Background
Saccades play a fundamental role in visual processing, beyond the obvious role in directing the gaze. During free viewing, saccades occur on average 3 times a second in primates, and they evoke transient responses in V1 neurons [1-7]. Saccades also modulate V1 local field potentials (LFPs) [5-6], which are known to correspond to fluctuations in cortical excitability on multiple time scales [6-9], and which are themselves modulated by the visual input [13-18]. Thus, these studies suggest a complex set of interactions between the retinal input, V1 network activity, and single unit activity that is likely important for understanding V1 processing of natural vision.

Here, we seek to better understand how saccades shape cortical processing in terms of their effects on V1 ‘network’ activity, coupled with models describing how units are modulated by the stimulus and network activity.

Methods
Two monkeys viewed a natural images in a free viewing setup. The spatial component of the model was given by a Gabor energy. The temporal component was modulated by a complex Morlet mother wavelet (with degrees eccentricity).

Organization of V1 activity by saccade-evoked network activity

Conclusions
Here we use the LFP in different frequency bands as a proxy for underlying network state. The observed relationship between LFPs and neuronal firing rates suggests an important role of network modulation in structuring neural activity in V1.

The relationship between LFP and unit activity during free viewing is most prominent in the alpha (~10 Hz) and gamma bands (20-50 Hz), and mostly at nearby depths, although LFPs at other depths also contribute.

The low-frequency (~20 Hz) LFP in V1 are stimulus (image)-dependent, with stimulus modulation of ~400-500 ms.

While the LFP in the gamma band is not phase-locked to saccade onset, the envelope of gamma power is consistent with modulation throughout the ‘fixation’ period.

Both stimulus-specific and ‘spontaneous’ components of LFP activity are highly correlated across the array, with clear spatial structure and correlation length scales of ~0.1 mm.

Using the models of unit modulation by LFPs, both the stimulus-specific and spontaneous components of the LFP significantly improve predictions of unit activity. The spontaneous component of the LFPs had a much larger effect.

Thus, both stimulus-driven and spontaneous network activity may serve to temporally and spatially organize V1 activity during natural viewing.

References: