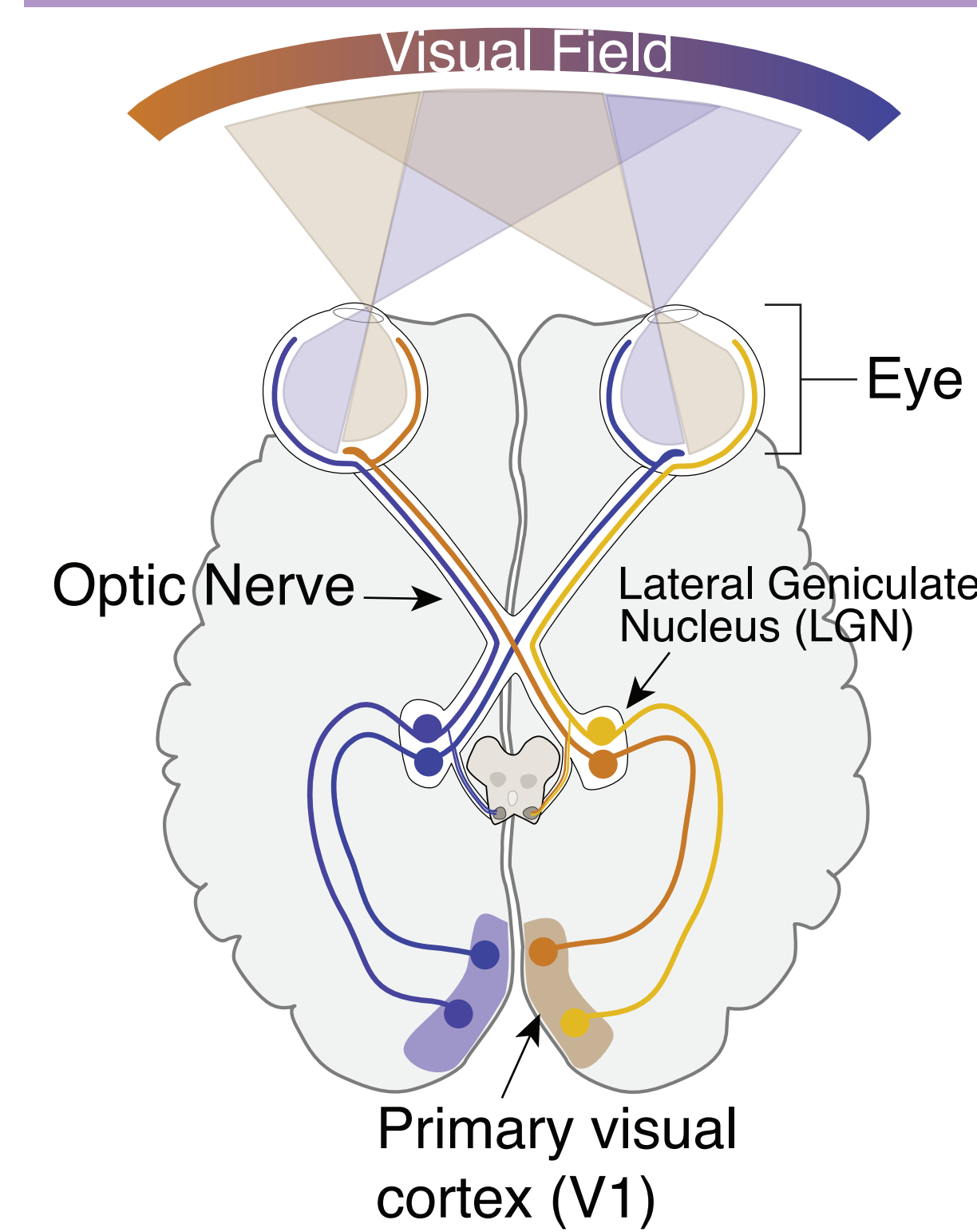


Interarea Communication for Visual Processing

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Background



Perception relies on sensory processing, which takes place in hierarchical pathways involving cortical areas. These pathways have been primarily defined through anatomical connections, but their functional connectivity is not well understood. We seek to understand how populations of neurons selectively communicate with one another. Understanding how the brain uses population activity to build representations of the world will help us better understand sensory, psychiatric, and other disorders.

