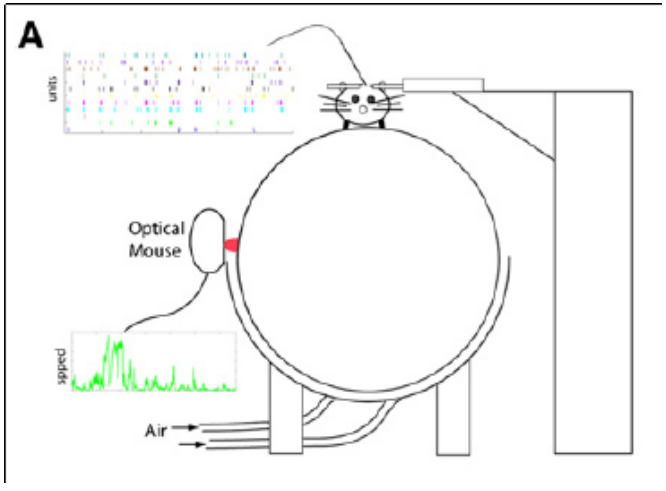
A neural circuit that controls plasticity and the gain of sensory responses in mouse visual cortex

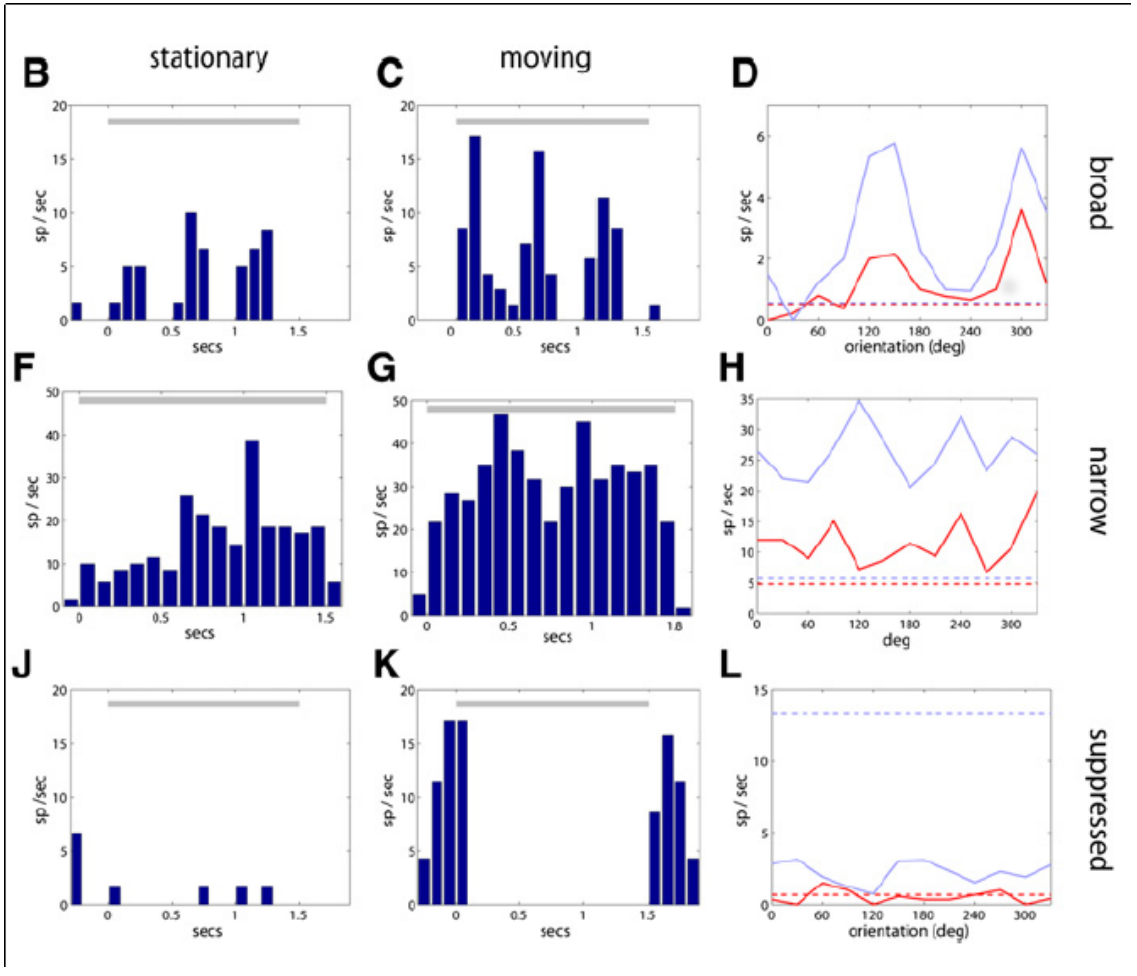
Neil and Stryker, Neuron 2010 + Fu et al, Neuron 2014 + Kaneko and Stryker, eLife 2014

Running modulates neural responses in mouse V1

Mouse on a ball

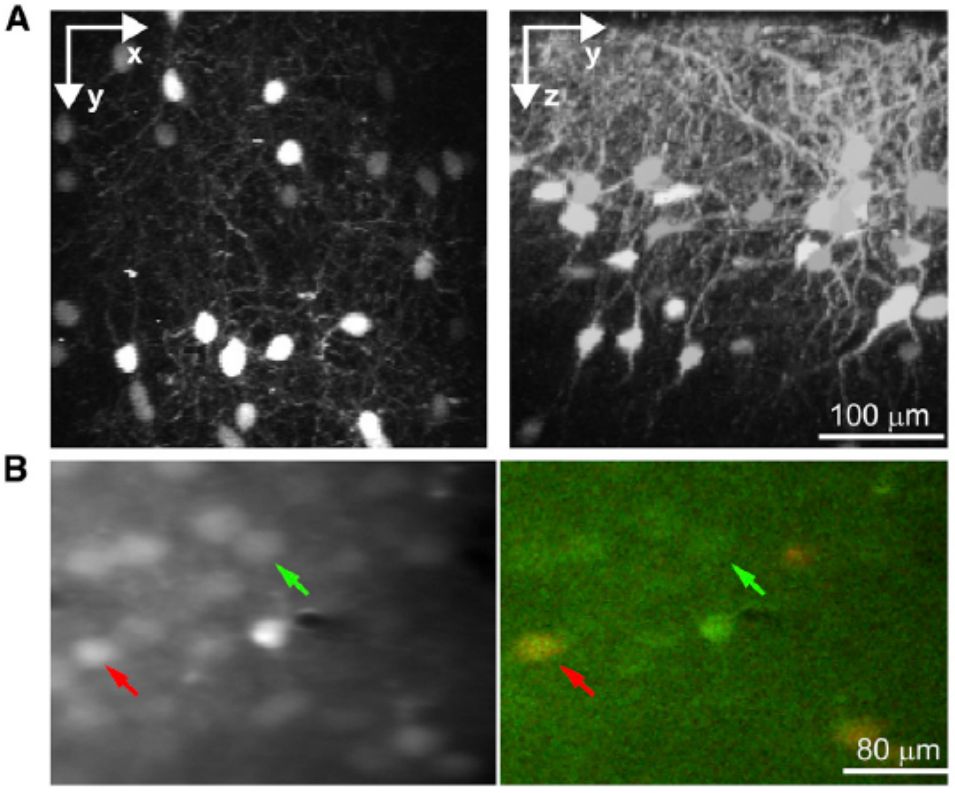


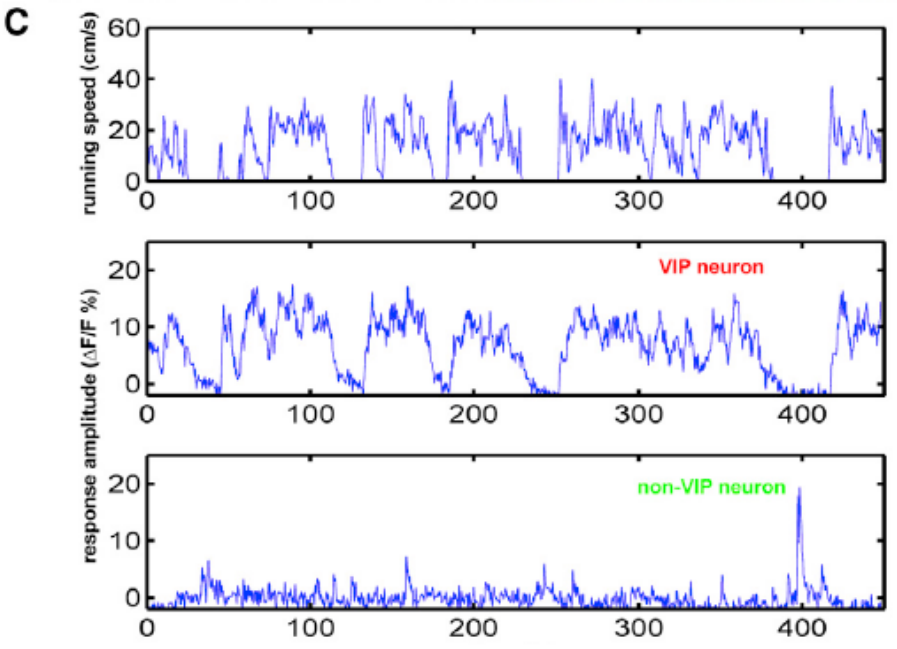
Gain modulation of orientation-selective responses



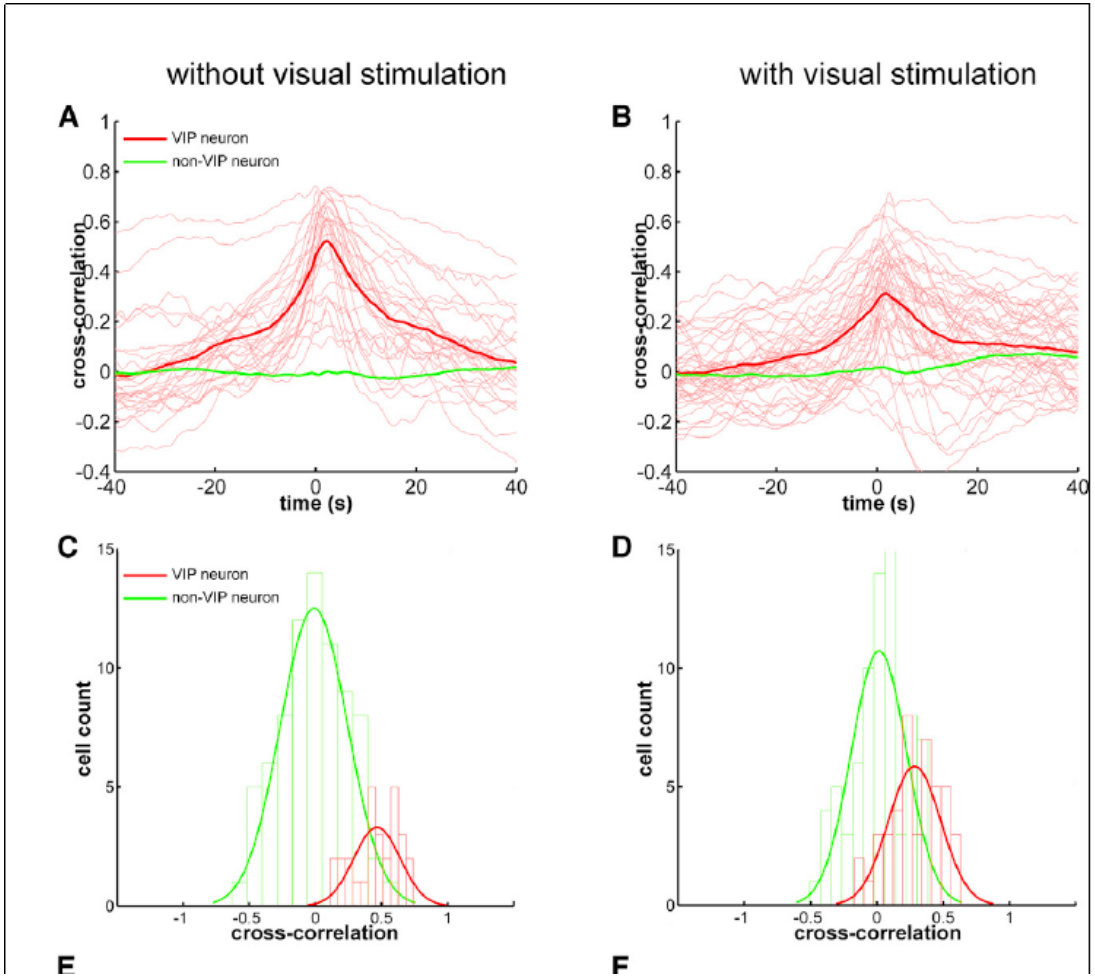
VIP interneurons, highly active during running

