Supplemental Figure 1:

The *black line* in panel A shows the average geometric mean firing rate for pairs of neurons (n=4488) recorded from electrodes at different separations. There was a slight decline in firing rate with distance. In order to determine if the change in rate with distance was related to the changes in r_{sc}, we chose a subset of the pairs from each bin such that the average rate for that bin matched the value for nearby neurons. After this procedure, the rate for the remaining pairs was the same at all distances (*red line*). We calculated r_{sc} for pairs of neurons in the full data set (*black line*, panel B) and in the rate-matched data set (*red line*, panel B). The curves are nearly identical before and after the rate correction. In panels C and D we show the same analysis for the dependence of r_{sc} on r_{signal}. In this case, firing rate was high for pairs of neurons with r_{signal} near 1 or -1. The high rate for neurons with r_{signal} near -1 (i.e. with opposite preferences) occurs because those neurons have broad tuning and therefore have higher average firing rates across the range of orientations; pairs of narrowly-tuned cells with opposite preferences have r_{signal} that rarely drop below -0.2 since both neurons fail to fire to many of the stimuli. We found that r_{sc} was higher for neurons with similar orientation preferences before and after the rate correction (*black* and *red lines* in panel D). In the case of both distance and r_{signal}, there is an increase in r_{sc} (when there is any change at all) after the rate correction. This is likely due to the removal of very low firing rate pairs, which tend to have low r_{sc} values because many of the trials contain no spikes.

To confirm that the larger r_{sc} we observed in the spontaneous activity could not be explained by a difference in firing rate, we also measured the influence of firing rate on r_{sc} in the spontaneous and evoked data. We calculated r_{sc} for all pairs of neurons which met our SNR criterion (see *Methods*), regardless of firing rate. We then adjusted the rate threshold from 0 to 10 sp/s in increments of 0.5 (21 steps), and calculated r_{sc} for the pairs in which both neurons exceeded that threshold. The two lines in panel E show the average r_{sc} as a function of mean firing rate for pairs of neurons which met each of the 21 rate thresholds. Each point represents a single threshold, with the lowest threshold, 0 sp/s, on the left of the panel. We observed an increase in r_{sc} with firing rate for both spontaneous and evoked data. However, for all of the threshold settings, the value of r_{sc} in the spontaneous data (*blue line*) was much higher than in the evoked data (*black line*). Overall, this analysis shows that the changes in correlation with distance and r_{signal}, as well as between spontaneous and evoked activity, can not be explained by changes in the firing rate among neuronal pairs.
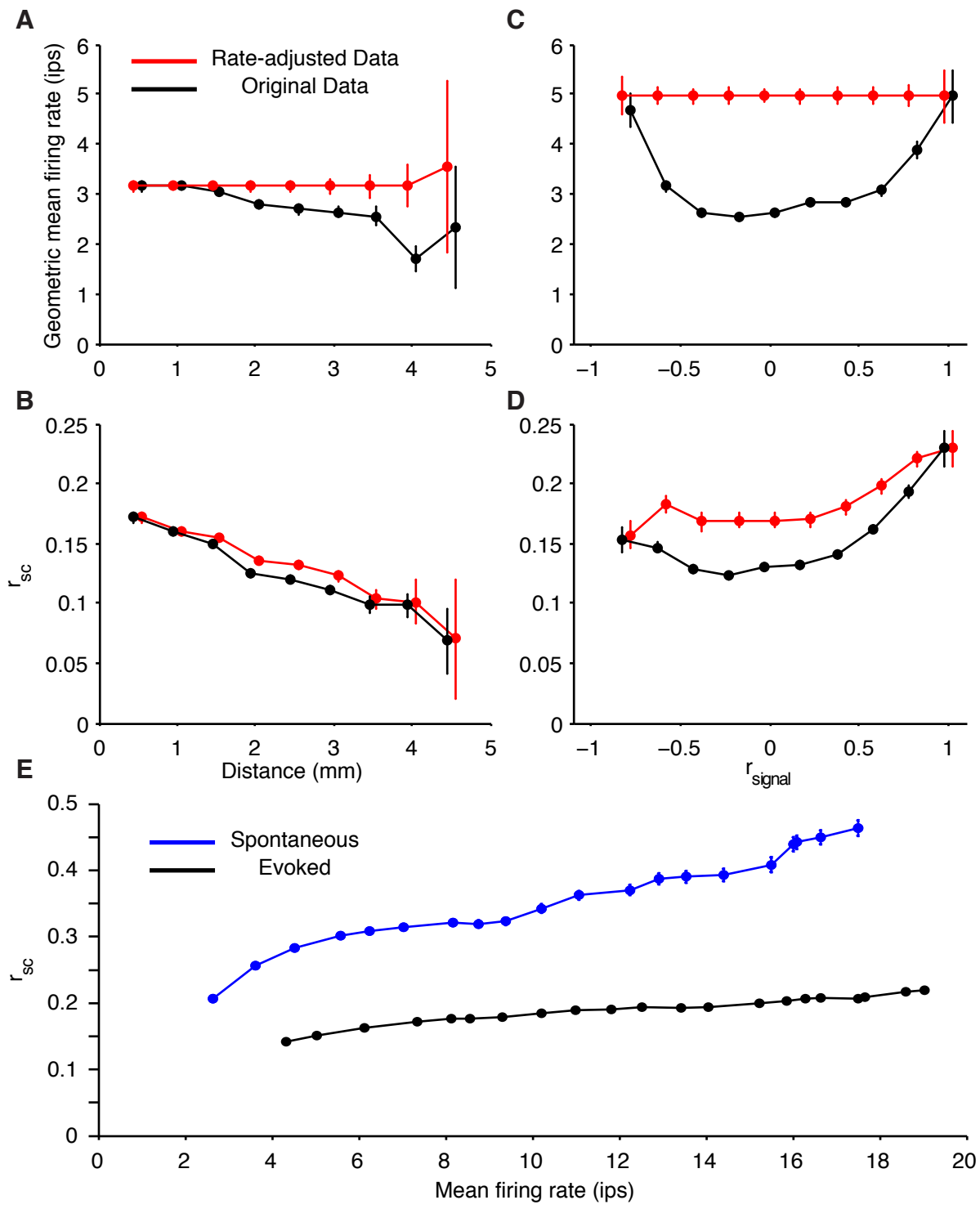
Figure 1: Smith and Kohn (Supplemental)

