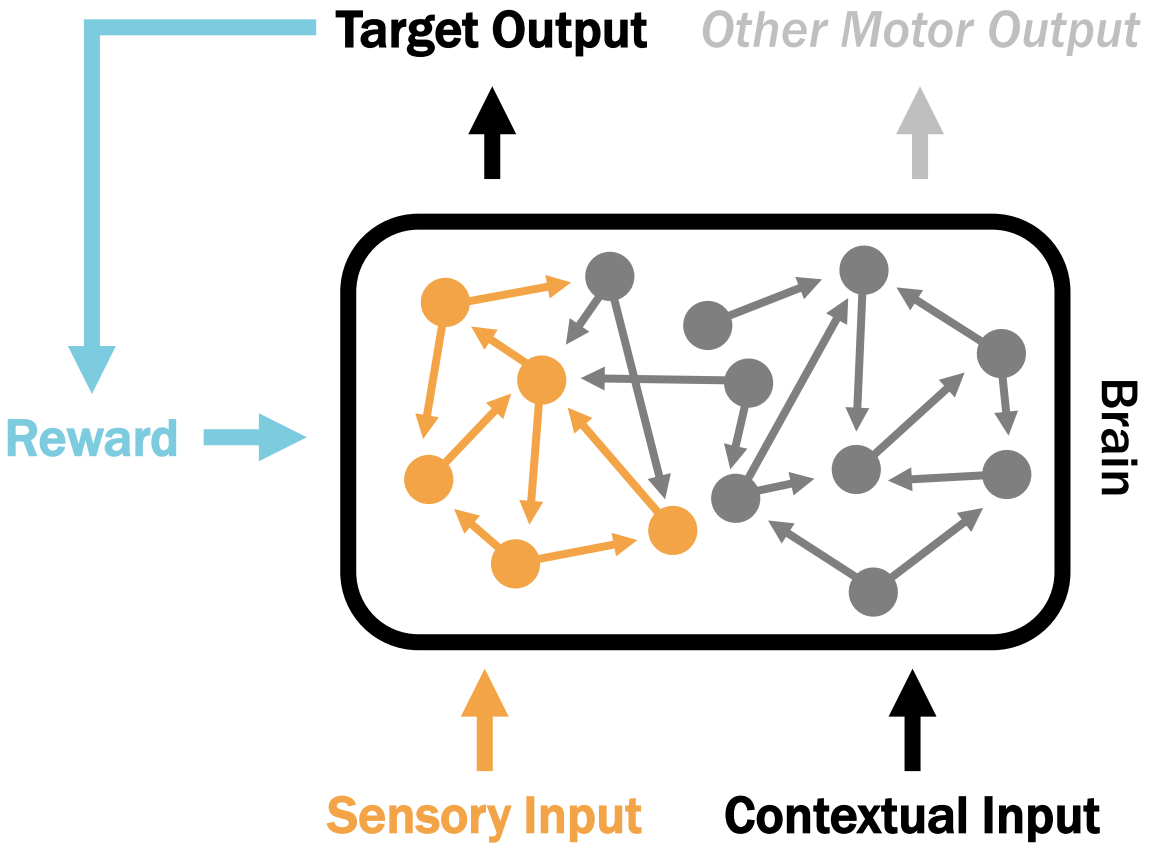
Neural Circuits for Sensorimotor Transformation

Understanding how neural circuits can learn and implement input-output functions is one of the big question in neuroscience

The Carl Petersen's laboratory (LSENS) identify circuits responsible for the transformation from sensory input to motor output (well-understood cortical regions)