Used genetic markers to identify interneuron subpopulations, VIP was special





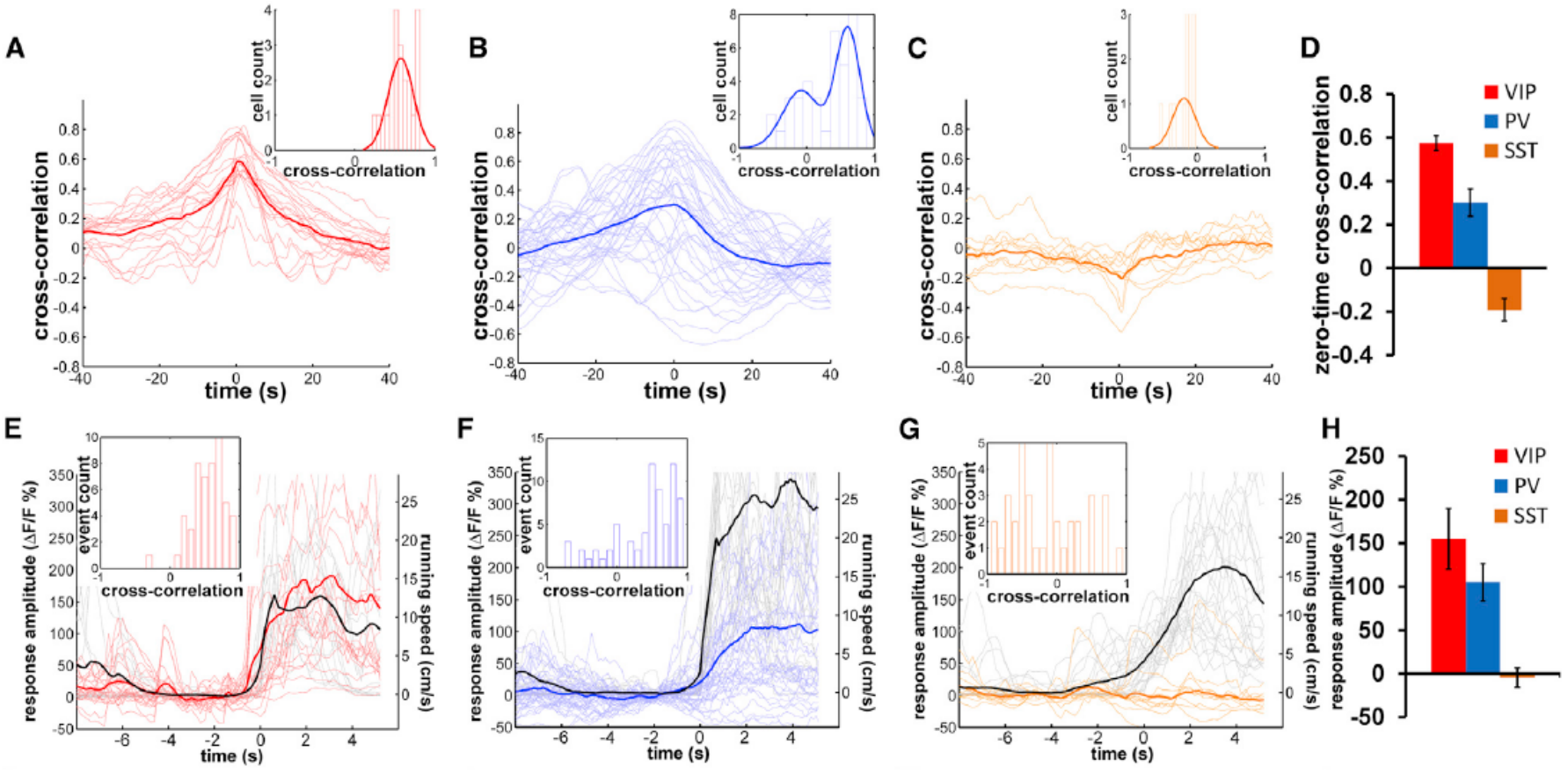
Correlation between VIP neurons and running speed