Aims:

- 1) Simultaneously record from 3 visually responsive areas
- 2) Transiently modulate the activity of one of these areas and measure the response in others

Methods

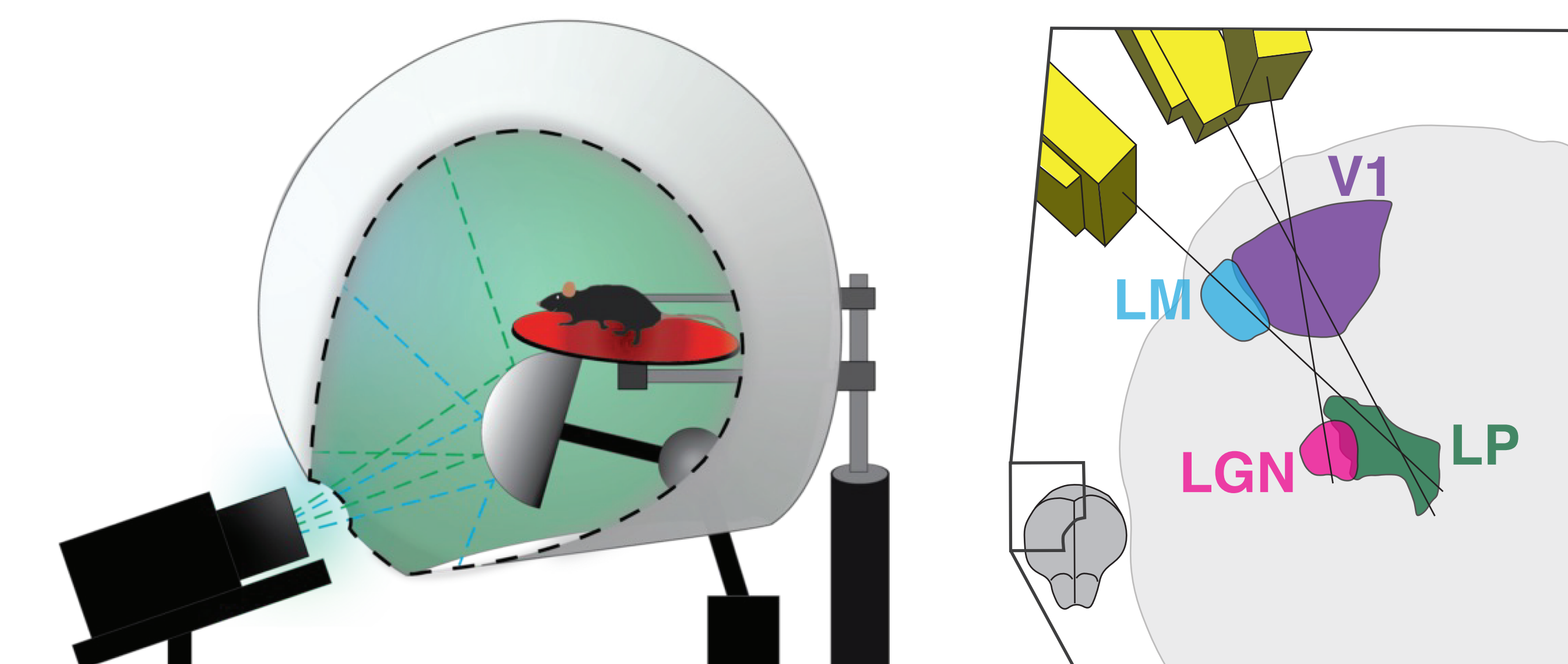
Surgery: Head plate is attached to mouse skull to allow for head-fixation. Minimum 1 week of habituation with handling and progressive head-fixation on the experimental rig. Immediately before electrophysiological recordings, a cortical window is opened.

Widefield retinotopic imaging: overhead camera acquires registered images of during different visual stimuli

Acute electrophysiology: 3 Neuropixels probes are inserted through the window for high-density recording. Visual stimuli (bright and dark flashes of light) are projected in an immersive environment.

Optogenetics: eOPN3 rhodopsin inhibits neurotransmission in neurons via activation of the $G_{i/o}$ pathway and reduction of Ca^{2+} channel activity. Fiber optic is placed on the cortical surface.