Mice as Model Organism

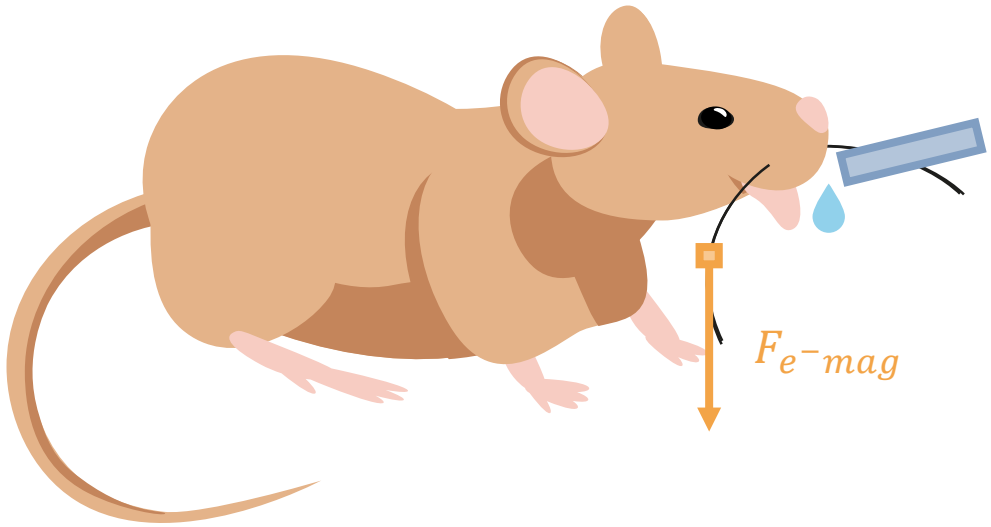
Taichi Suzuki, eLife 2015, https://doi.org/10.7554/eLife.05959.004

Mice (*Mus Musculus*) are widely used as model organism in research

- Similar genetic makeup to human (both mammals)
- Fast reproductive cycle

Mice are nocturnal animals, they perceive the world primarily through whisking, odour and audition

Whisker Detection Task



Hit

Whisker + Lick ↦

Miss

Whisker + ~~Lick~~ ↦ ~~💧~~

In a whisker detection task, mouse report a whisker sensory event by licking: upon which they receive water as a reward

