Attention-dependent reductions in response variability in macaque area V4 can be accounted for by changes in spike power spectra and burstiness

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We recently reported that directing attention to a sustained stimulus in the receptive field of macaque area V4 neurons reduces their response variability, as measured by the Fano Factor (Mitchell et. al., Neuron, 2007). Here we examine several properties of neuronal spiking that could be altered by attention to cause the observed changes in response variability including: 1) changes in the firing rate from trial to trial, 2) increases in firing rate with attention that impose regularity in spiking due to the spike refractory period, and 3) fluctuations in firing rate within trials as indicated by changes in power spectrum. The first two factors account for only a modest fraction of the reduction in variability. The third factor, fluctuations of rate within trials at frequencies <10Hz, accounts for most of the observed attention-dependent reduction in variability. Additionally, there is a significant reduction in the spike-LFP coherence at the lower frequencies, suggesting that these reductions reflect reductions in synchronous low frequency oscillations across the population.

We also examined how attention dependent reductions in variability differ between cell classes. Studies in cortical slices have found that parvalbumin-expressing inhibitory interneurons can be distinguished from pyramidal neurons on the basis of their shorter action potential duration. As reported in Mitchell et al. (2007), the distribution of action potential widths in macaque area V4 is clearly bimodal. Narrow spiking neurons, putative interneurons, exhibit a reduction in response variability that is more than twofold stronger than broad spiking neurons, putative pyramidal neurons. Correspondingly, narrow spiking neurons also show a stronger reduction in the low frequency spike power. The two classes also differ in the degree to which they exhibit burstiness in spiking. Broad spiking neurons more frequently exhibit bursts as indexed by larger peaks at short inter-spike intervals in their spike auto-correlation (ISI’s < 8ms). Among those neurons with burst firing, there is a significant reduction in the burstiness of firing when attention is directed to the stimulus in the receptive field.