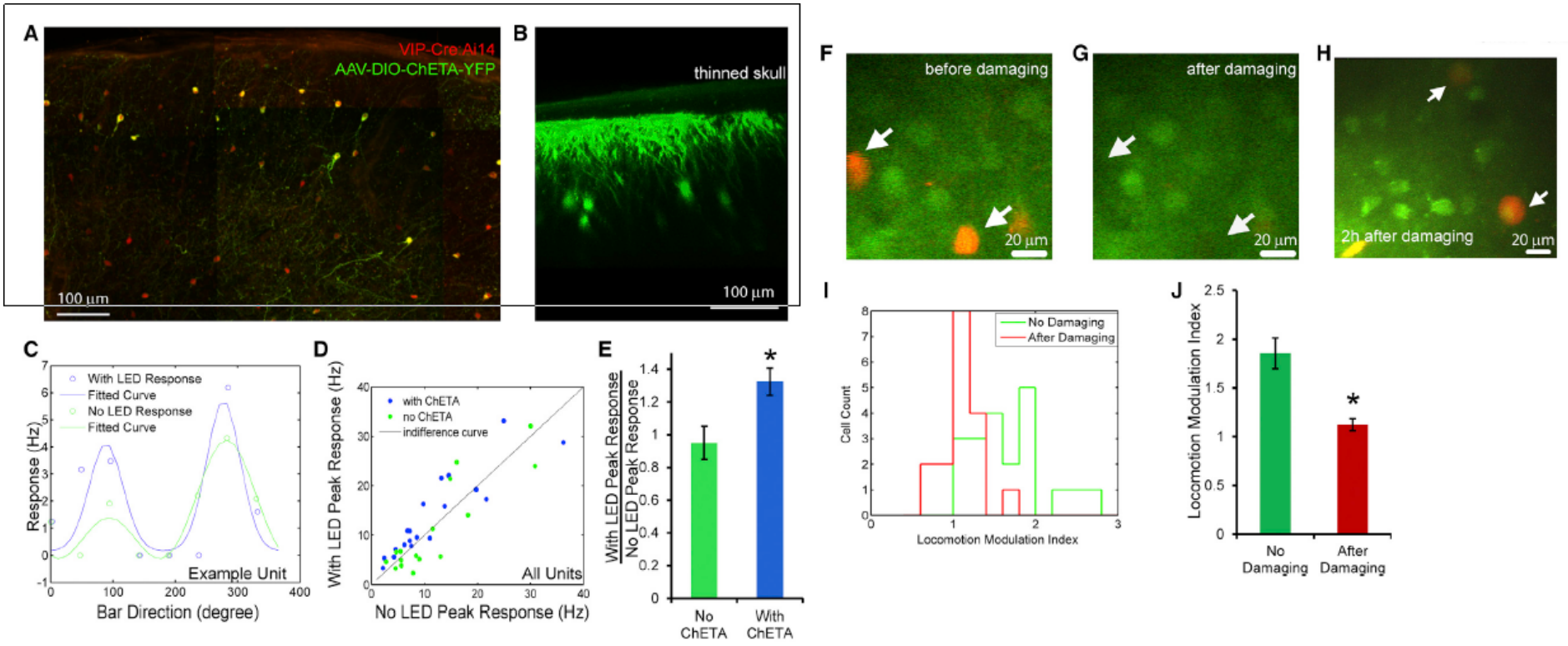
non-VIP neurons are mostly pyramidal

VIP, SOM and PV interneurons have differentiated responses during running

Pfeffer et al, 2013, disinhibitory loop: VIP→SOM→Pyr



VIP interneurons sufficient and necessary for gain modulation during running



Origin(s) of modulation

Lee, Neill et al, unpublished

1. Midbrain nucleus activation triggers running. Subthreshold activation increases gain without running.
2. **Cholinergic** input to VIP from basal forebrain, necessary for gain modulation.