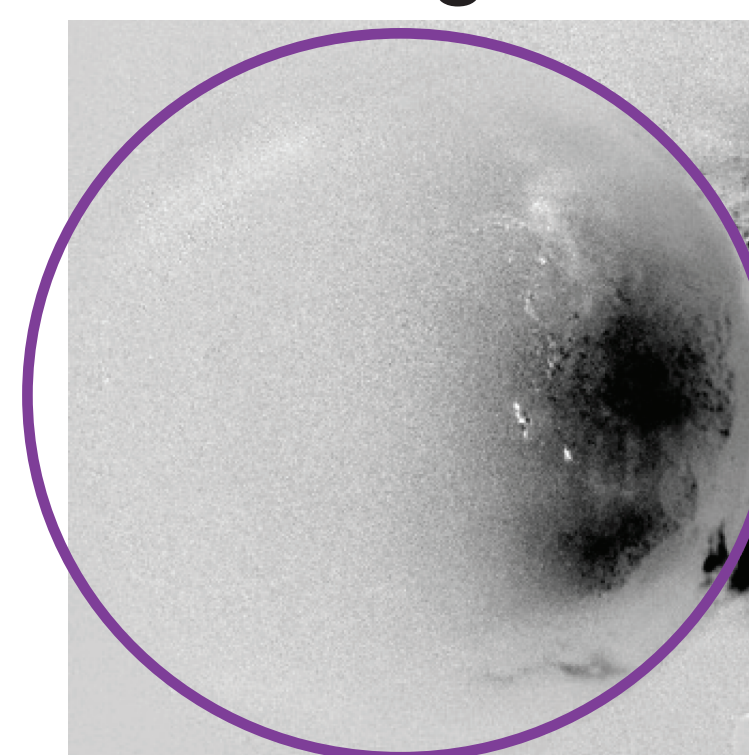
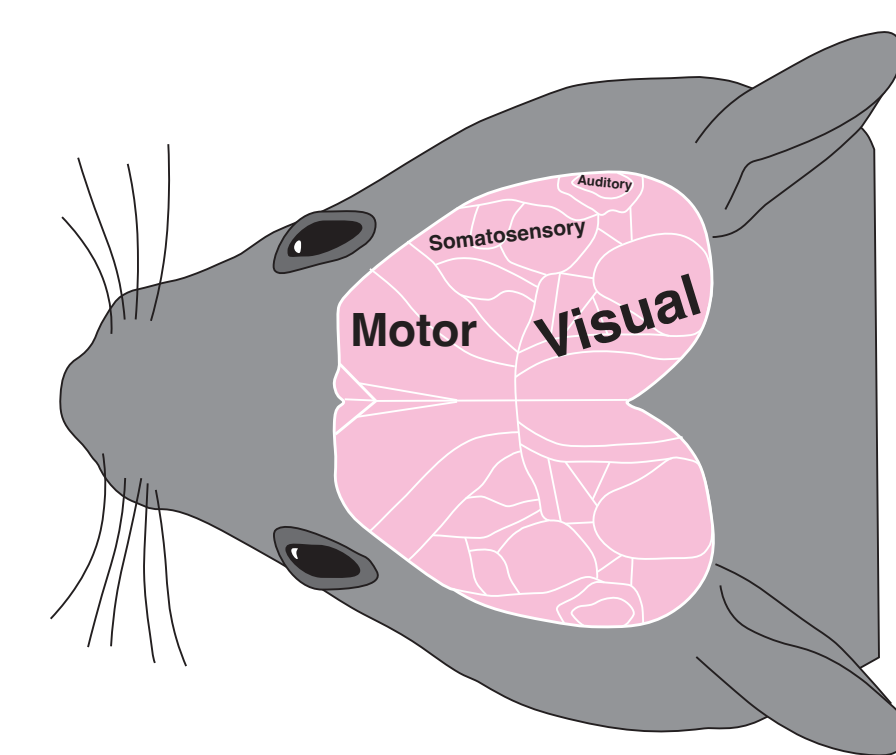
Data analysis: Template matching (Kilosort 2.5) to identify and sort action potentials into units which represent single neurons. Then, quality control of algorithmic sorting and unit selection through quality metrics (interspike interval violations and Mahalanobis contamination)



