Seminar Presentation

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Group 5

Visualizing the Cortical Representation of Whisker Touch: Voltage-Sensitive Dye Imaging in Freely Moving Mice.

Ferezou, Isabelle; *Bolea*, Sonia; *Peterson*, Carl. Ecole Polytechnique Federale de Lausanne. Neuron 50 617-629. Elsevier, 2006.

Outline

- Project Recap
- Paper Relevance
- Objectives
- Design setup
- Summary of results
- Discussion/Assessment

Project Overview

- NIH wants to observe neurotransmitters transported through the brain in real-time
  - Current imaging modalities can't do this
  - Or are very invasive
- Dyes that react to pH or voltage can meet spatiotemporal requirements
- Photo acoustic imaging picks up acoustic output of a material bombarded by light

Paper Relevance

- Proof of concept (yes, VSDs do work)
- Yields interesting insight on live animals studies
- Mathematical background to biological phenomenon
- Authors ask interesting questions

Objectives

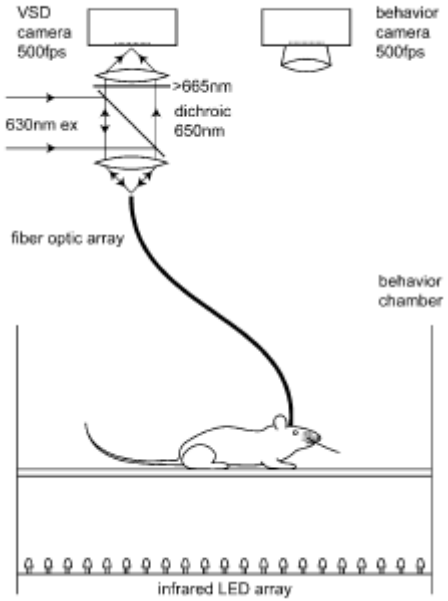
- Processing of sensory input from mystacical vibrissae (whisker)
  - Neocortical sensory processing can be imaged with VSDs to high spatial and millisecond temporal resolution in head-fixed mice.
- Compare processing from varying brain states
- Specifically
  - Observe somatosensory response in anesthesized mice
  - Observe somatosensory response in anesthesized mice vs awake mice
  - Observe sensory reponses during Quiet and Active Whisker behavior
  - Observe cortical representation during active touch

Design

- 630 nm light reflected by dichoric mirror into optic cable

- Head fixed mouse with portion of skull removed
  - Optic cable would shine directly to exposed brain
  - Exposed brain stained with RH1691
  - Excitation light picked up by high speed camera

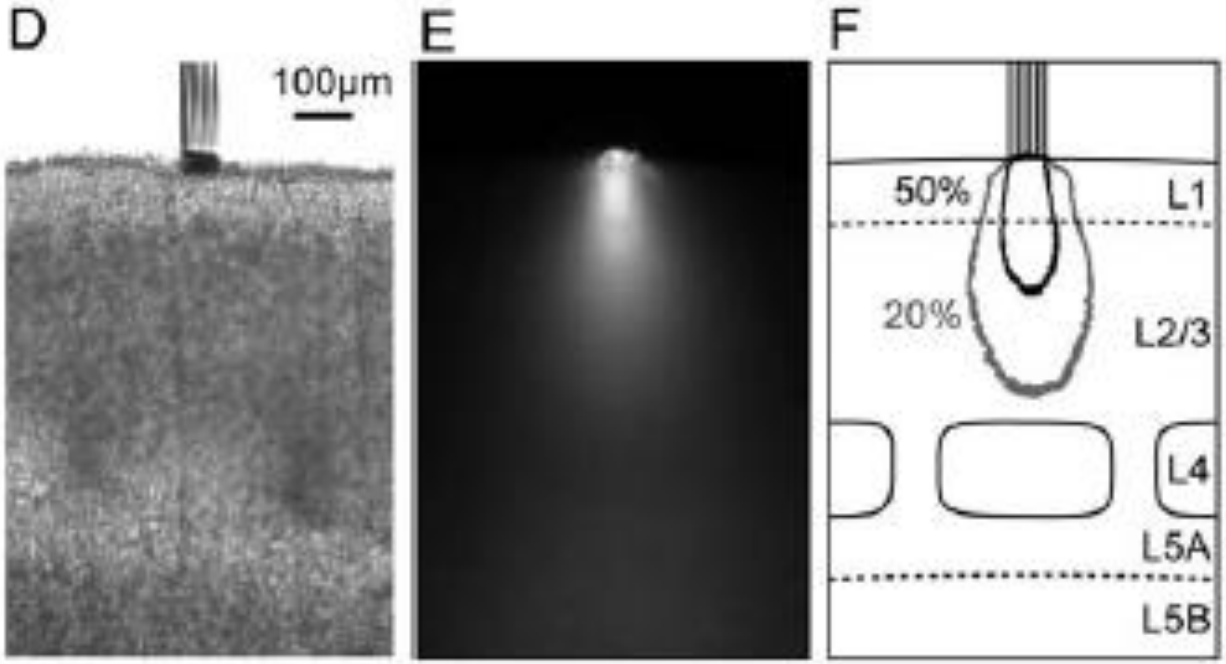
- For monitoring active touch, LED array illuminated below to give outline of mouse