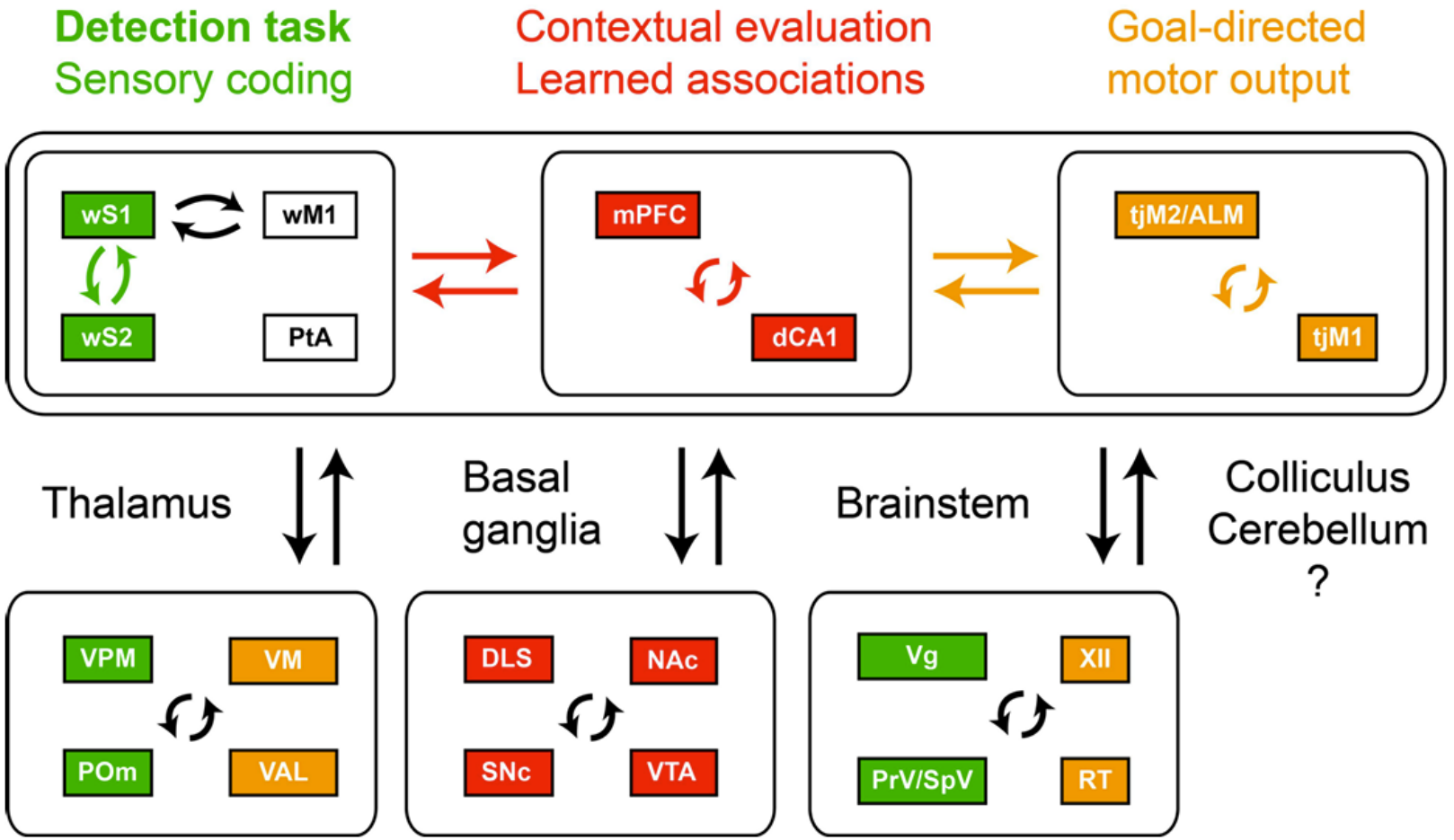
The whisker movement is initiated by a small ferromagnetic weight attached to a single whisker. The weight is moved down when a magnetic field is turned on

P. Ghaderi et al. 202X (in review)

Complex Brain-Wide Circuits

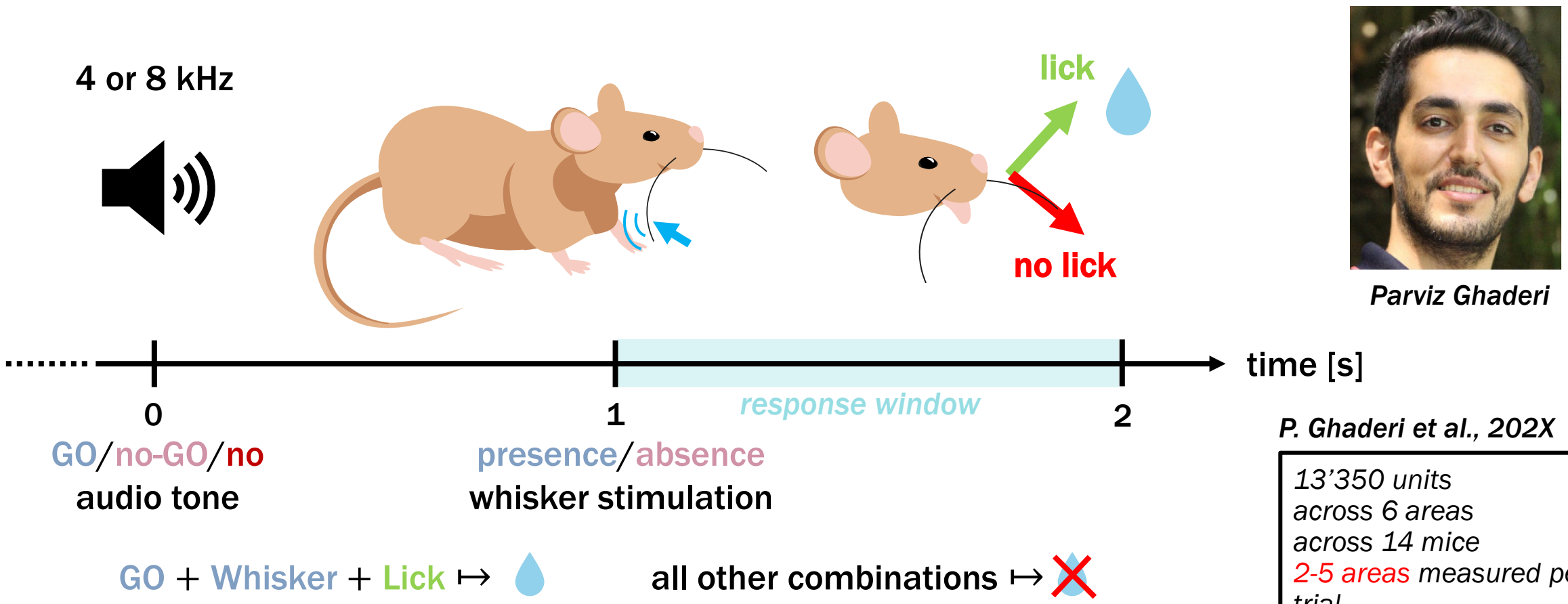
Even for such a “simple” task, the circuitry involves various areas across the brain, among which in the cortex:

