Miniscope Analysis

Wilke Lab Mtg.

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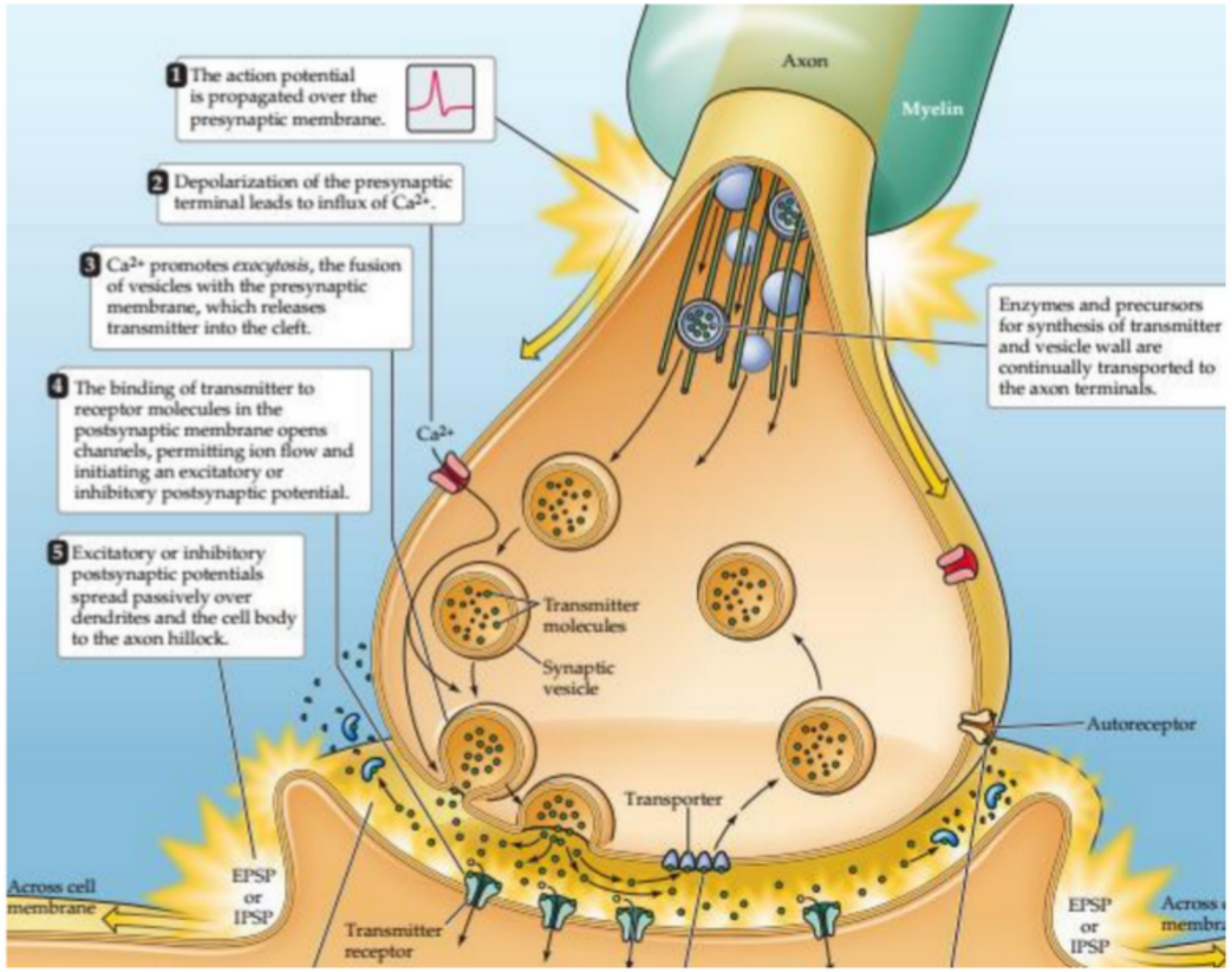
Outline

- Motivation/Background
- Setup/Procedure
- Analysis
- Next steps

Motivation/Background

- ACC necessary for Effort-Based Decision-Making (EBD)
- Decision -> ACC activity -> Action Potentials -> Ca2+ ion influx



When the action potential arrives at the end of the axon terminal, voltage-gated calcium channels open. Entry of calcium triggers a biochemical cascade leading to fusion of neurotransmitter-containing vesicles.

