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Presentation Abstract

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Title: Integration of optical neural control and high-field fMRI: Towards systematic exploration of functional neural dynamics with 'Opto-fMRI'

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Abstract: Full understanding of the function of a neuron type or brain region requires a means for causally controlling that element during simultaneous measurement of its functional impact on networks across the brain. Optogenetic control of specific cell types allows selective neural circuits to be activated and silenced with different colors of light (Boyden et al., 2005). Here, we present methods for combining this technique with high-field fMRI, 'Opto-fMRI.' Because 9.4T fMRI provides high-resolution (<.5mm functional voxel size) whole-brain coverage in rodents and primates (Nelson et al., 2005), we can assess activation across multiple brain areas generated by activity of a single optically-driven cell type without pre-selecting target regions for electrode placement. Further, because fMRI is non-invasive, this combination provides an elegant tool for repeated measurement of changes in whole-brain connectivity resulting from long-term plasticity, for example during task acquisition. This approach may also improve our understanding of the basis of fMRI, and enable monitoring of neural networks during delivery of therapeutic neuromodulation protocols.

We have successfully implemented this Opto-fMRI method in the rat 'barrel' cortex transfected with Channelrhodopsin-2 (ChR2) under control of the CAMKII promoter, imaging at 9.4T under light isoflurane anesthetic with optical stimulation delivered by fiber optic. In this preparation, we have replicated the same cortical and subcortical activation patterns across multiple imaging sessions,

and observed the dependence of these signals on the duration and frequency of optical drive. We have further replicated our cortical activation findings from rat in transgenic mouse barrel cortex expressing ChR2 under control of the Thy-1 promoter. In both preparations, the time course and amplitude of the BOLD response follows the typical hemodynamic response function observed in sensory neocortex during external tactile stimulation.

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