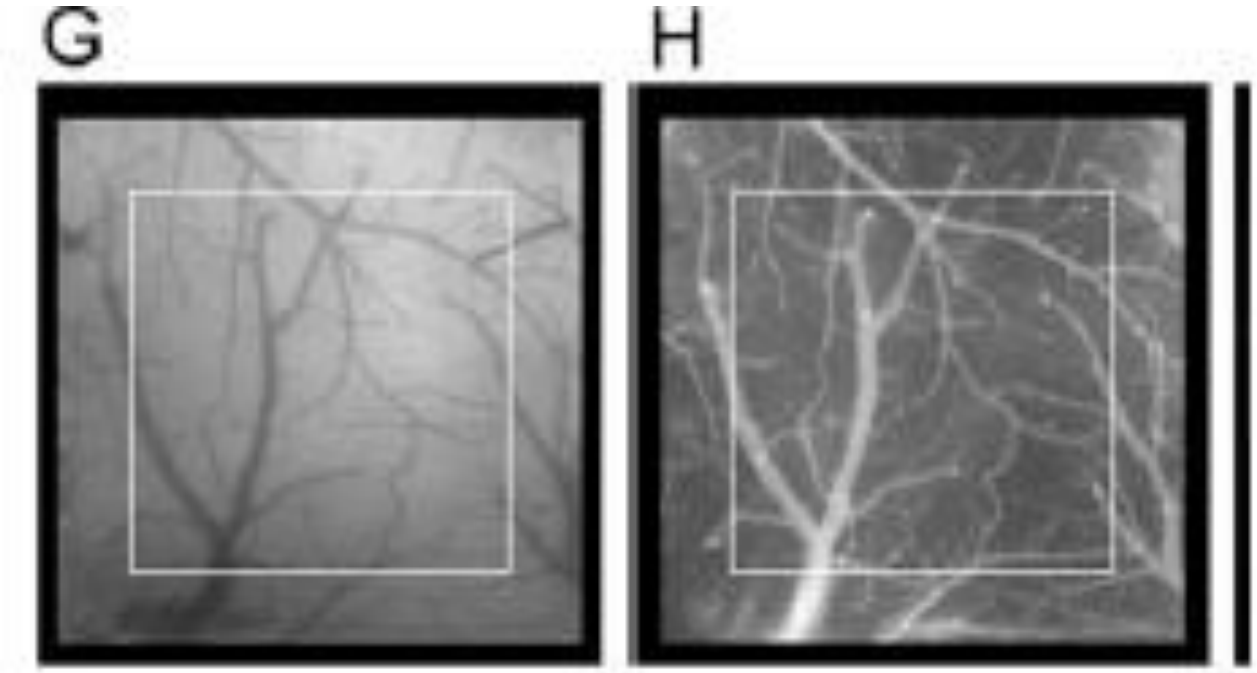
Pre-experiment checkpoint

- Determine light penetration
- Observe lateral spatial resolution at top layer
- Determine VSD penetration