- primary whisker sensory areas wS1, wS2
- Primary motor area wM1
- Motor coordination area ALM



Adapted from Carl Petersen BIO-493

Context-based Delayed Detection Task



Parviz Ghaderi

P. Ghaderi et al., 202X

13'350 units
across 6 areas
across 14 mice
2-5 areas measured per trial
+ tongue & jaw activities

P. Ghaderi et al. 202X (in review)

Trial Types

Type	Audio	Whisker
1	GO	Yes
2	GO	No
3	NOGO	Yes
4	NOGO	No
5	-	Yes

Lick	Reward
Yes	Yes
No	No
Yes	No
No	No
Yes	No
No	No
Yes	No
No	No
Yes	No
No	No

Raw Dataset

animal PG085

session 20221215

Neuron ID	Firing Times [s]
0	0.0024, 0.00157, …
1	0.0056, 0.02564, …
2	0.0078, 0.0099, …
…	

Trial ID	Onset [s]	Type	Lick	Early Lick
0	0.01256	1	True	False
1	4.7256	5	False	False
…				

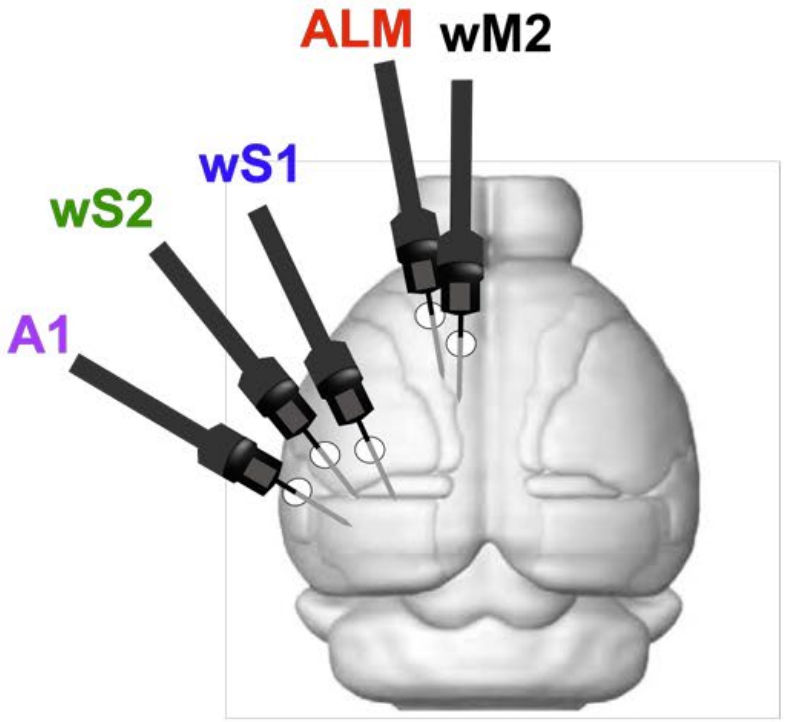
Neuron ID	Area	Depth	Type
0	wS1	L2/3	EXC
1	A1	L5	INH
…			