Release of neurotransmitter from the pre-synaptic cell completes the goal of the action potential!

25

Photo Credit: Avishek Adhikari, PSYCH 115 Lecture 4 Slides

Background

- GCaMP7f binds to calcium and fluoresces green
- brightness of neurons ~ analog neural activity signal

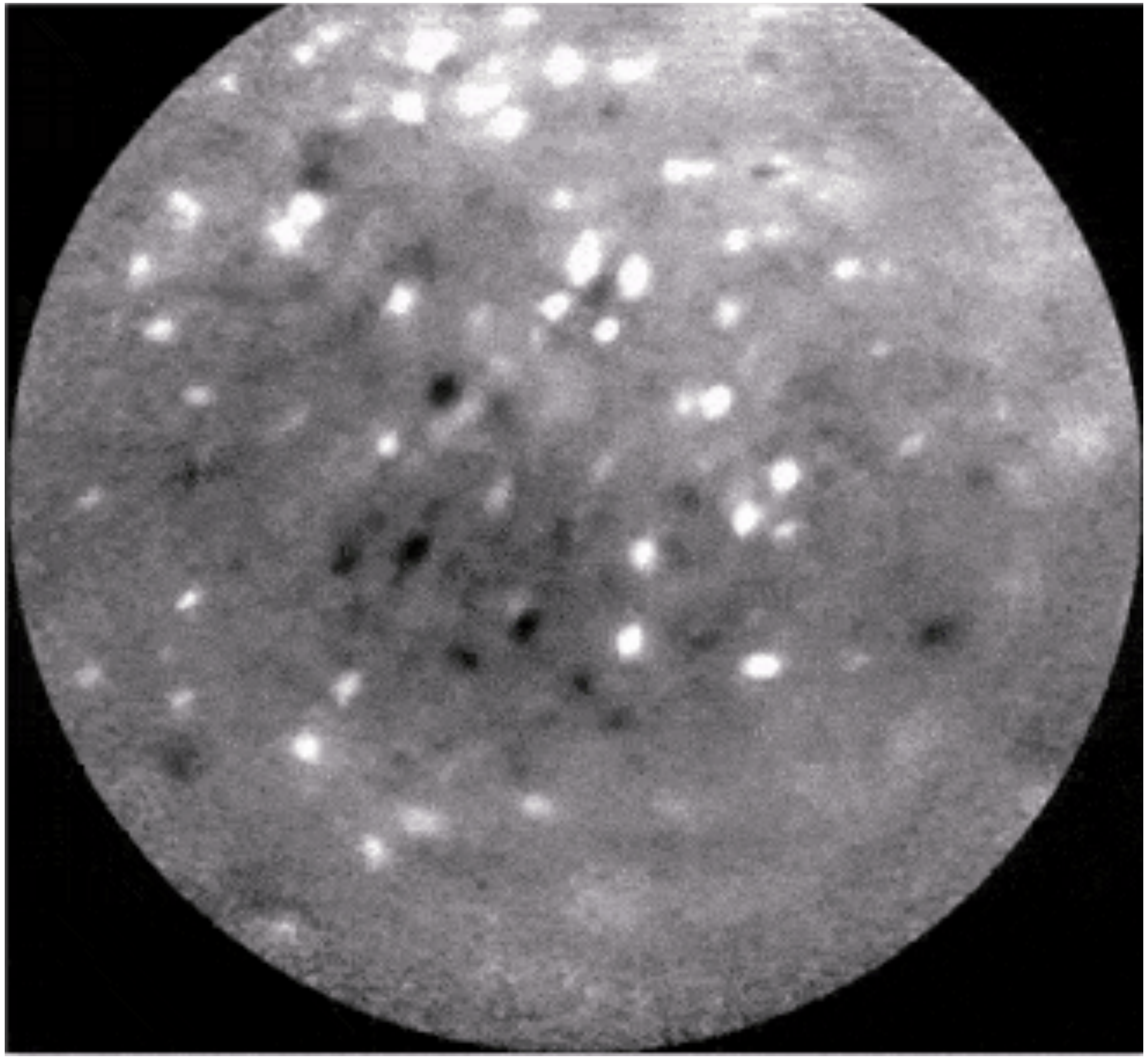
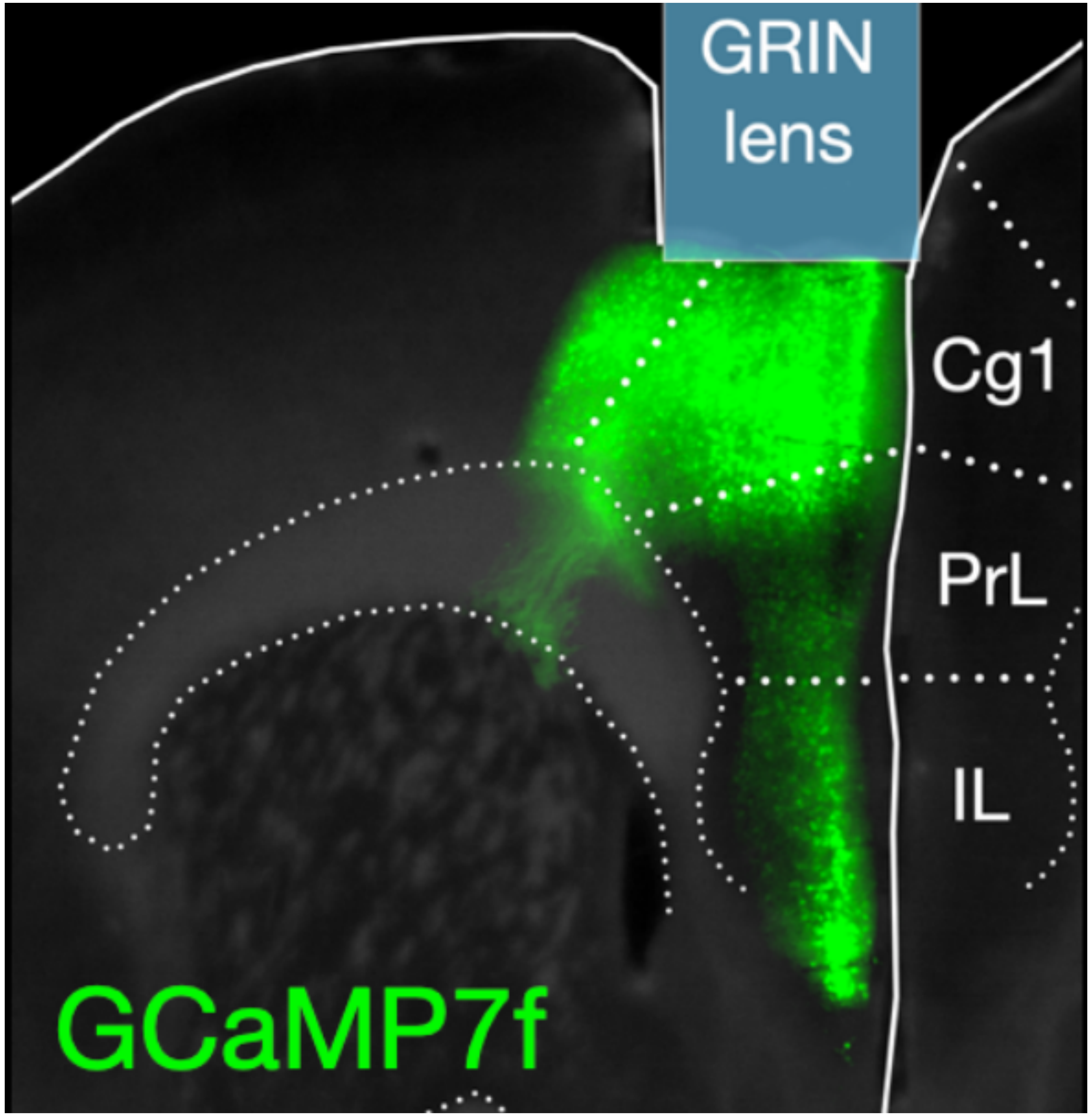
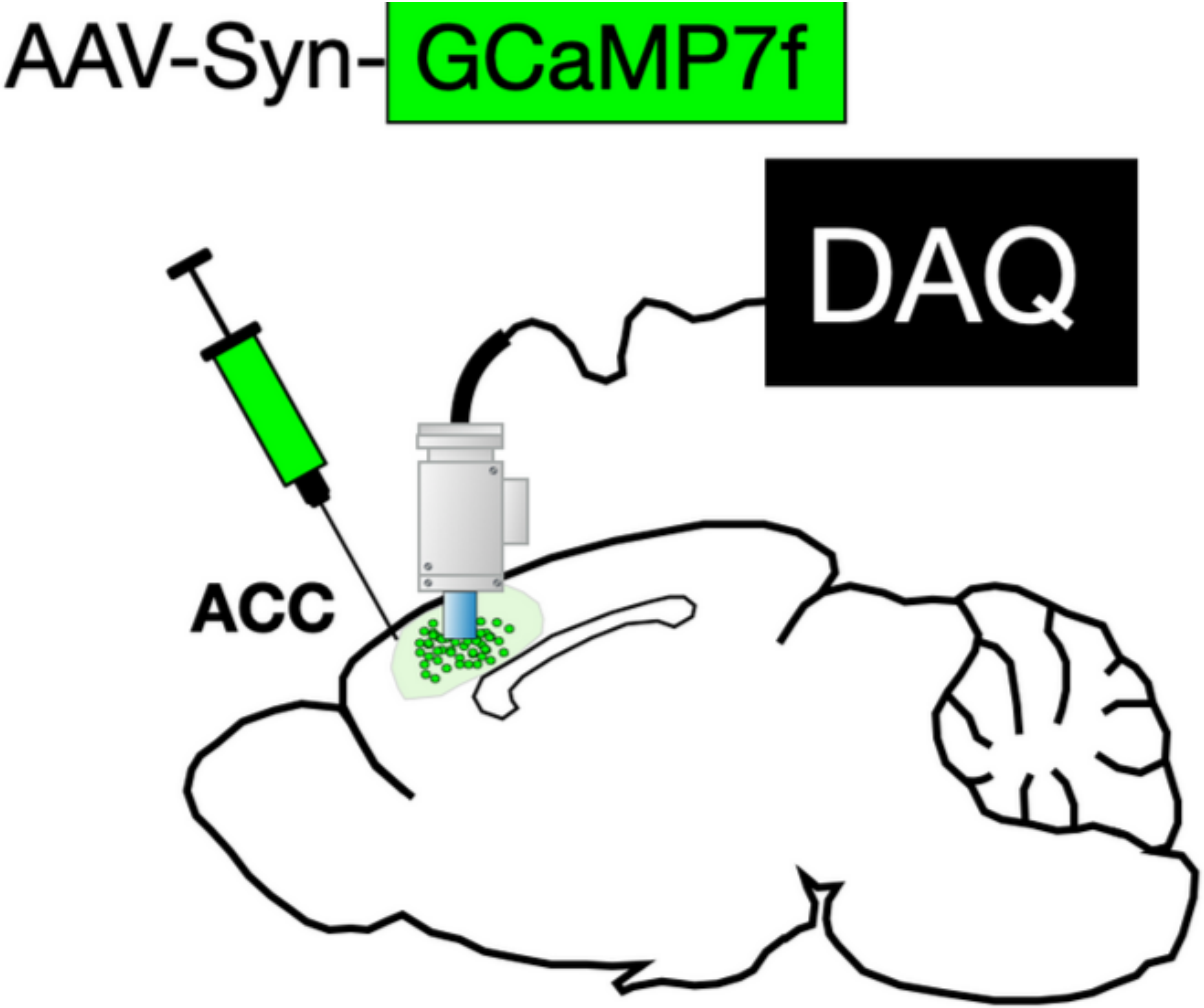