Results

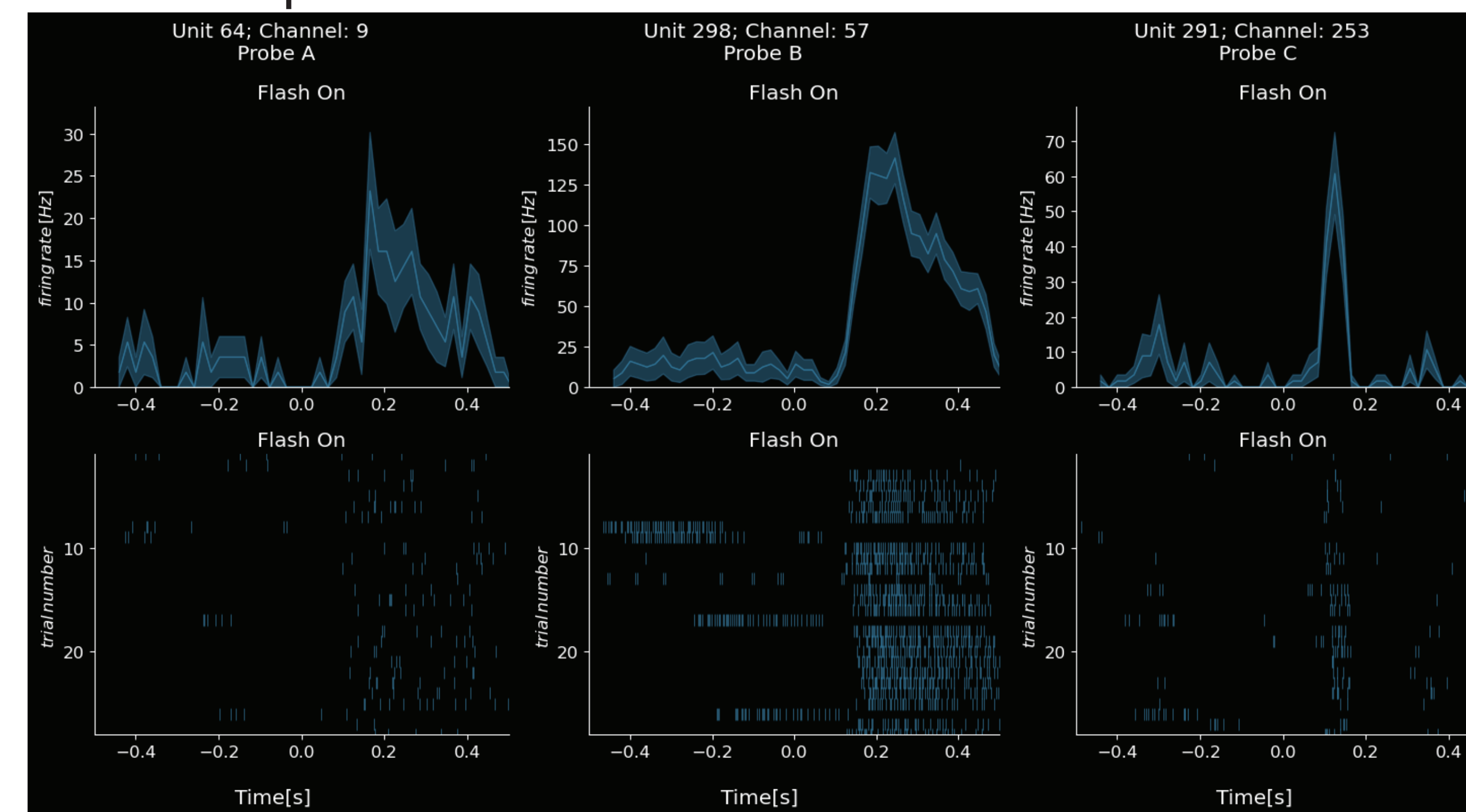
Recording from Visually Responsive Areas

Widefield retinotopic imaging: identifying areas of increased activity following visual stimuli



Intrinsic imaging shows increased blood flow when the visual stimulus is present, which suggests increased population cortical activity.