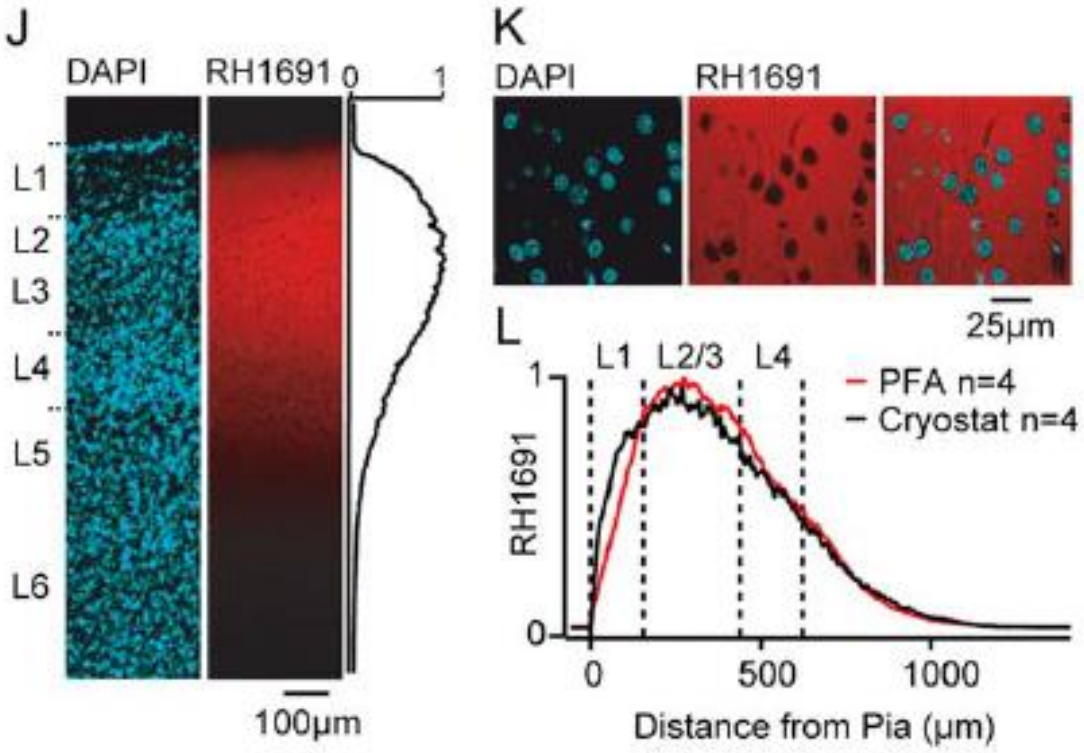
Light Penetration



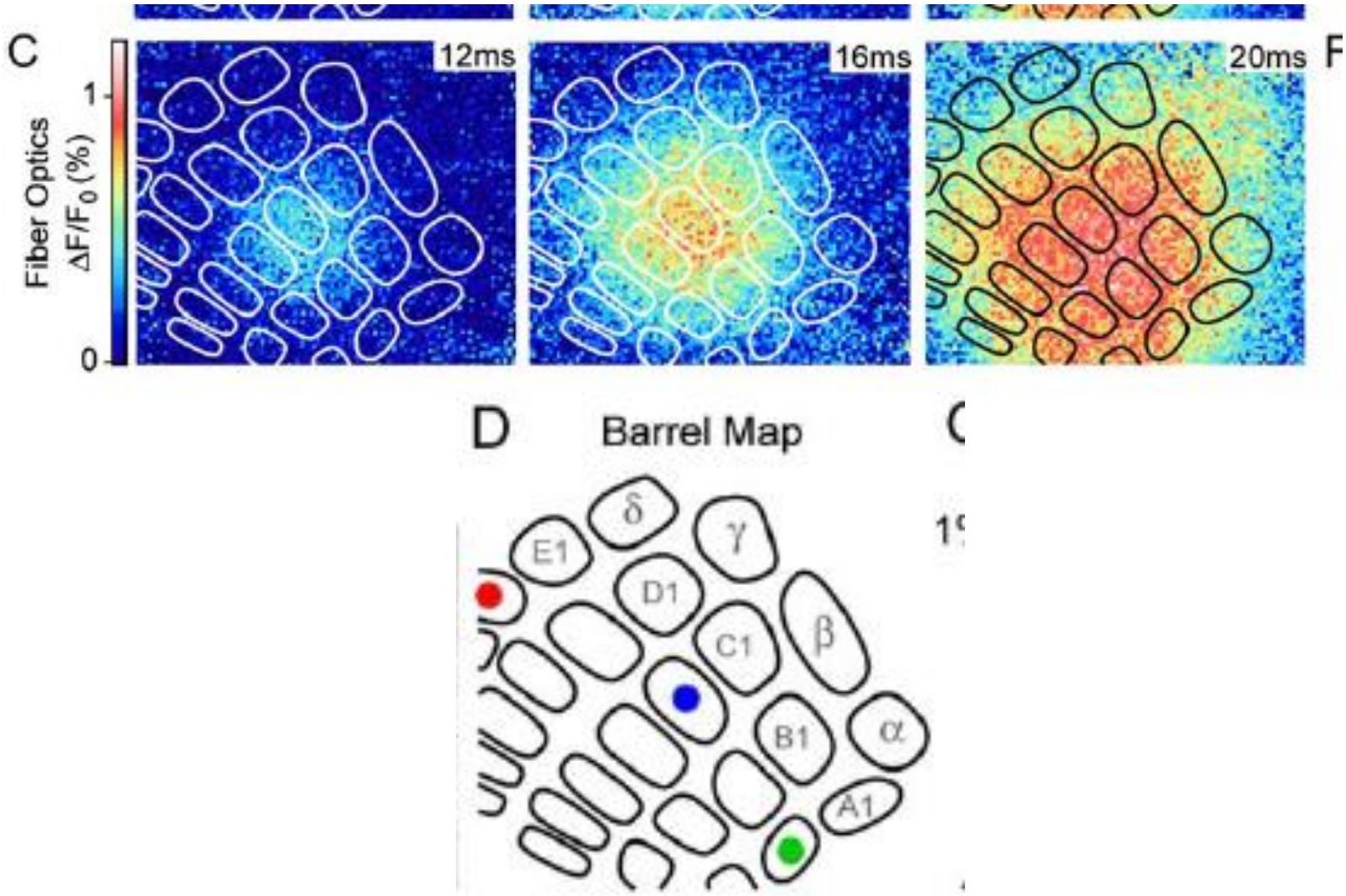
Top Layer Lateral Resolution