Polack, Friedman and Golshani, 2013

1. During immobility, **cholinergic** input essential for maintaining depolarization/unimodal membrane potential.
2. During locomotion, **noradrenergic** input necessary for tonic depolarization.

Recovery from long-term monocular deprivation

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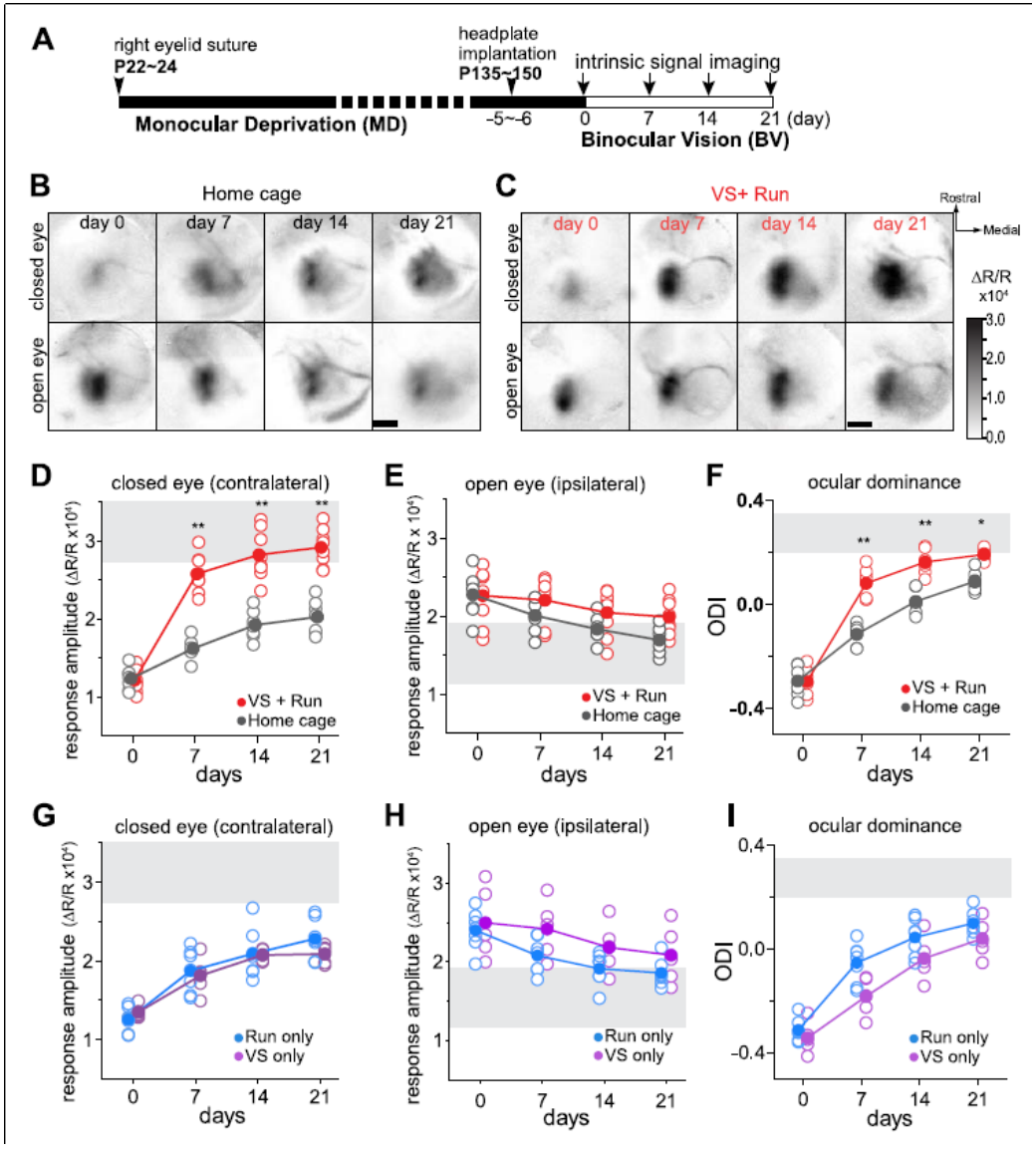
