SUPPLEMENTARY METHODS

Analysis of imaging data. Images obtained by optical imaging were 655 x 480 pixels in resolution. Raw data images were acquired at 12 bits per pixel and were clipped to 8 bits (pixel values 0 to 255) for presentation and further analysis. Clipping was done on a case-by-case basis in order to maximize the signal for that position while ensuring that not more than a few pixels were saturated (pixel values > 255 or < 0). Typically, values of mean ± 0.8 standard deviations up to mean ± 2.0 standard deviations in the raw data images were assigned to the values 0 to 255, and values outside this range were clipped to 0 or 255, respectively. For most animals, and for all images presented in this paper except **Fig. 5c**, the camera lens combination used resulted in an ultimate resolution of either 75 or 150 pixels/mm. For the imaging case shown in **Fig. 5c**, the final resolution was approximately 400 pixels/mm. In order to preserve the entire response to the bar, no filtering of signals that varied slowly across the cortical surface was performed. To help reduce vascular artifacts in the optical imaging data for position preference, we used a mask filtering procedure[1] using a mask drawn from a reference image taken during the experiment. This procedure selectively filters the raw images in locations known to be directly beneath or in the immediate vicinity of blood vessels. The grayscale value of each pixel in these locations was replaced by the mean of pixels in the surrounding region. After mask filtering, high frequency noise in the images was reduced by mean filtering using a 15 x 15 pixel kernel (40 x 40 for data shown in **Fig. 5c)**.

To evaluate the minimal separation distance at which reliable shifts in the population response occur, we determined the chi square values for each separation distance and used linear regression to estimate the separation distance at which the difference between the population response profiles failed to reach statistical significance.

Generation of artificial maps. Artificial maps of visual space were generated so as to have rate of change in position preference be either inversely or positively correlated with the rate of change in orientation preference along a particular axis (**Supplementary Fig. 3**). Artificial maps were constrained to map 8° of visual space on each axis within a distance of 1.6 mm. This resulted in a base magnification factor for the artificial maps that is similar to the average magnification factor we obtained for our real data (200 μm/°). Every pixel in the first row of the artificial maps was assigned a position preference of 0°. Position preferences for the next row were determined by assessing the rate of change in orientation preference at the corresponding location in the orientation preference map. We set the correlations between maps so that a local variation of 1 standard deviation away from the mean rate of change in orientation preference produced a rate of change for position preference that was 3 standard deviations away from the base magnification factor. Note that this setting results in large changes in position preference comparable to those seen in cat visual cortex; i.e., receptive field-sized changes found over distances of 100–200 μm[2,3].

Sources of error in electrophysiological recordings. Electrophysiological determination of the preferred position of a site is subject to several sources of error that are not present for optical imaging, including small errors in placement of the electrode and the ability to detect spiking neurons that are some distance away from the electrode. Because such errors would affect our ability to assess the regular progression of receptive field locations observed from serial recording with electrodes, we have attempted to arrive at a reasonable estimate of the quantitative effects of such errors. Assuming that we were able to place the electrode within 50

μm of the intended target and that the electrode can record spikes from neurons up to 100 μm away[4], the total possible error in location of the recorded neurons is 150 μm. At the magnification factor for central visual space in the tree shrew, this results in a possible error in preferred position of ± 0.75°. In addition, we assume that the full-width of scatter in receptive field centers (or position preference) is equal to one half of the average full-width of our position turning curves[5] (approximately 2.5°). By combining these sources of errors, we would predict that when recording from a single neuron or small group of neurons we would encounter preferred positions that could differ from the preferred position determined by the optical imaging by as much as ± 2° at each site (**Fig. 5d**).

References

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