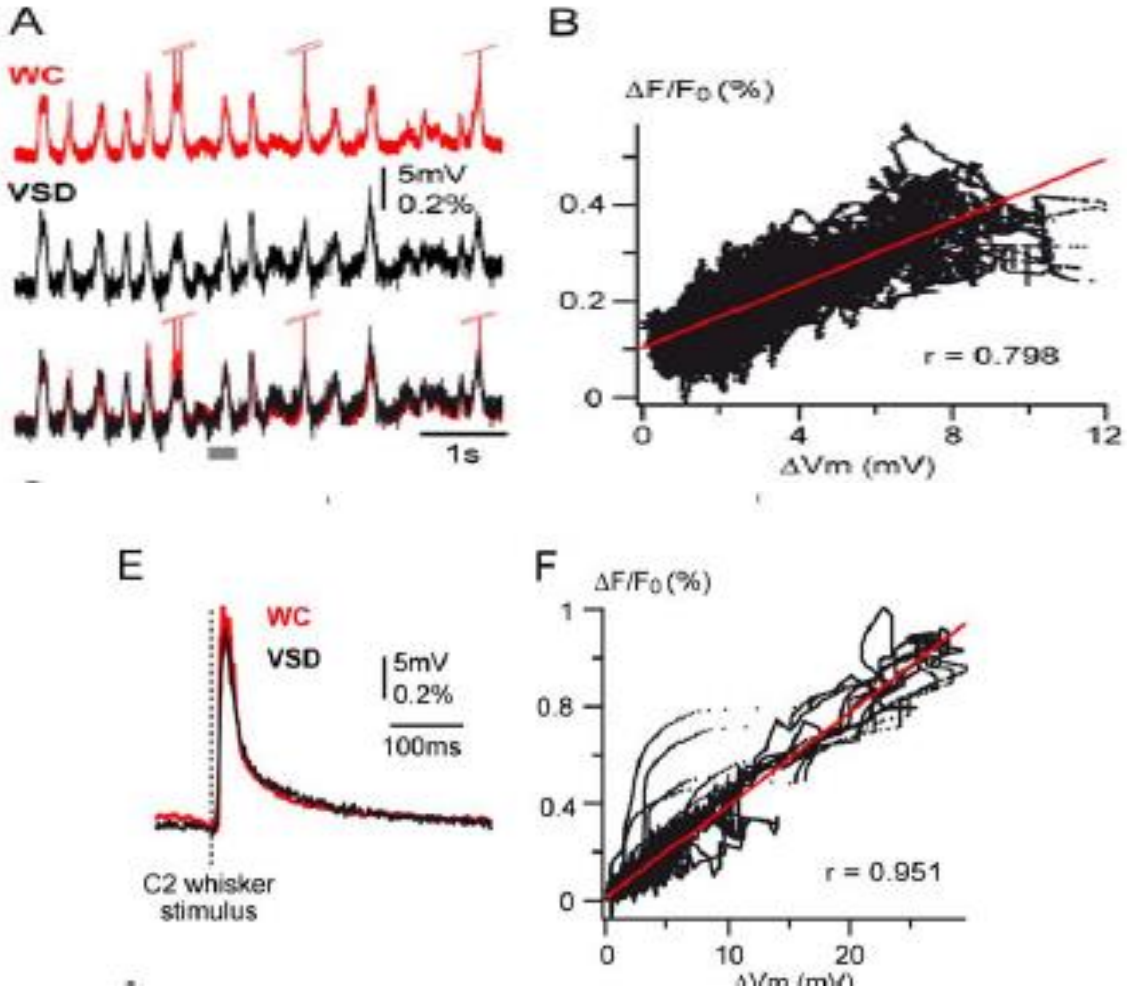
VSD penetration



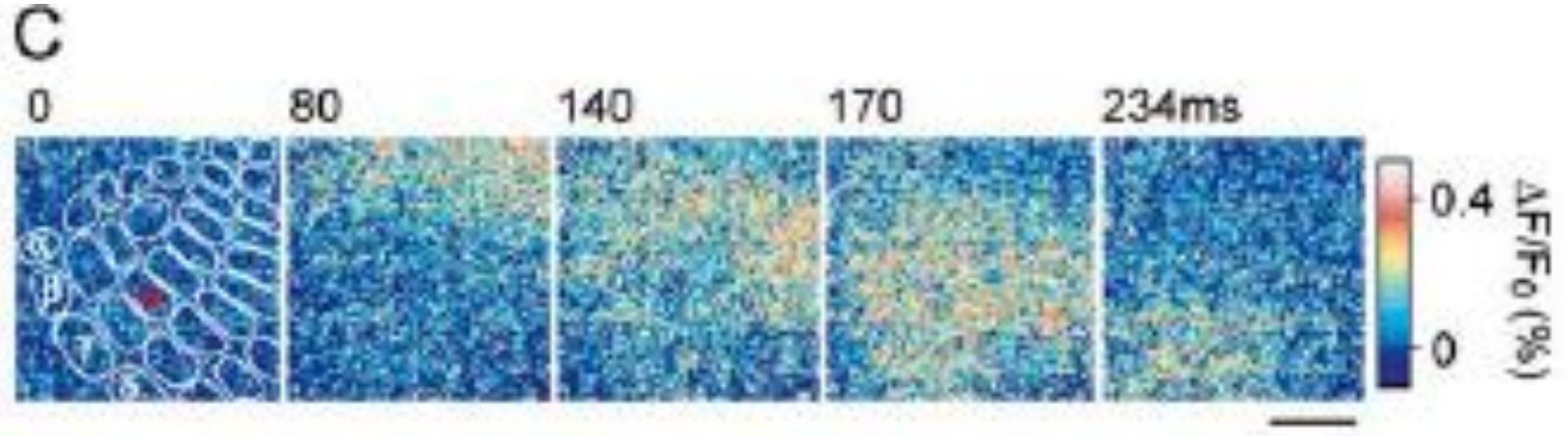
Cortex response in anesthetized mice



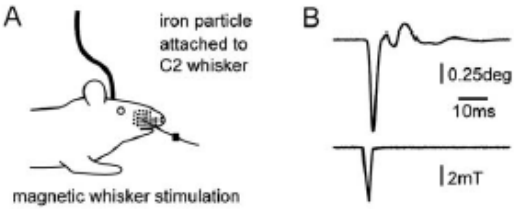
VSD signal correlation & membrane potential fluctuations