Supplemental Figure 2:
We have previously found that synchrony is stimulus dependent. Specifically, the magnitude of synchrony is greatest for orientations that are effective in driving the pair of neurons well, and is reduced for orientations that are ineffective (Kohn and Smith, 2005; see also Samonds and Bonds, 2005). We analyzed our data to determine if that effect was maintained over distance. For each pair of neurons, we calculated a CCG for each of the 12 stimulus orientations. We then sorted those 12 CCGs based on the geometric mean firing rate each stimulus evoked in the pair of neurons. In Figure 2A–D, we show the average CCGs (created in the same way as in Figure 5A) for each of those 12 stimulus orientations for pairs of neurons divided into four distance groups (500 μm bins centered on the values shown at the top of each panel). The tick marks to the left of the CCGs indicate a value of 0 coinc./sp. The tick marks at the bottom of the CCGs indicate zero time lag.

We found that synchrony was stimulus dependent for nearby neurons, as in our previous data. This dependence was also evident at longer distances (1.0–2.0 mm): at all distances in which we observed synchronous activity, the most effective stimuli evoked the strongest synchrony. At distances greater than 2.0 mm (not shown), no peak was evident in the average CCGs. Thus, the spatial extent of synchrony was limited to short distances, even when choosing for each pair the particular orientation that evoked the strongest response and synchrony. We did not observe, in either the average CCGs or in the subset of CCGs with a significant peak near zero, substantial long-range synchrony to any stimulus orientation.
