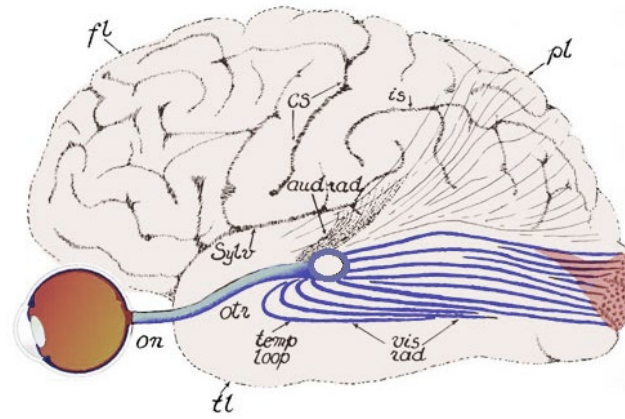
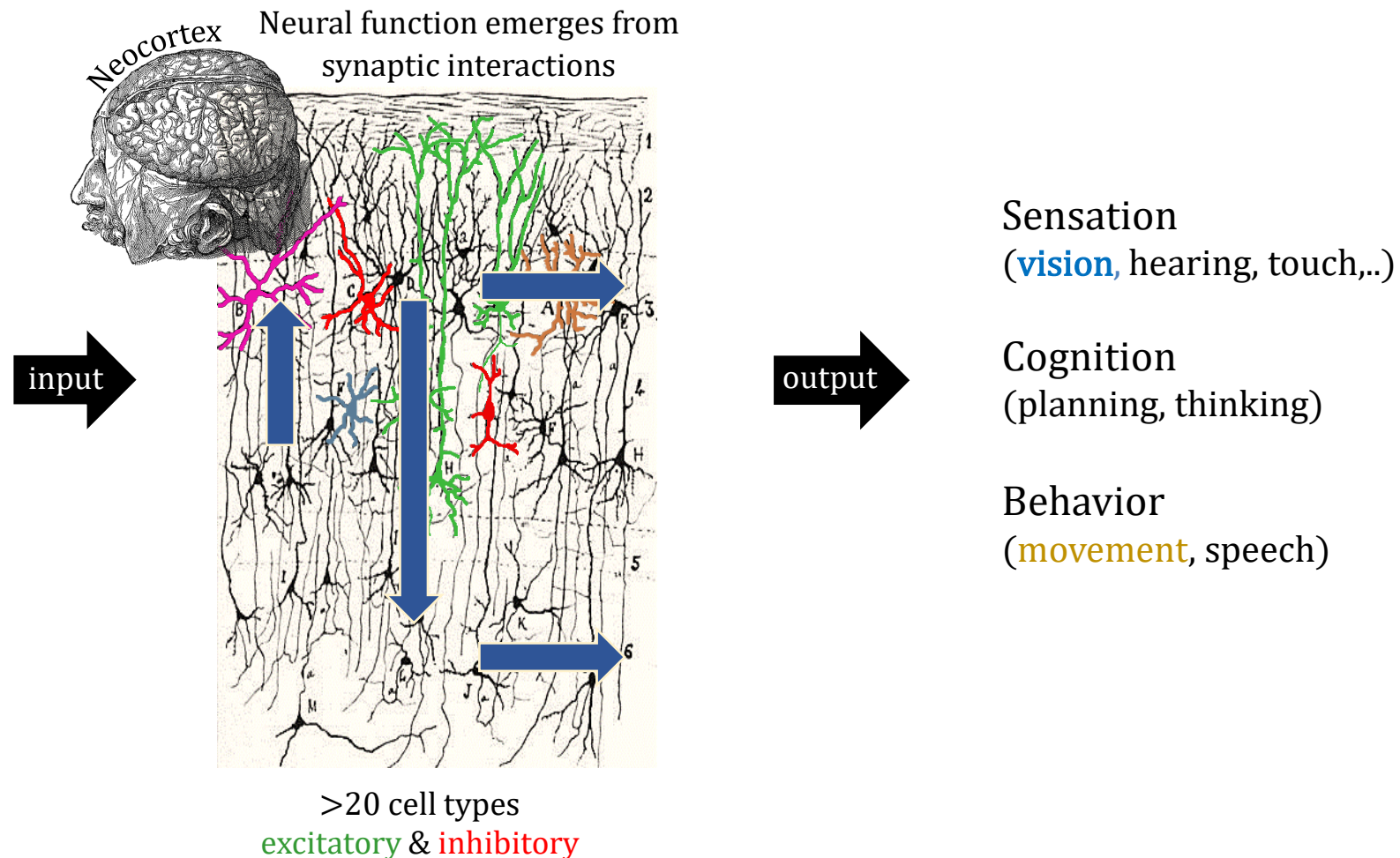


# Connectivity and interactions between visual and motor circuits

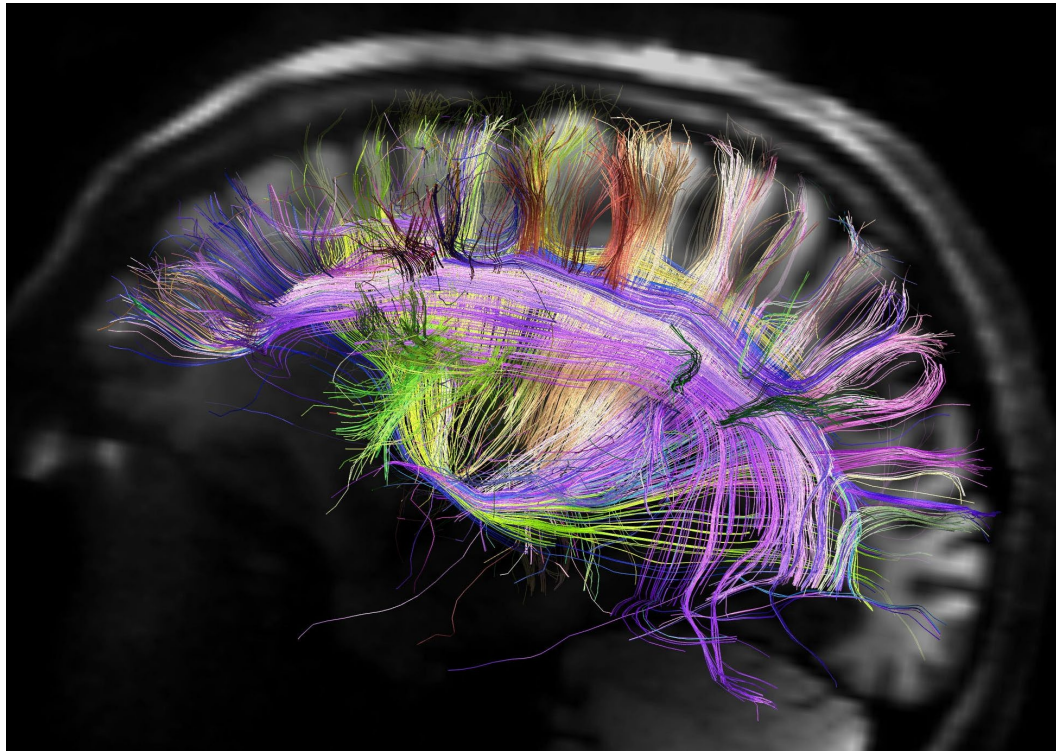


Ko Ho, CUHK

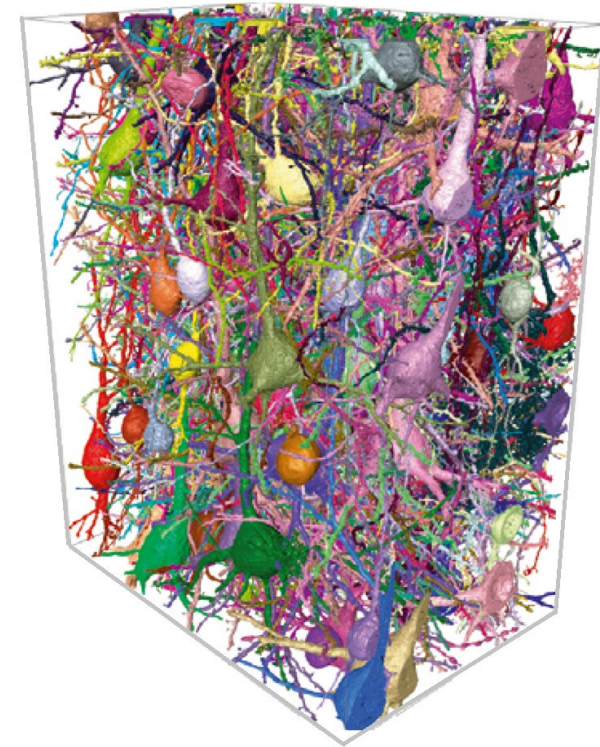
# Connectivity/connectome: a key physical basis of brain functions



# Connectivity/connectome: macro-/meso-scale vs microscale

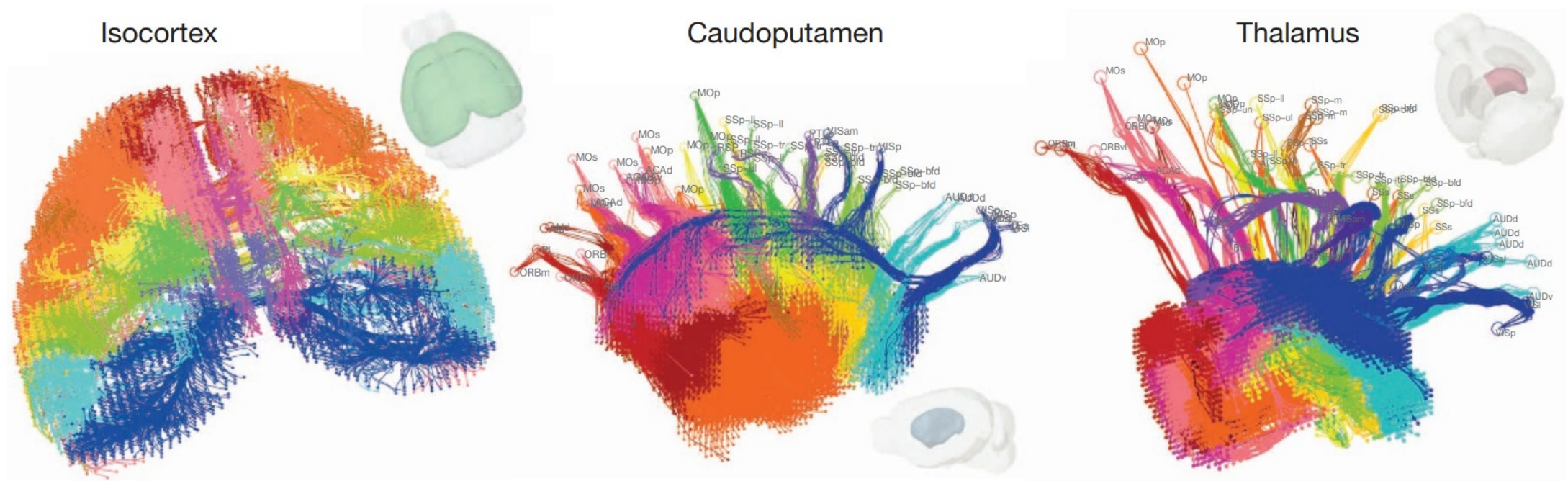


Human Connectome Project



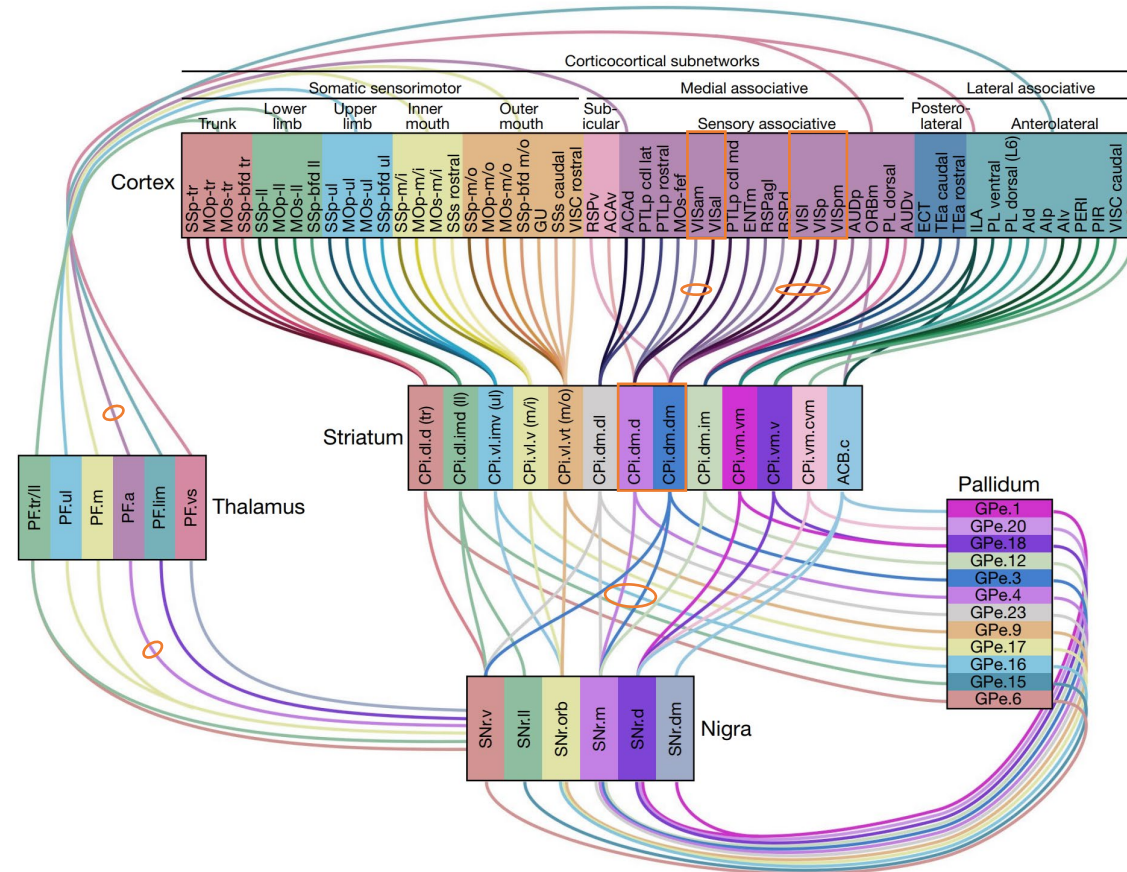
Lomba et al., Science, 2022

# Mesoscale connectome of the cortico-striatal-thalamic network



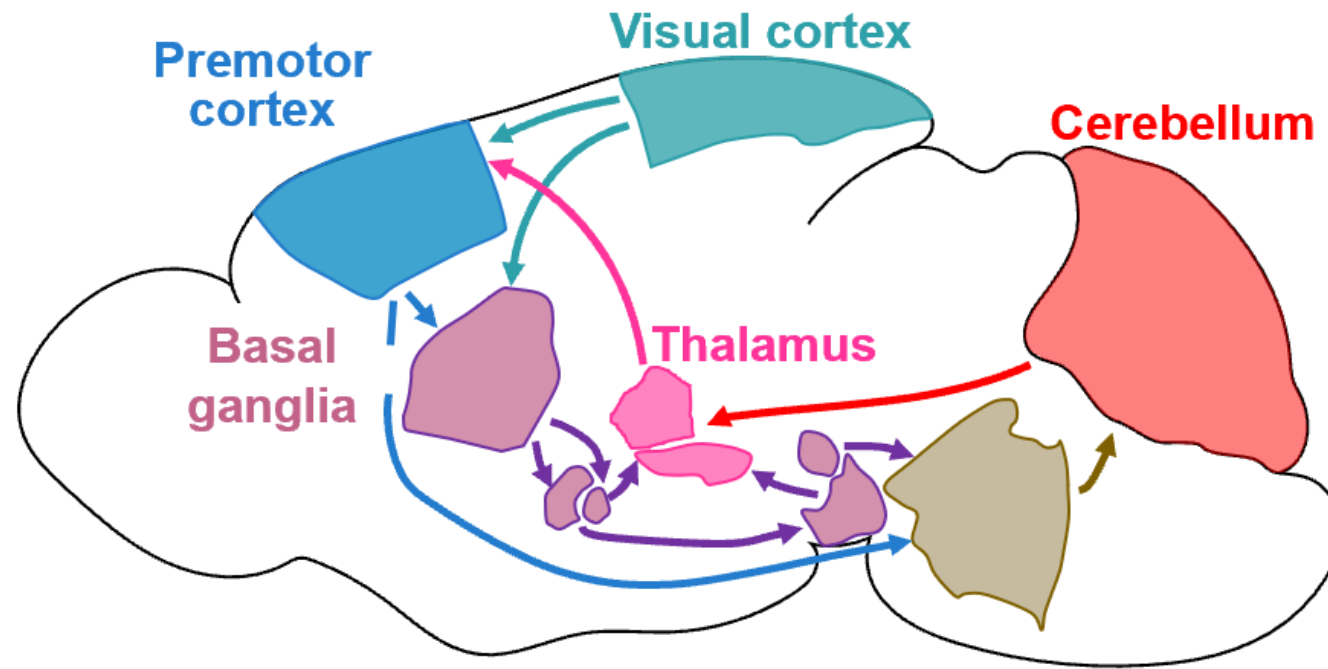
Oh et al., Nature, 2014

# Mesoscale connectome between mouse visual and motor areas



Foster et al., Nature, 2021

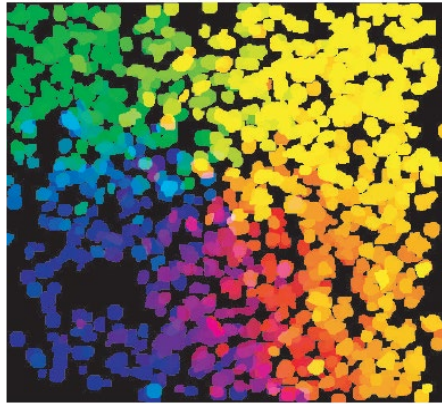
# Mesoscale connectome between mouse visual and motor areas



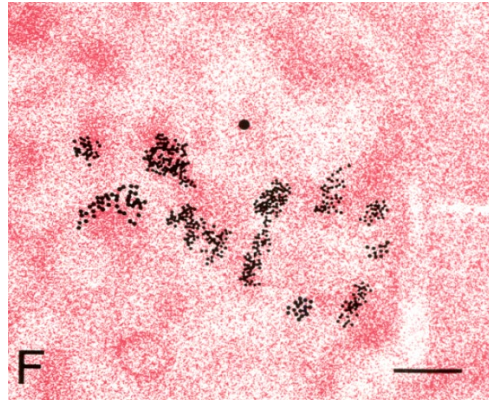
<https://www.sainsburywellcome.org/web/groups/mrsic-flogel-lab>

# Microscale functional connectivity/connectome of the visual cortex

Cat

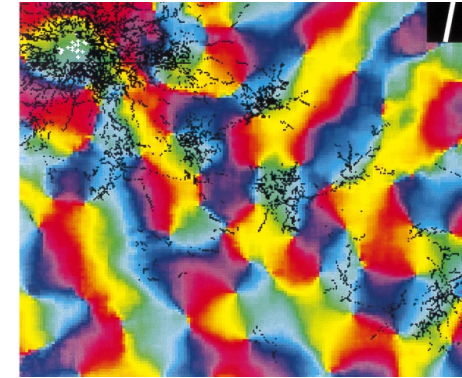


Ohki et al., 2006



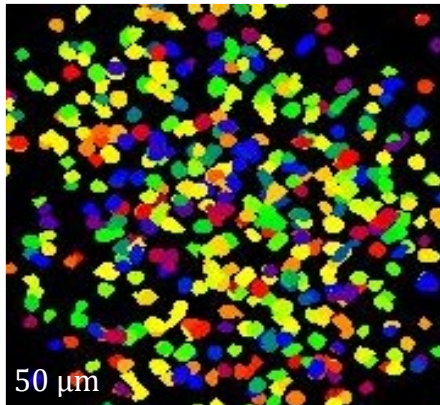
Gilbert et al., 1989

Tree shrew

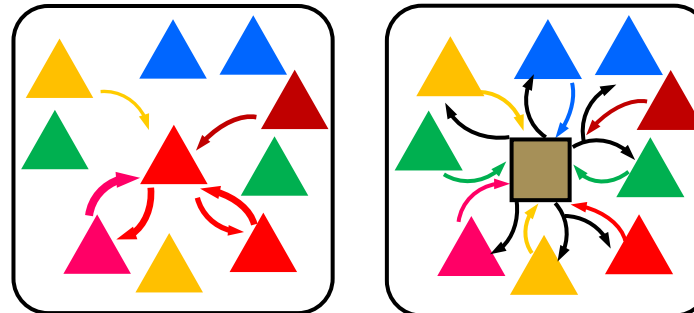


Bosking et al., 1997

Mouse



Conserved local synaptic connectivity patterns



- Yoshimura et al., Nature, 2005
- Yoshimura et al., Nat. Neuro., 2005
- Bock et al., Nature 2011
- Ko & Hofer et al., Nature, 2011
- Hofer & Ko et al., Nat. Neuro., & 2011
- Ko et al., Nature, 2013
- Ko et al., J. Neurosci., 2014
- Wertz et al., Science, 2014
- Cossell et al., Nature, 2015
- Lee et al., Nature, 2016
- Rossi et al., Nature 2020
- Most exciting recent development:



# How much do we know about the connectivity between visual and motor areas?

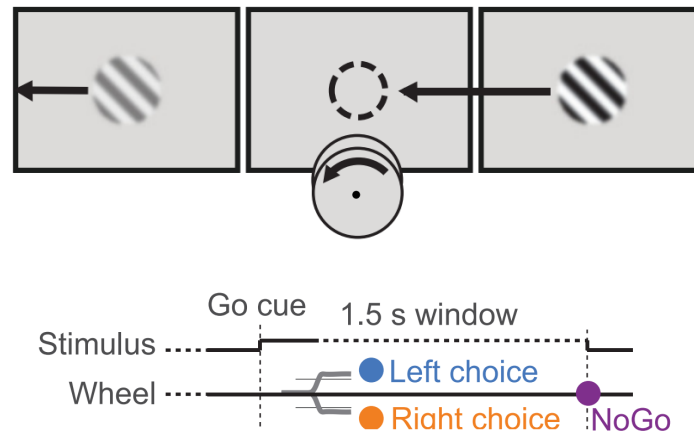
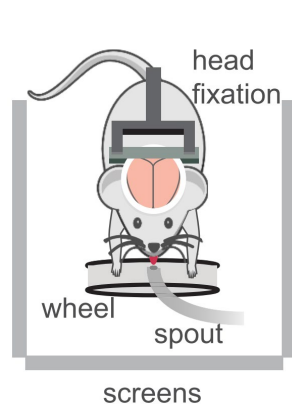
- To be honest, not much beyond the (relatively coarse) mesoscale connectivity/connectome.
- Many studies had however examined the projection pathways and neuronal activities across visual and motor areas to determine their interactions.

How are visual and motor areas involved in visual cue-guided motor behaviors or learning tasks?

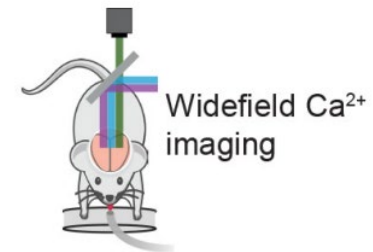
- Various tasks designed to study this question.
- Benefits from (i) well-standardized behavioral task, and (ii) high-throughput neuronal activity recording methods.

# A two-alternative unforced choice visual discrimination task

## Behavioral task

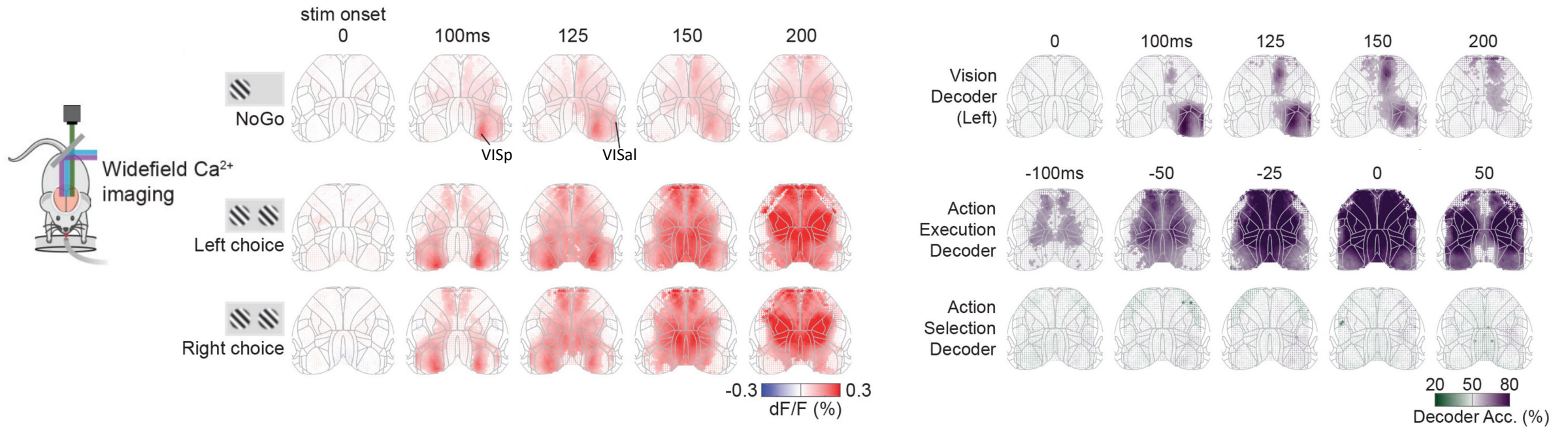


## Recording techniques



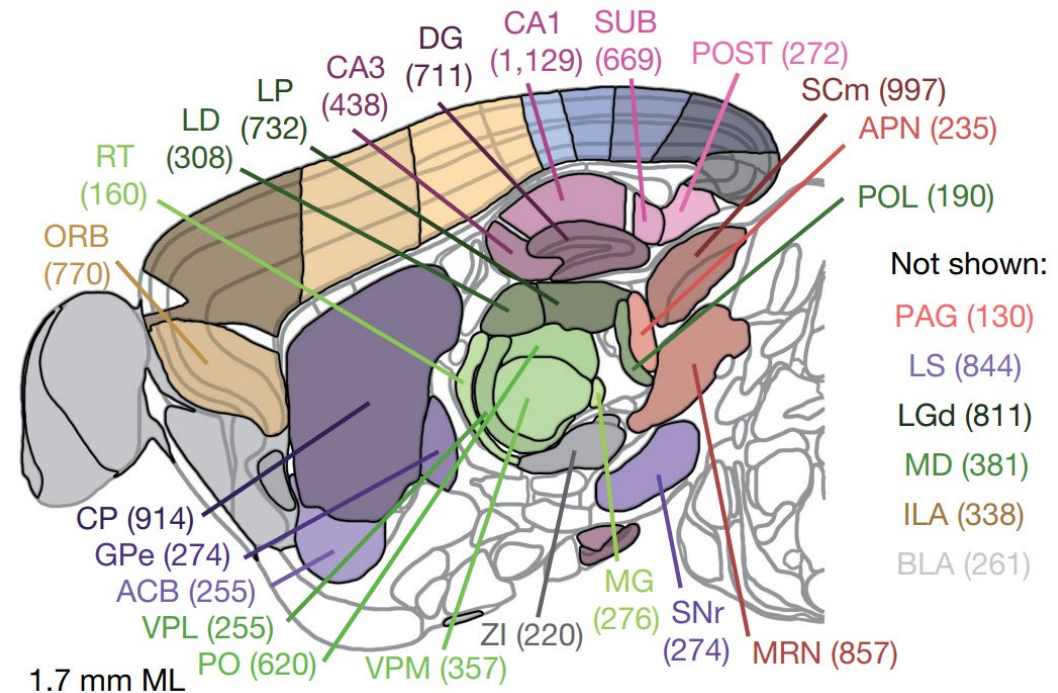
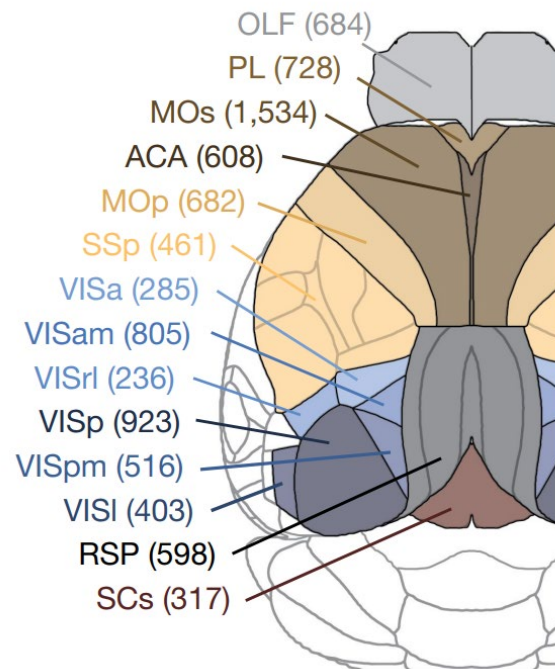
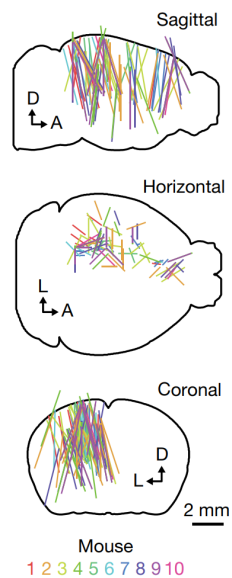
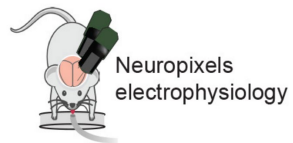
The International Brain Laboratory, eLife, 2021  
Zatka-Haas et al., eLife, 2021

# Cortical area activation during the visuomotor task



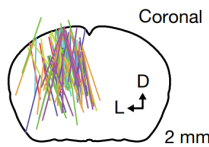
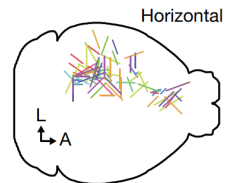
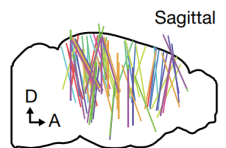
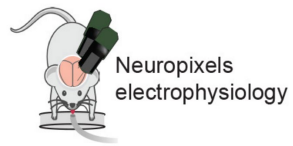
Zatka-Haas et al., eLife, 2021

# Coding of visual, decision/choice, and action across the brain

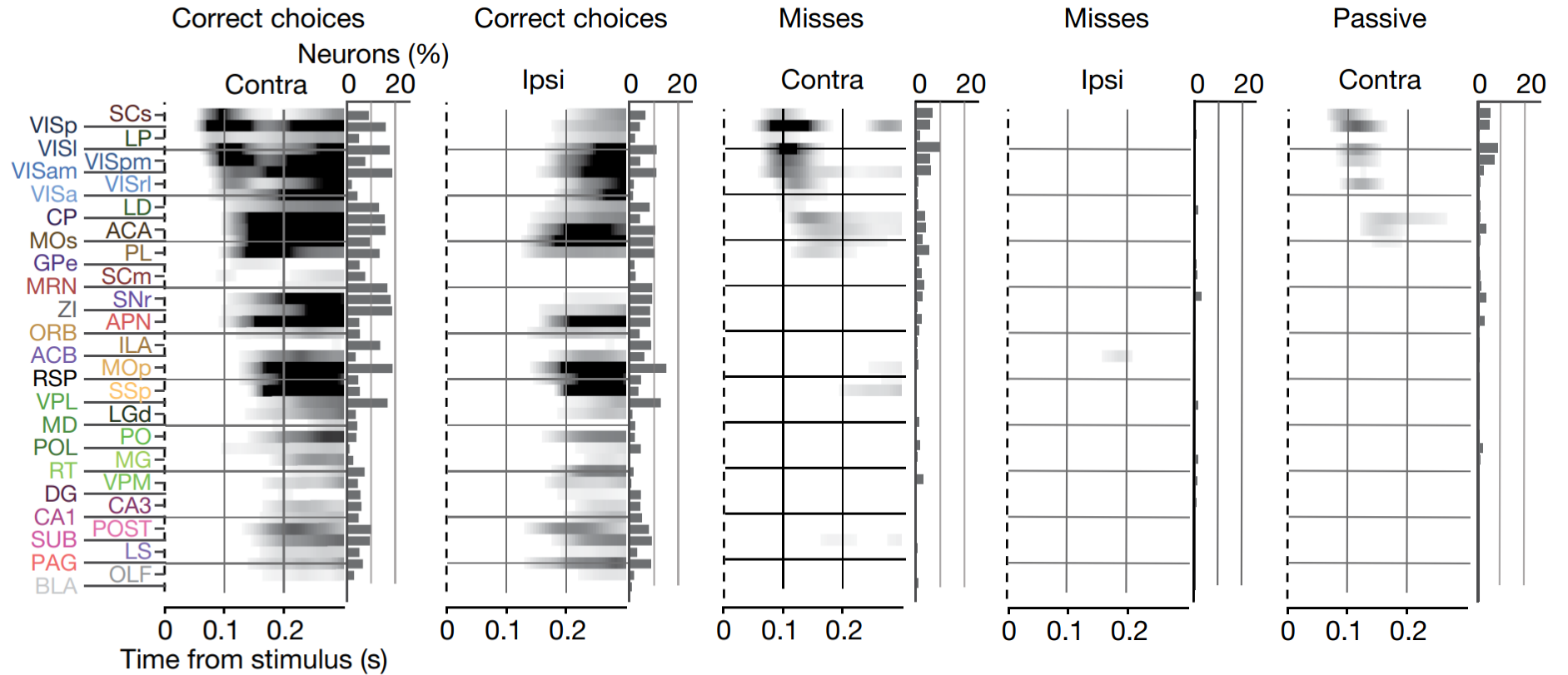


Steinmetz et al.,  
Nature, 2019

# Coding of visual, decision/choice, and action across the brain

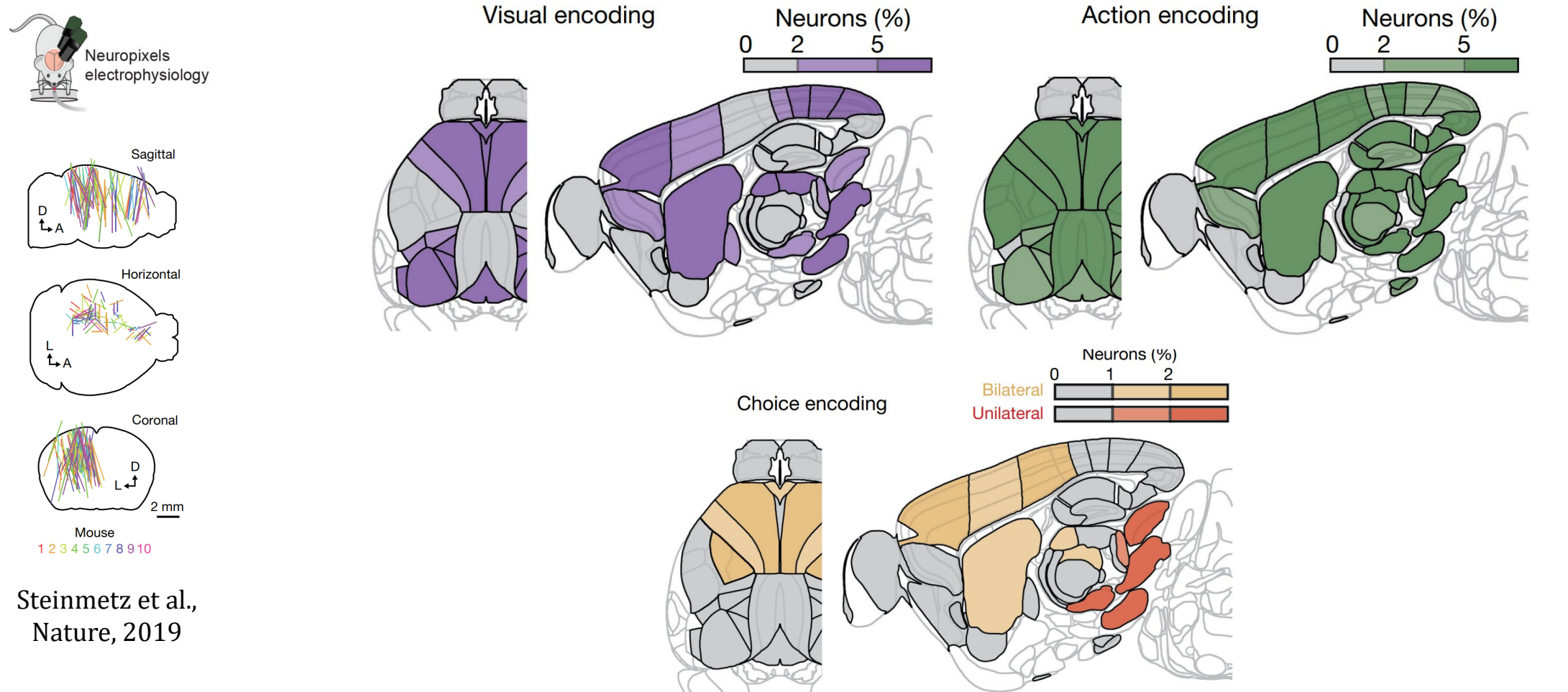


Mouse  
1 2 3 4 5 6 7 8 9 10



Steinmetz et al.,  
Nature, 2019

# Coding of visual, decision/choice, and action across the brain

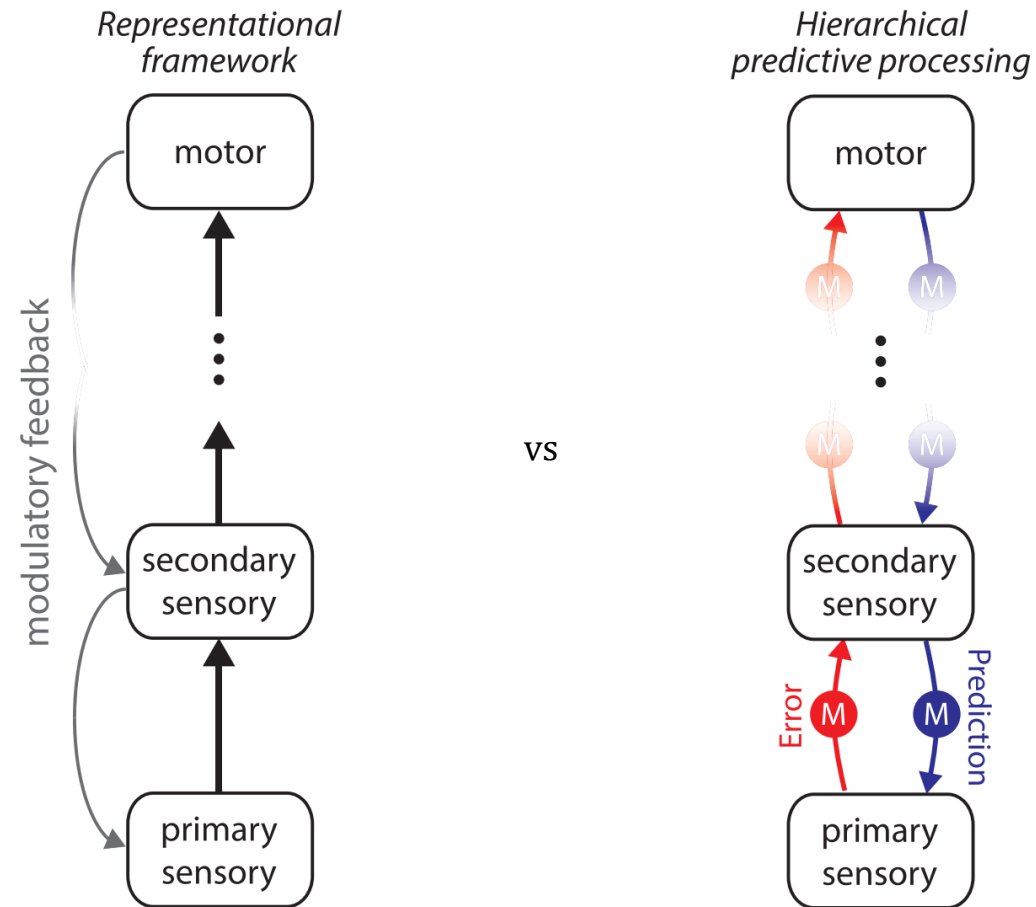


Steinmetz et al.,  
Nature, 2019

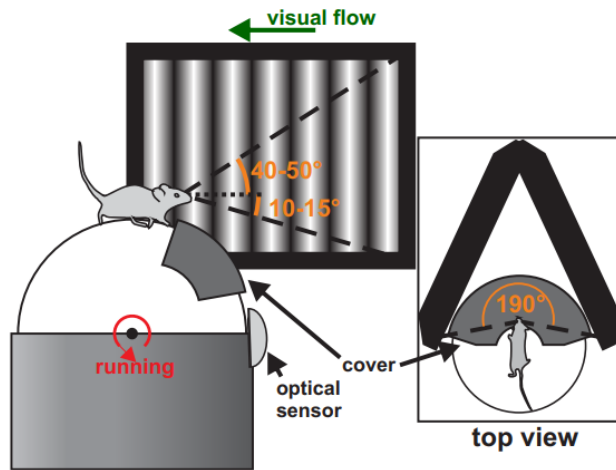