Acute multi-scale electrophysiological recordings: individual responses to visual stimuli in distinct areas



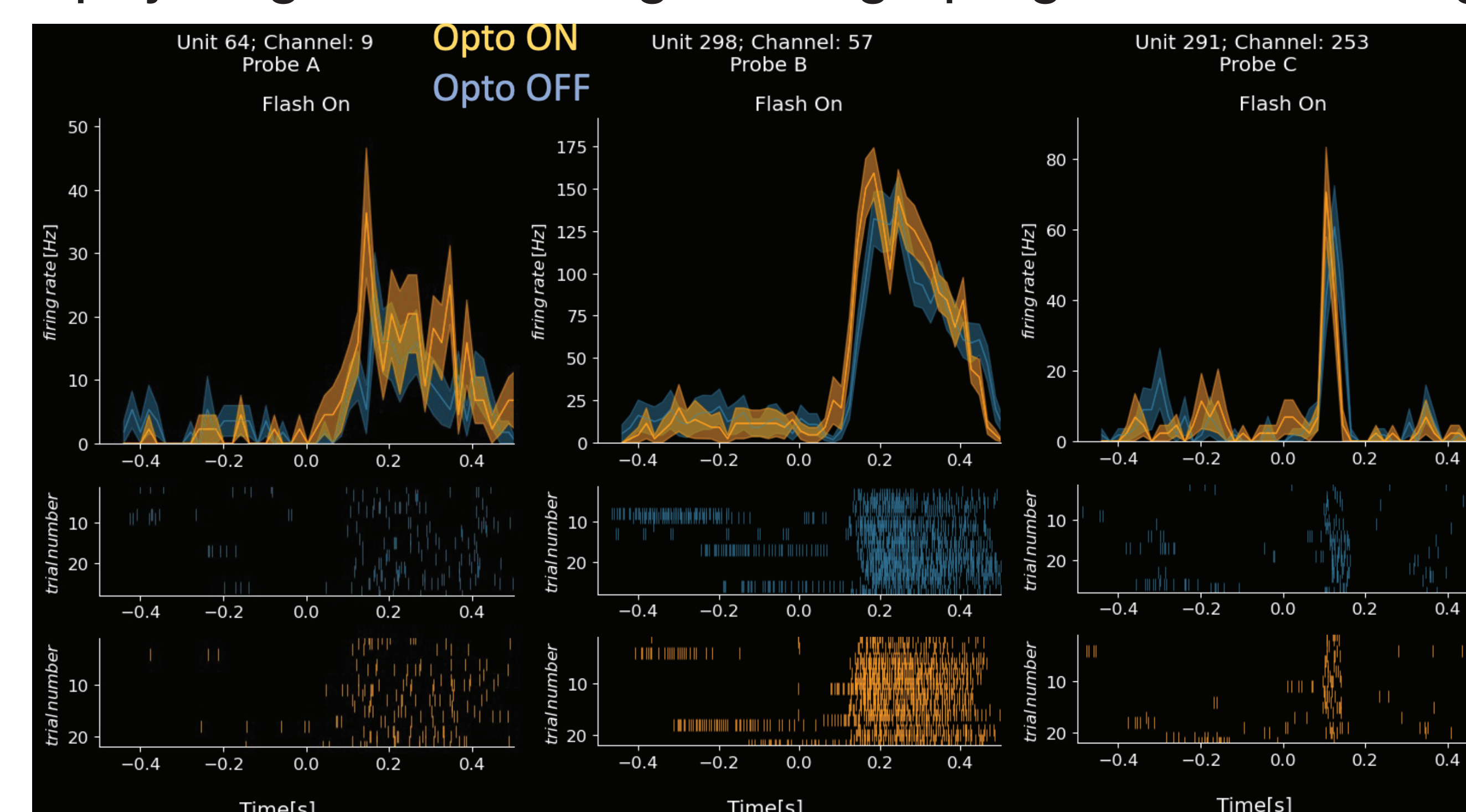
Top row: PSTH show the times at which neurons fire relative to the stimulus time.

Bottom row: raster plots show spike trains for every trial.

We aimed towards primary visual cortex (V1), lateromedial area (LM), and the lateral posterior nucleus (LP; pulvinar) in an awake mouse. These are some sampled individual units during a simple flash on/flash off visual stimulus.