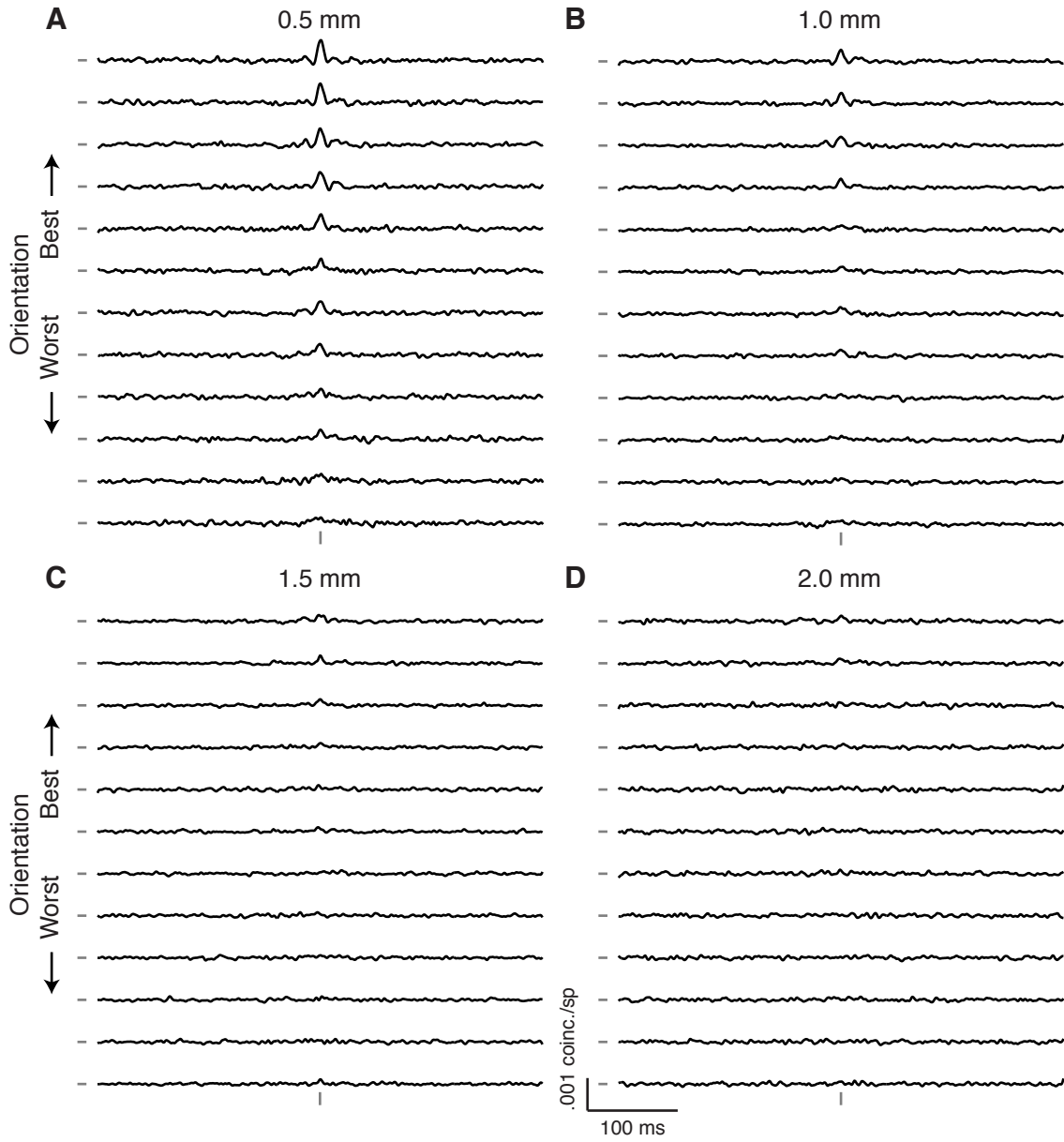
Figure 2: Smith and Kohn (Supplemental)

Supplemental Figure 3:

In addition to distance and r_{signal}, we analyzed the effect of stimulus orientation on correlated variability. Using the same analysis described above for synchrony, we calculated r_{sc} separately for each of the 12 stimulus orientations and sorted the 12 r_{sc} values based on the effectiveness of each stimulus in driving the pair. We analyzed these data in the same manner as the grouped r_{sc}, shown in Figure 3C. Color plots of the dependence of r_{sc} on distance and tuning similarity, for the most and least effective of the 12 orientations, are shown in Figure 3A and B, respectively. We found that r_{sc} was higher for stimuli that drove a pair of neurons more strongly. The average r_{sc} across all bins was reduced by 34% between the best and worst stimulus (panels A and B), whereas the firing rate decreased by 76% for the same comparison. Correlated variability has a similar structure for effective and ineffective orientations.

It is important to note that the plots in Figure 3 are an artificial construct, based on choosing a different best and worst stimulus for each pair of neurons. No single stimulus would evoke the correlation structure in either plot. Defining the best and worst stimulus condition on the basis of the population response as a whole would result in the correlation structure presented in the main text (Figure 3).