## Predictive coding in the mouse visual cortex

- The neurons in the primary sensory areas are not just passive encoders of input features
- Locomotion-derived expectation of visual flow modulate neuronal firing in primary visual cortex too.

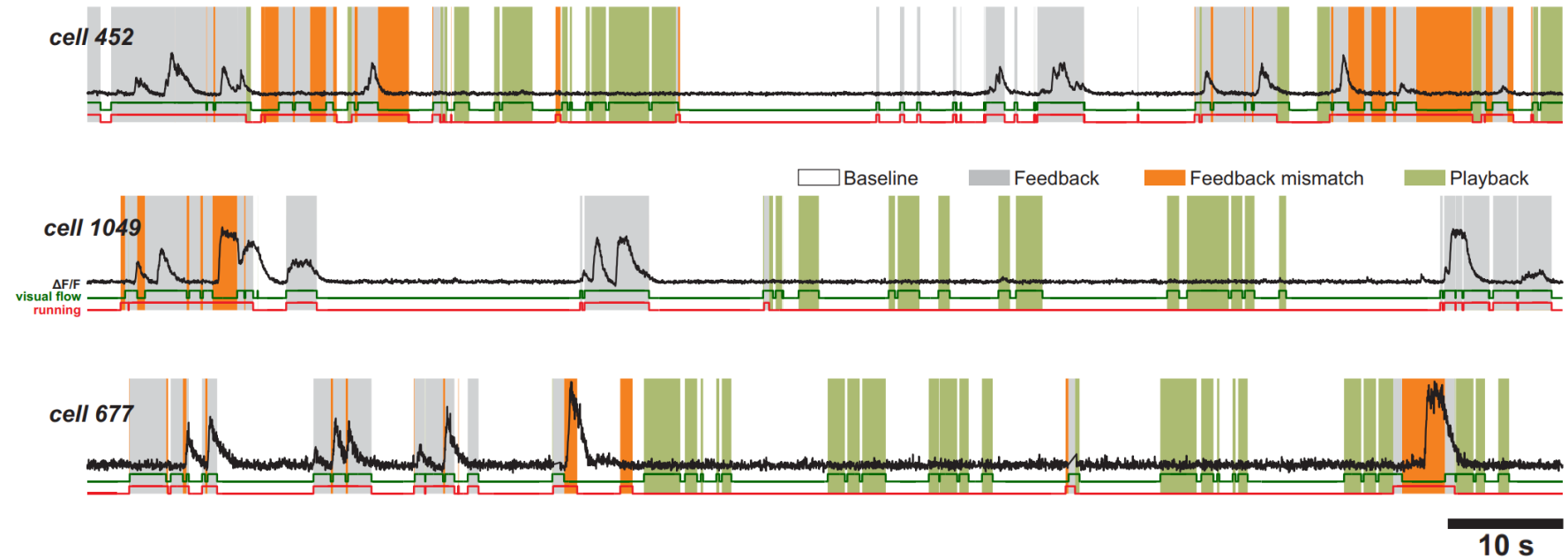
# Predictive coding in the mouse visual cortex



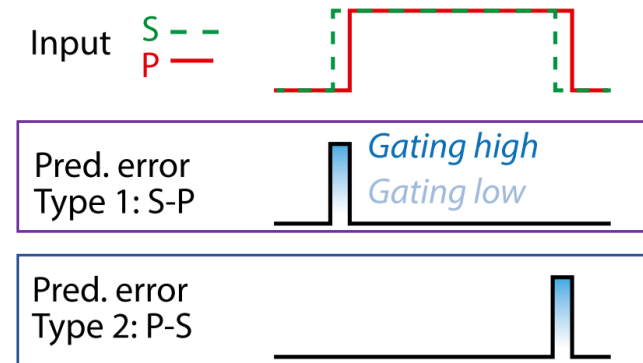
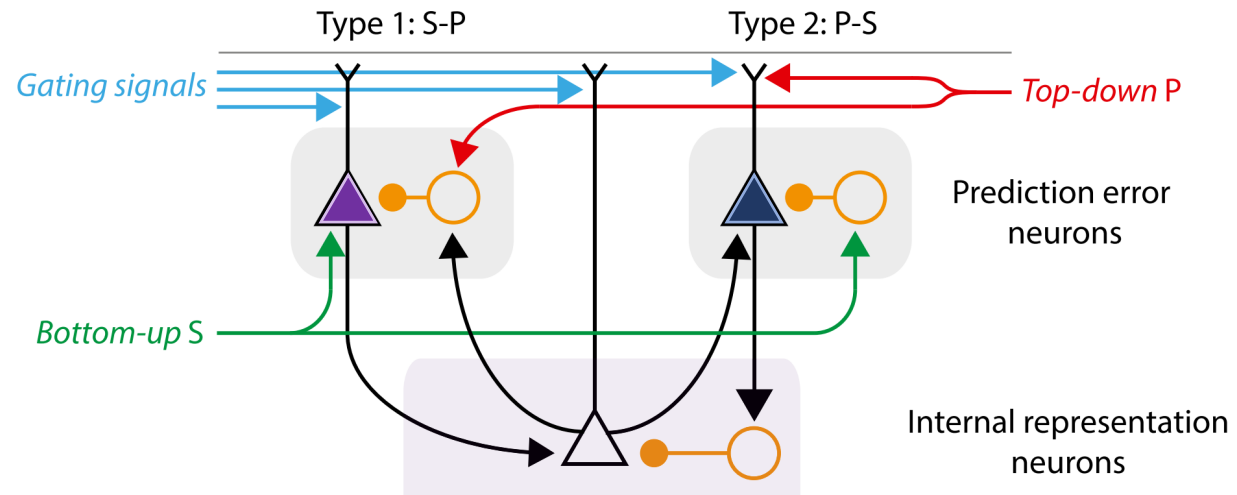
# Evidence of predictive coding in the mouse V1: mismatch neurons



