Encoding models of diverse spectral phenomena in human visual cortex

Visual stimulation gives rise to a diversity of responses in cortical field potential recordings. These include evoked potentials (stimulus-locked), broadband power increases spanning at least 30 to 200 Hz, and a rhythmic gamma band oscillation (centered between about 30 and 80 Hz). We developed predictive models of these responses in human V1-V3, as assessed with intracortical electrodes (ECoG) and MEG.

We report a novel image computable model of gamma oscillations. The model explains the stimulus selectivity of gamma oscillations, measured with ECoG, to a wide range of static, gray-scale images. Gamma oscillations showed starkly different stimulus selectivity compared to broadband responses. Gamma responses were large for only a small number of images, especially high contrast gratings. Our model of gamma oscillations is sensitive to the variation across the spatially pooled outputs of the orientation channels in the population receptive field, and accurately predicts responses to 86 test images. Findings suggest that gamma oscillations may be a biomarker for neuronal inhibition or normalization, rather than being a fundamental mechanism of information transmission or perceptual binding. In contrast, broadband responses were observed for all stimuli with appreciable contrast in the electrode receptive field, and were consistent with previous models of the fMRI response in visual cortex.

A second set of experiments measured MEG responses to contrast modulating dartboard patterns. The responses were separated into a broadband and stimulus-locked (evoked) component. The spatial pattern of MEG responses differed systematically for the two components. Computational modeling showed that the differing patterns could be explained by accounting for neuronal synchrony: we modeled the two responses as arising from identical cortical sources in V1-V3, differing only in whether the sources were phase-locked or not. Phase-locked sources predict the spatial pattern observed in the evoked response, and non-phase locked sources predict the pattern of broadband responses. Results show that MEG sensor topography can help explain the degree of widespread neuronal synchrony.