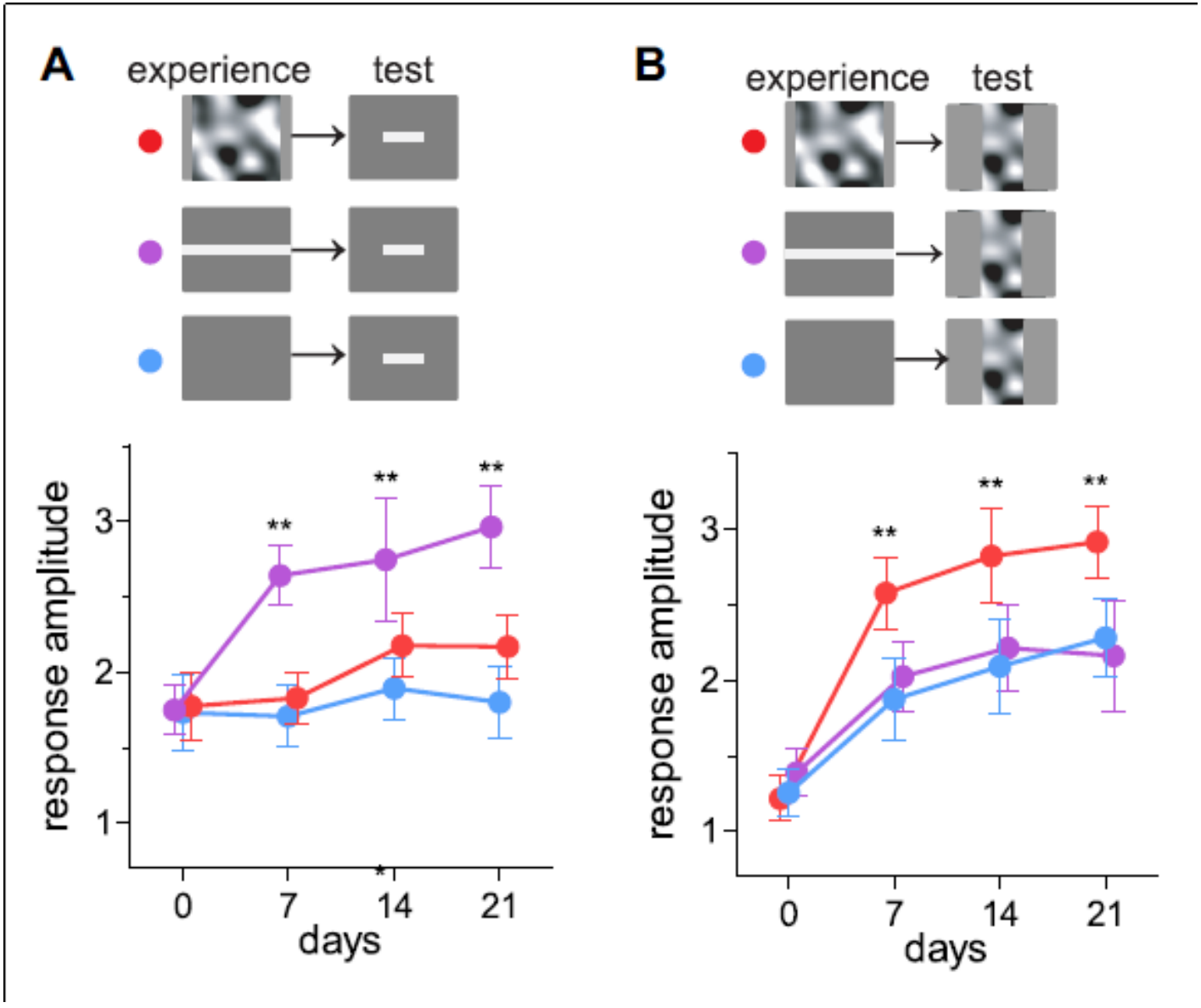


Recovery is specific to experienced stimulus class



Conclusions

- Cortical gain and cortical state are changed by locomotion **in the mouse** (Neil and Stryker, 2010).
- VIP→SOM→Pyr disinhibitory mechanism mediates these changes (Fu et al, 2014).
- Plasticity is enhanced by pairing visual stimulation with running (Kaneko and Stryker, 2014).