Keller et al., Neuron, 2012



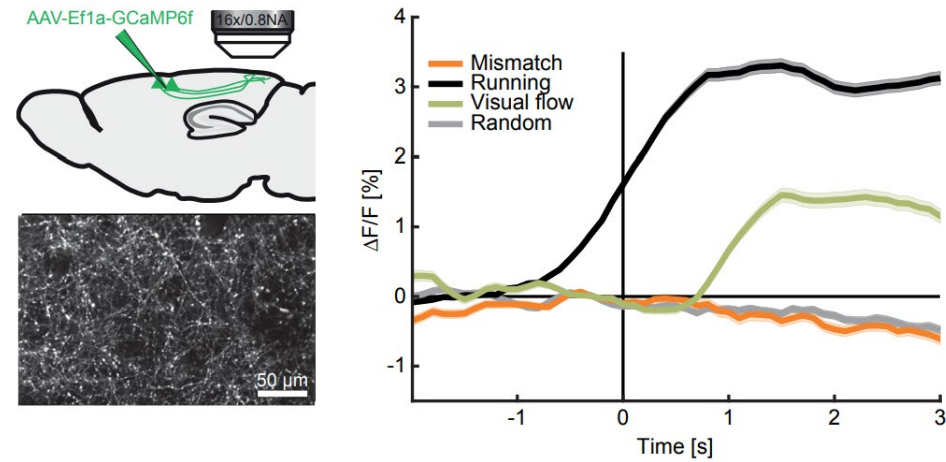
# Canonical circuits for predictive coding



Keller et al., Neuron, 2018

# Canonical circuits for predictive coding

Source of motor signals to mouse V1: A24b/M2



Leinweber et al., Neuron, 2017

Do we have more tractable models for visual and motor circuit interactions?

- Larval zebrafish is a very attractive model organism, especially for studying innate behaviors.
- A good illustrating example would be the circuit basis for phototaxis.

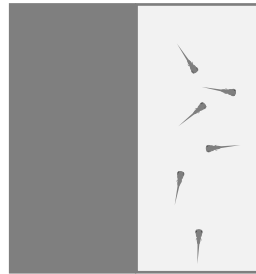
# Larval zebrafish

Larval zebrafish

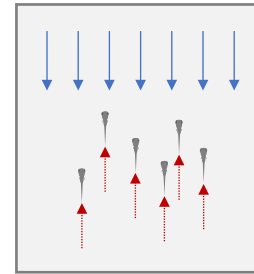


5 – 7 d.p.f.

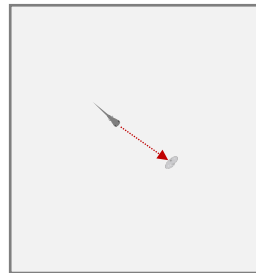
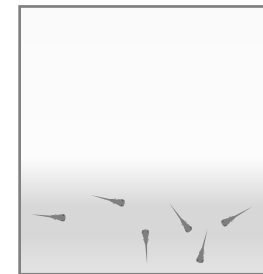
Phototaxis



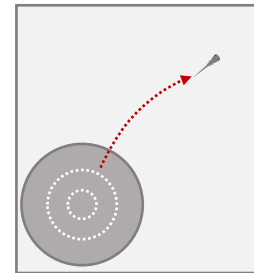
Rheotaxis



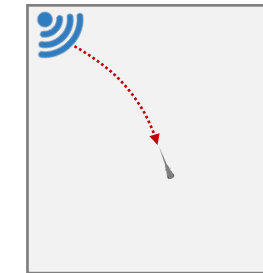
Chemotaxis



Prey capture



Looming  
escape



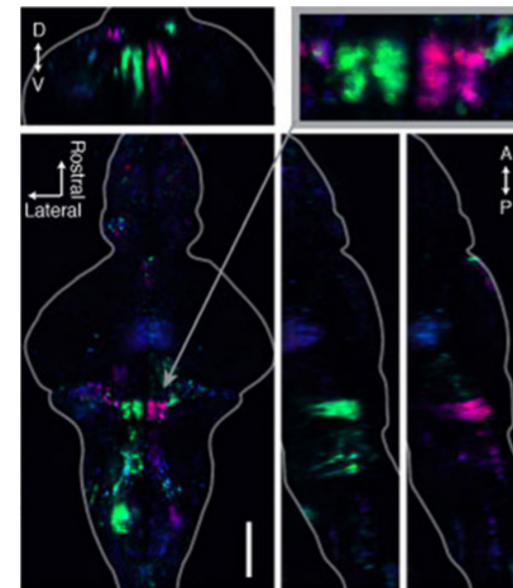
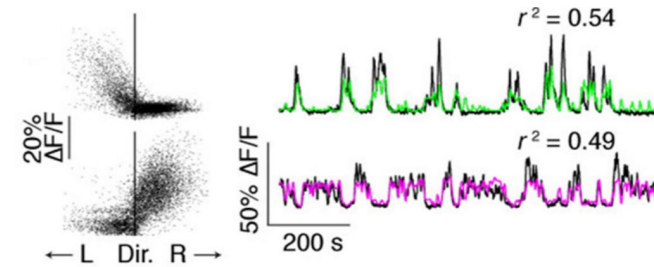
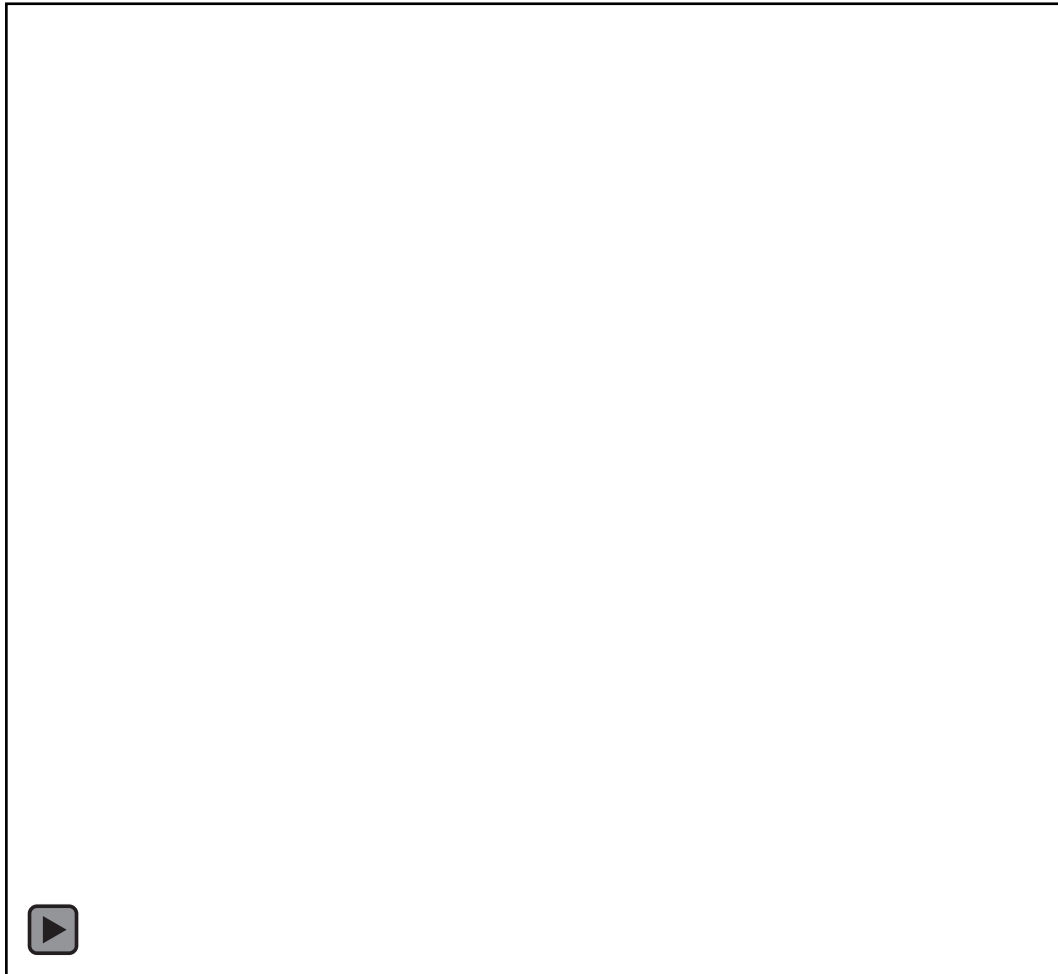
Startle  
responses