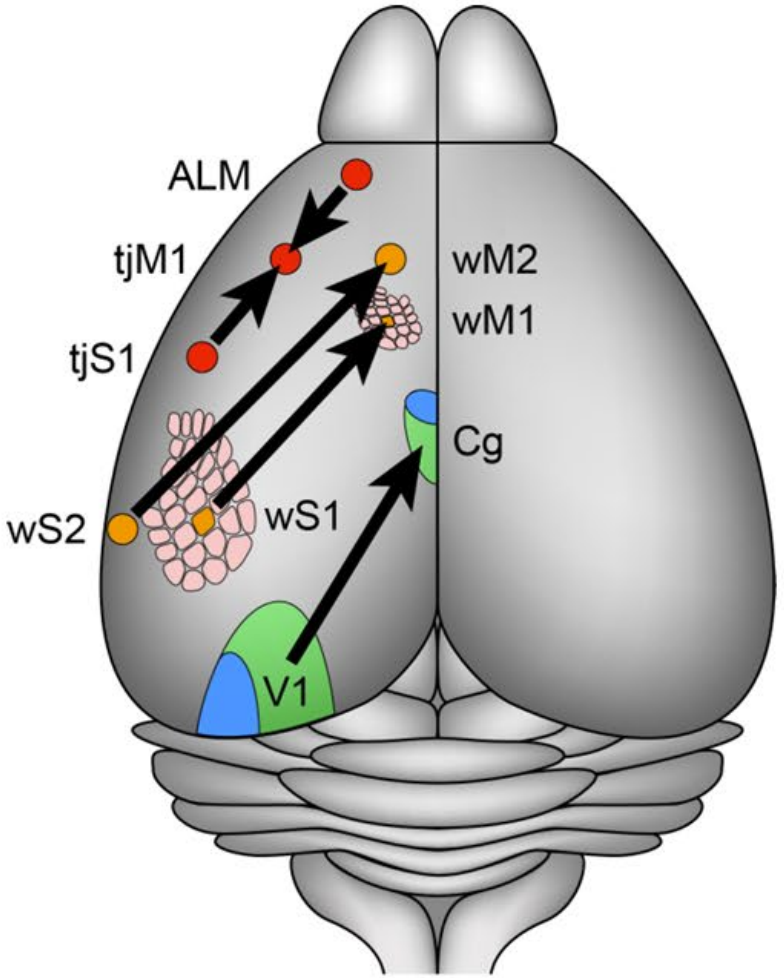
Recorded areas comprise wS1, wS2, A1, wM1, ALM

With three mice, each having 3 sessions with roughly 500 trials each.

Neurons recorded change each session!

Recorded Areas





Adapted from Carl Petersen BIO-493

Pre-Processed Dataset

X

Session ID	Trial #	AREA_DEPTH_TYPE_time_T	...
PG082_20221113	0	0.8333	
PG082_20221113	1	0.3888	
PG082_20221113	2	0.3333	
PG082_20221113	3	0.5000	
...			

y

Trial Type+Response
NOGO W+ nolick
GO W+ lick
GO W- lick
NOGO W- nolick

Average # spikes in time bin T **for neurons in area** *AREA* **at depth** *DEPTH* **and of type** *TYPE*

Time bins are 200 ms long and cover the span from -1s before trial start up to 2s after trial start (end of the response window)