In previous work, we found for nearby ($< 500\mu$m) neurons that correlated variability was not altered by stimulus orientation (Kohn and Smith, 2005). Here, we find a 34% difference in r_{sc} between the best and worst orientations. This difference can be largely explained by the influence of low firing rate neurons on measurements of spiking variability (de la Rocha et al., 2007). In our recordings from nearby neurons (Kohn and Smith, 2005), we measured r_{sc} for activity evoked by 5 orientations which spanned the tuning curves of each pair. The spatial frequency, temporal frequency, size and position were chosen to optimize the response of each pair. The geometric mean firing rate, across all pairs, ranged from 42 sp/s to 12 sp/s from the best to worst orientation. In the data reported here, we used a set of 12 orientations spaced equally over 360 degrees. The stimuli were not optimized to individual pairs of neurons, and the geometric mean firing rates were thus much lower (ranged from 7.7 sp/s to 2.2 sp/s for best to worst orientation). Comparing the results across the two studies, r_{sc} varied from 0.18 for an optimized stimulus that evoked a firing rate of 42 sp/s (Kohn and Smith, 2005) to 0.17 for non-optimized stimuli that evoked a firing rate of 2.2 sp/s (left column of Figure 3B representing cells separated by less than 0.75 mm).

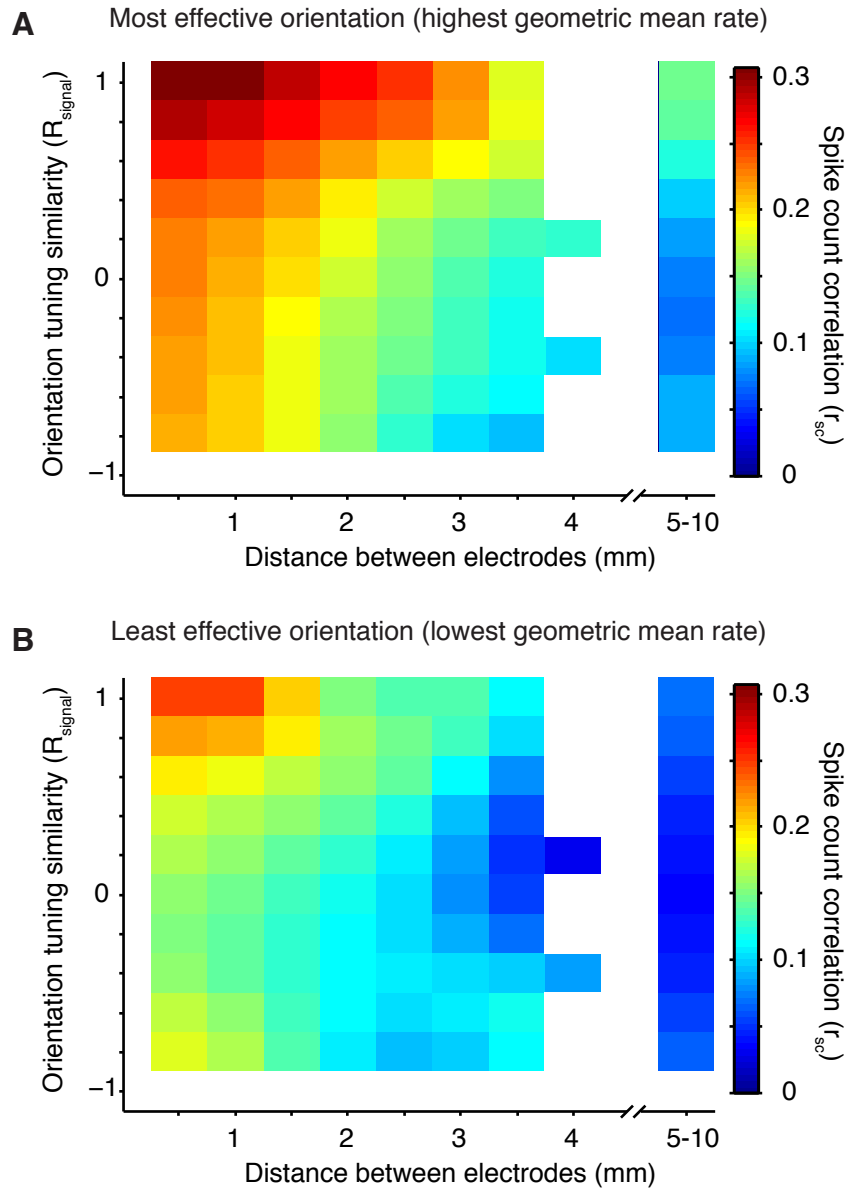**A** Most effective orientation (highest geometric mean rate)

B Least effective orientation (lowest geometric mean rate)

Figure 3: Smith and Kohn (Supplemental)