# Properties of spontaneous locomotion of larval zebrafish



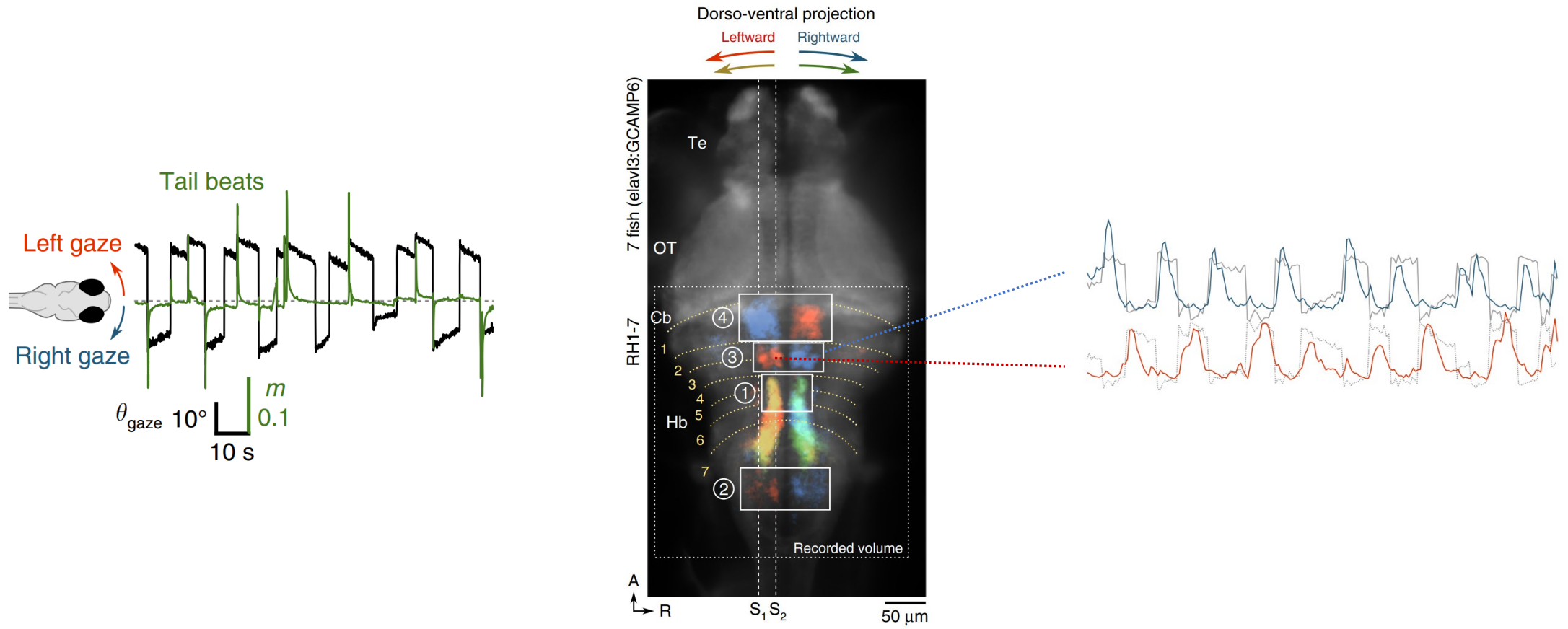
Dunn et al., eLife, 2016

# Hindbrain oscillatory activities underlying locomotion

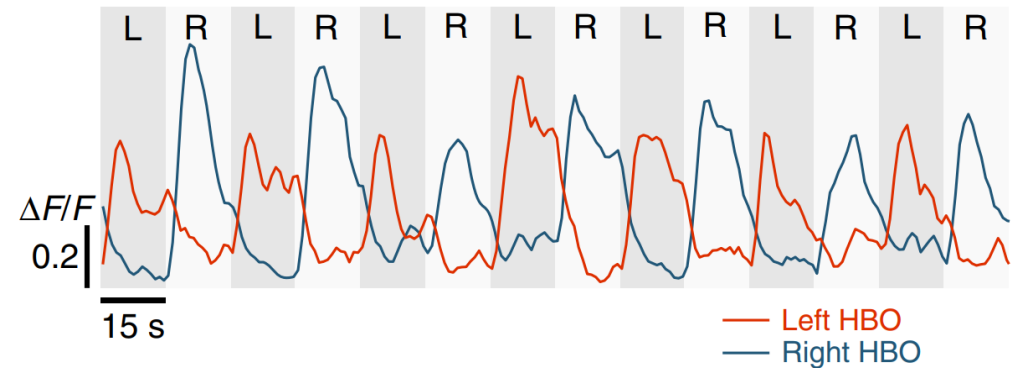
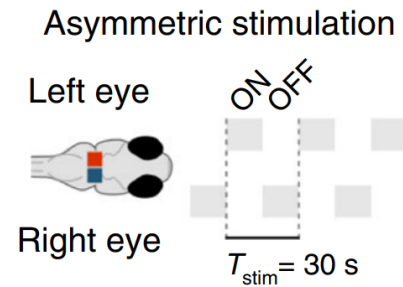
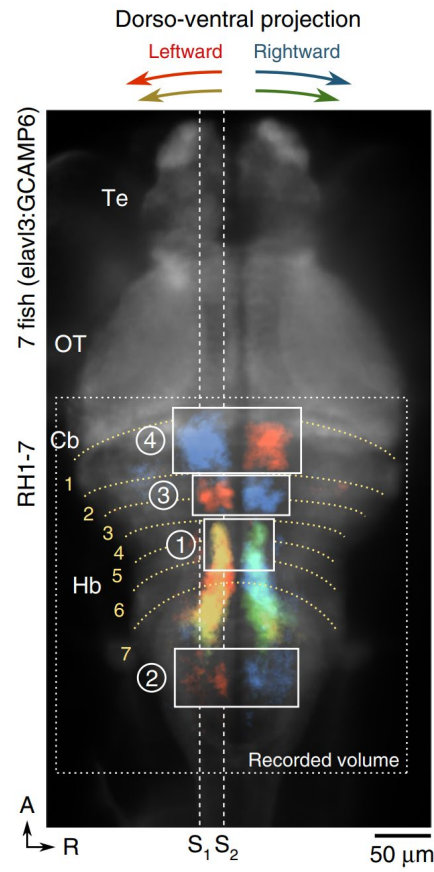


Dunn et al., eLife, 2016

# Neural circuits mediating saccades and phototaxis



# Neural circuits mediating saccades and phototaxis



# Model of larval zebrafish neural circuits mediating phototaxis

