denote responses that were equal to that evoked by the 70° and 110° lines, respectively. NDM values were close to 0 within roughly 1mm of the cortical representation of the crossing point. Because regions of cortex where none of the stimuli evoked any response also had NDM values close to 0, the NDM map has been cropped to include only those areas that were activated by the lines, and to excise blood vessels.
**Supplementary Figure 3.** Within a single neuron, the component mean predicts both spiking activity and membrane potential. Spiking and membrane potential responses to superimposed gratings are plotted with respect to the sum of responses to corresponding single gratings, for one neuron. Each datum represents one of the 28 superimposed grating pairs in our stimulus set. Consistent with data from separate populations of extra- and intracellularly recorded neurons, regression lines (red) for both spiking and membrane responses had slopes very close to 0.5. R² values were 0.79 for \( V_m \) and 0.54 for spike rate. Both spike rate and membrane potential were averaged during a 200ms window starting 50ms following stimulus onset that captured the peaks of both depolarization and spike density.
**Supplementary Figure 4.** Schematic figure showing how divisive suppression allows stimulus orientation spectrum and strength to be independently encoded by the population response. (a) For a single grating, reducing contrast from high (darkest line) to low (lightest line) shrinks the area under the curve (AUC) defining population activity, while leaving the shape of the distribution unchanged. (b-d) For any pair of superimposed gratings, the shape of the distribution differs according to their orientation spectrum, but divisive suppression dictates that the area under the population curve (red lines) remains the same as the area for a single grating (black). Because the component mean predicts responses to superimposed gratings at all contrasts, it permits stimulus strength to be “read out” from AUC according to a single rule regardless of the number and identity of orientations present.
Supplementary Figure 5. Contrast response function derived from a single imaging session in one animal. Each point represents the area under the PRP for a single grating presented at the contrast shown. The area of each PRP was computed by first subtracting the minimum value from each point in that PRP, and then evaluating the integral of a circular Gaussian function fit to the results. Areas were normalized to the maximum across all contrasts. Data are fit with a Naka-Rushton function, with parameters $c_{50} = 0.24 \pm 0.13$ and $n = 1.24 \pm 0.35$. 
Supplementary Figure 6. A square-wave grating with 3° degree separation produces uniform activation across the map of visual space in V1. (a) Single-condition image evoked in one animal by a full-field rectangle-wave grating composed of 0.25° lines separated by 3°. (b) To ensure that the 3° separation produced uniform activation of cortex, we also acquired images using another grating composed of 0.25° lines separated by 1.5°. (c) If the 3° separation left some regions of V1 understimulated, subtracting a from b should reveal periodic dark stripes, corresponding to activity evoked by the “extra” lines in the 1.5° stimulus. Instead, subtracting a from b produces a image devoid of any visible signal modulation. Each image is ΔR/R based on subtraction of a frame acquired immediately prior to stimulus onset. No filtering was applied.
Supplementary Figure 7. An 8-second interstimulus interval (ISI) is sufficient to allow stimulus-evoked optical signals to decay to baseline. To assess whether images collected during presentation of a given stimulus carried information about the previous stimulus, we examined the time course of optical signal during a blank condition that was interleaved among stimulus conditions. Because the blank stimulus was a gray screen identical to that displayed during the (ISI), it can be thought of as an “extended ISI” that should reveal the continuing decay of any signal still present from the preceding stimulus. The black squares show $\Delta R/R$ averaged across all of V1 in a series of 500 ms frames starting with the beginning of the blank period, exactly 8 second following offset of the previous stimulus. We observe essentially no change in reflectance during this period, particularly compared to the response evoked by a single grating, shown in red. We conclude from this that the ISI was of sufficient duration to allow virtually complete decay of signal evoked by the previous stimulus.