Attention in V4: A biophysical model

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When a monkey pays attention to a stimulus inside the receptive field (RF) of a V4 neuron, there is an increase in the firing rate \textsuperscript{[1]}, an increase in the local field potential (LFP) power and spike-LFP coherence in the gamma frequency range \textsuperscript{[2]}. Attention is transferred by top-down inputs, presumably coming from prefrontal areas including the frontal eye field (FEF) \textsuperscript{[3]}. In this direction, recent experiments have shown the existence of precise links between FEF and V4 dynamics during attention \textsuperscript{[4]}. These top-down inputs, produced by cortical feedback connections, are presumably excitatory and drive pyramidal neurons \textsuperscript{[5]}. Using a computational modeling approach, our goal is to find by which mechanisms such top-down inputs can produce the observed attentional effects.

Our biophysical model of V4 consists of networks of pyramidal neurons and interneurons, interconnected with AMPA, NMDA and GABA\textsubscript{A} synapses and receiving stimulus and attentional inputs. The gamma range oscillations of the LFP imply a certain level of firing synchrony in the V4 network, which is nevertheless relatively weak \textsuperscript{[2]}. A network of inhibitory neurons interconnected by GABA\textsubscript{A} synapses is known to show gamma frequency oscillation for a wide range of noise levels, provided recurrent inhibition is sufficiently strong \textsuperscript{[6]}. Furthermore, a synchrony increase in the inhibitory inputs to a neuron has been shown to reproduce firing biases as in attention experiments \textsuperscript{[7]}. We propose here that the V4 network is in a dynamical state where pyramidal neurons are close to asynchrony and where local interneurons -associated to the locus of attention in the RF- increase their level of synchrony in the gamma range with attention. The interneurons receive slow (NMDA) and fast (AMPA) synaptic currents from pyramidal neurons that combine into a slowly varying noisy input. We show that the changes in this input, induced by an attentional signal, can enhance the level of interneuron synchrony.

References


