Spike count distributions, factorability, and contextual effects in area V1

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A challenging issue in computational sensory processing is understanding how neurons combine information across different contexts. We specifically focus on visual spatial integration of color in monkey primary visual cortex (area V1). It has been documented that the response of a neuron to an optimal center stimulus can be nonlinearly modulated by a surround stimulus that by itself exerts no response in the neuron. However, the computational nature of this interaction for a range of center and surround stimuli (i.e., not only center optimal) is not well understood.

Neural responses are often analyzed according to the mean firing rate. But when a neuron is presented with multiple stimulus repeats, one can characterize a full spike count distribution. Indeed, Movellan et al. (NIPS, 2002) have recently demonstrated that examination of the spike count distribution can provide insight into how center and surround color information are combined in V1 neurons. Specifically, the probability of spike counts given a center and surround, could be well fit by a model that factorizes into a component selectively determined by the center, and a component selectively determined by the surround. Stated differently, every bin of the spike count distribution is factorable, even though the overall mean response rate is not necessarily factorable.

The model constitutes a general statistical framework with a large number of free parameters. We also explore a simplified model, with significantly fewer parameters, that adheres to this form of factorability. We test the goodness of fit for the different models. This line of work suggests a computational principle for context integration that is experimentally testable in other neural areas, and poses theoretical questions about neural coding.