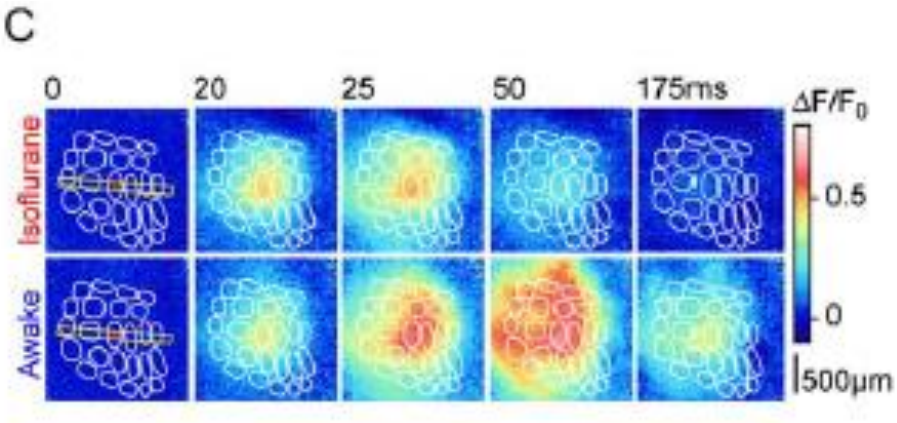


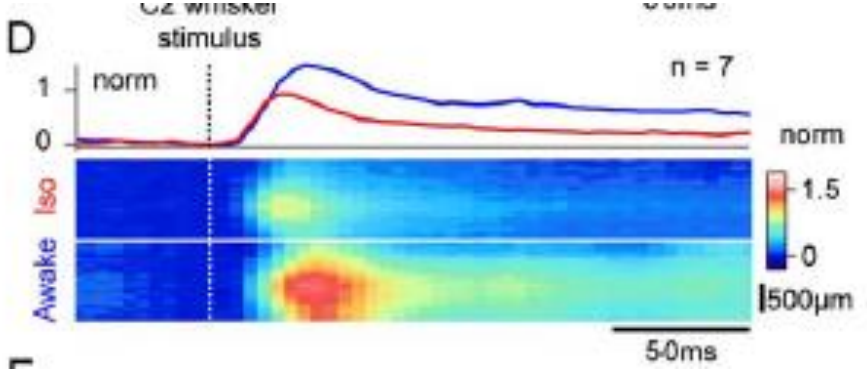
Propagating waves of excitation



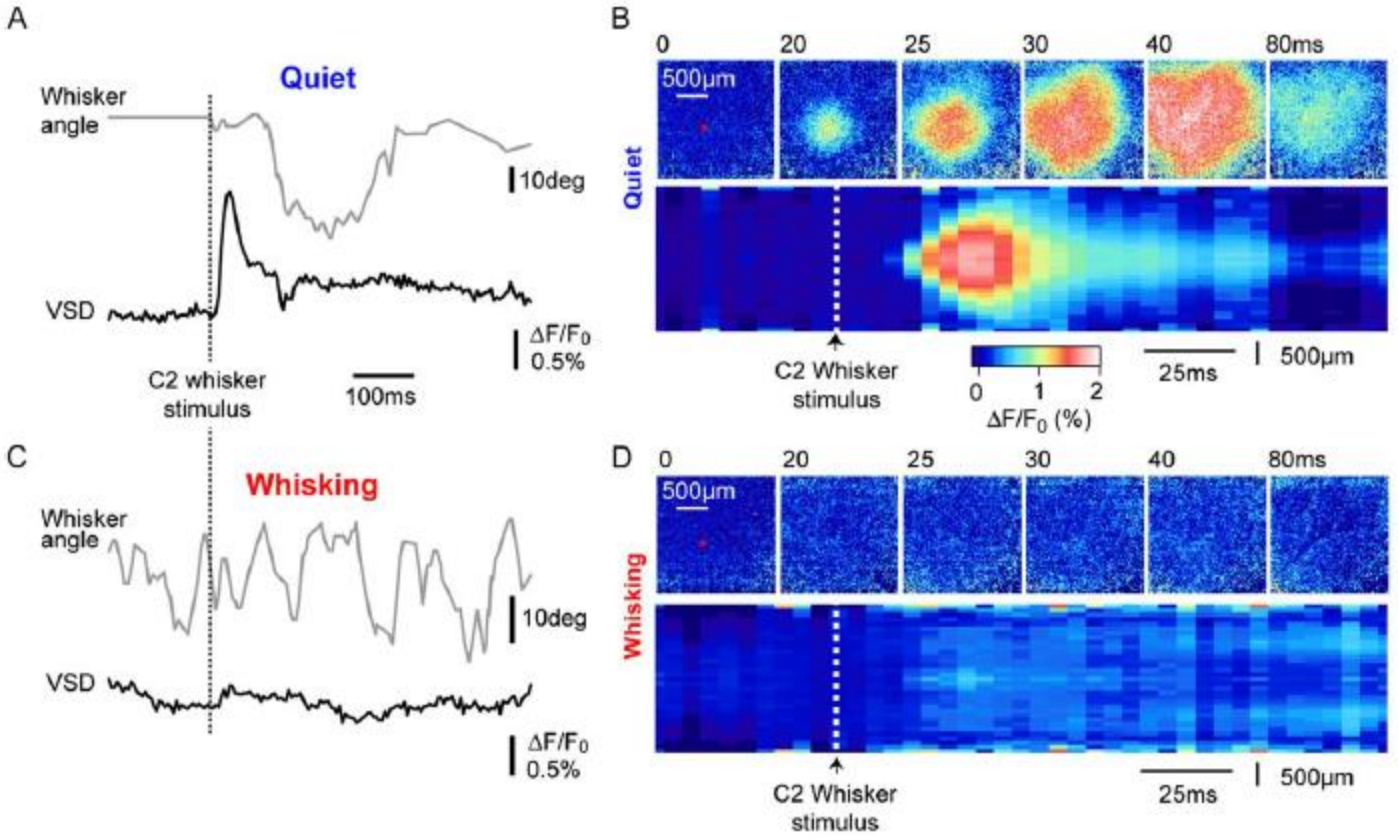
Cortex response in anesthetized mice vs awake mice



