

**Illuminating Causal Links between Neural Circuit Activity and Behavior**

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Understanding the causal relationship between activity patterns in neural circuits and behavior is one of the fundamental questions in systems neuroscience. Addressing this problem requires the ability to perform rapid and targeted interventions in ongoing neuronal activity at cellular resolution and with millisecond precision. I will describe results of experiments using a powerful new "all-optical" strategy [1, 2] for interrogating neural circuits which combines simultaneous two-photon imaging and two-photon optogenetics. This enables the activity of functionally characterized and genetically defined ensembles of neurons to be manipulated with sufficient temporal and spatial resolution to enable physiological patterns of network activity to be reproduced. I will describe how we have used this approach to identify the lower bound for perception of cortical activity, probe how brain state influences the role of cortex in perception, and provide causal tests of the role of hippocampal place cells in spatial navigation.

**References:**

- [1] Packer AM, Russell LE, Dagleish HW, Häusser M. Nature Methods 12(2):140-6 (2015).
- [2] Russell LE, Dagleish HWP, Nutbrown R, Gauld OM, Herrmann D, Fişek M, Packer AM, Häusser M, Nature Protocols 17(7):1579-1620 (2022).