Modulating Visually Responsive Areas

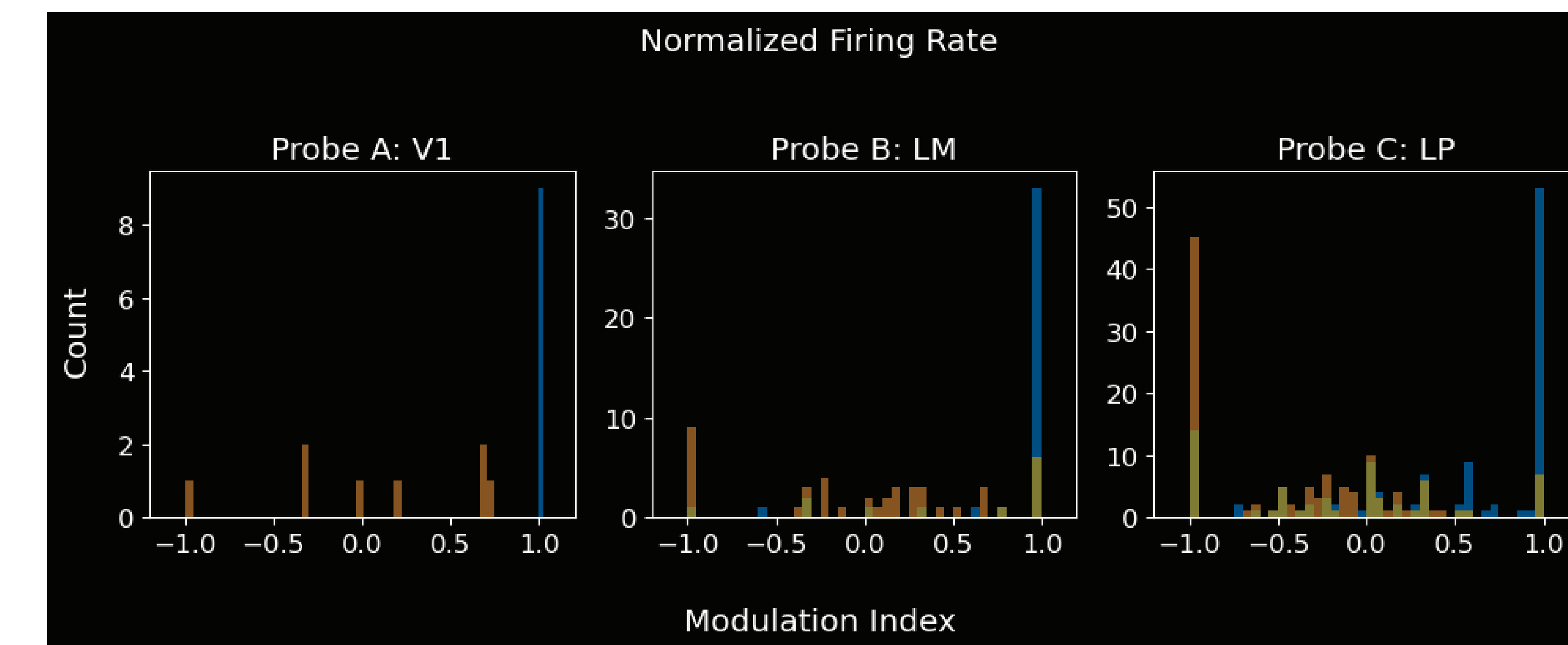
Electrophysiological recordings during optogenetic silencing of V1



We compared the activity of the same units with and without inhibition of V1. From these plots, it is not immediately clear what the overall effect of the optogenetic inhibition was on their activity.

Results

Aggregate analysis shows visually-evoked firing rate slowing in V1, LM, and LP with transient V1 inhibition



Modulation index is the normalized change in firing rate from baseline to the evoked firing rate. When we look at the modulation index of all of identified units after inhibition, we see a trend towards negative modulation indices.

Conclusions

Aim 1:

We were able to identify visual areas through widefield imaging. We also successfully recorded neuronal activity simultaneously from multiple visual areas using high-density probes and were able to identify clear individual units.

Aim 2:

While the response to optogenetic silencing of V1 in selected individual units was not immediately evident, in aggregate, we can see a trend of decreased visually-evoked firing rate across all probes.

Limitations & Future Directions

- **Experimental improvements:** clear cement for better visualization of vasculature, improved lighting for intrinsic imaging, improved head plate longevity & security
- Further analysis of **population dynamics** between visual areas
- Analysis of activity under **multiple different visual conditions** (vary luminance and color contrast)
- **Modulate additional areas** with optogenetics to better understand feedforward and feedback dynamics within the anatomical hierarchy
- **Increase sample size** with repeated experiments

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