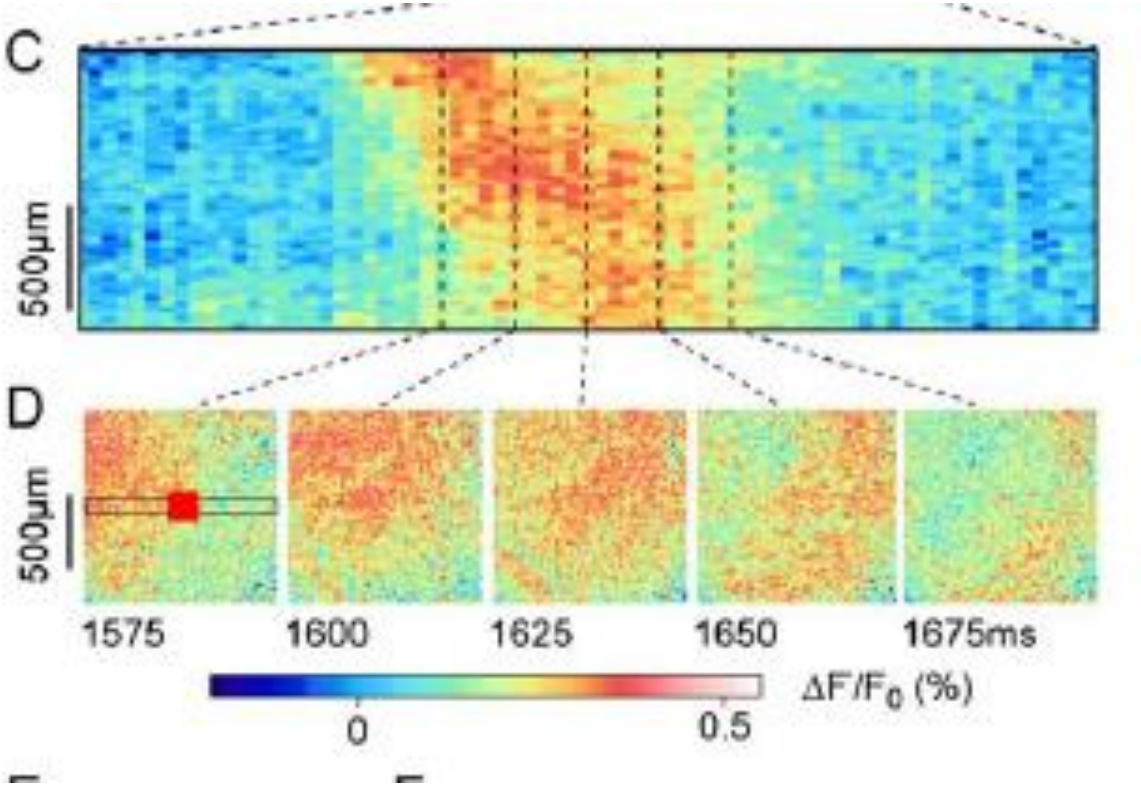




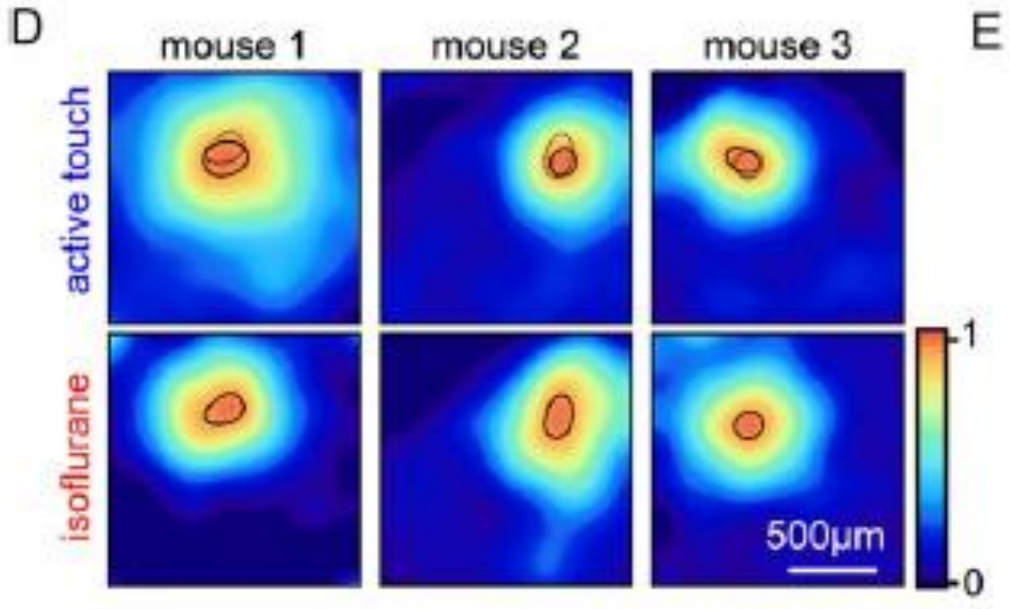
Quiet mice vs those actively "whisking"



Waves of excitation in quiet mice



Active Touch



Assessment

- VSDs work
- Novel way for testing head-set mice
  - System is simple and easy to use
  - Applicable for future work
- Tested for spatial and temporal resolution
  - Interesting they chose to determine temporal resolution after performing an experiment
- Fundamental understanding

Authors' questions

One big issue that the authors brought up was why smaller sensory responses to passive magnetic whisker stimulation are evoked during active whisker behavior.

- What role does the trigeminal nerve (serves as a connection between follicle and cortex) play in active whisking vs quiet behavior
- Is the suppression of whisking mediated by processes downstream of the whisker follicle?
- Are thalamaic synapses weakened during whisking by short-term synaptic depresion inducing by increased thamalic "background" firing rates
- Is the cortical brain state different between active and quiet whisking behavior?

Why is it that strong responses were recorded during active touch?

- Trigeminal sensory neurons may be engaged in a different manner during active touch
- During active touch the whisker is consciously accelerated into an object. Is trigeminal activity amplified by this conscious act?
- Is there a "top-down" influence on sensory activity in the barrel cortex. That is, when a mouse explores its environment it has a mental image. Is passive deflection just regarded as noise?

Questions? Comments?