Photo Credit: Daniel Aharoni, Miniscope-v4 wiki

Setup

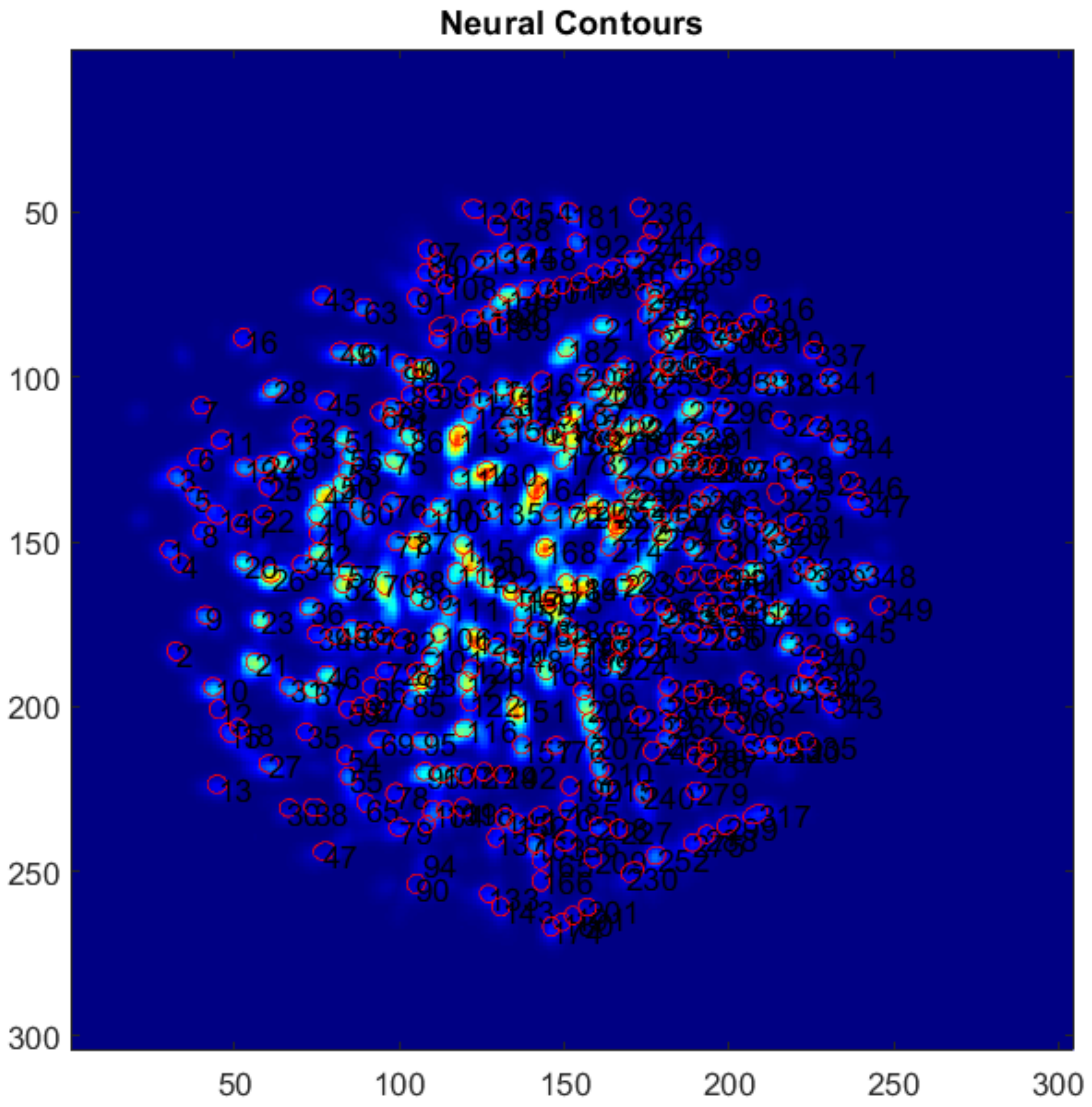
1. GCaMP7f injection into ROI (ACC)
2. Gradient Index (GRIN) lens implanted over injection site
3. Inscopix Miniscope mounted over lens

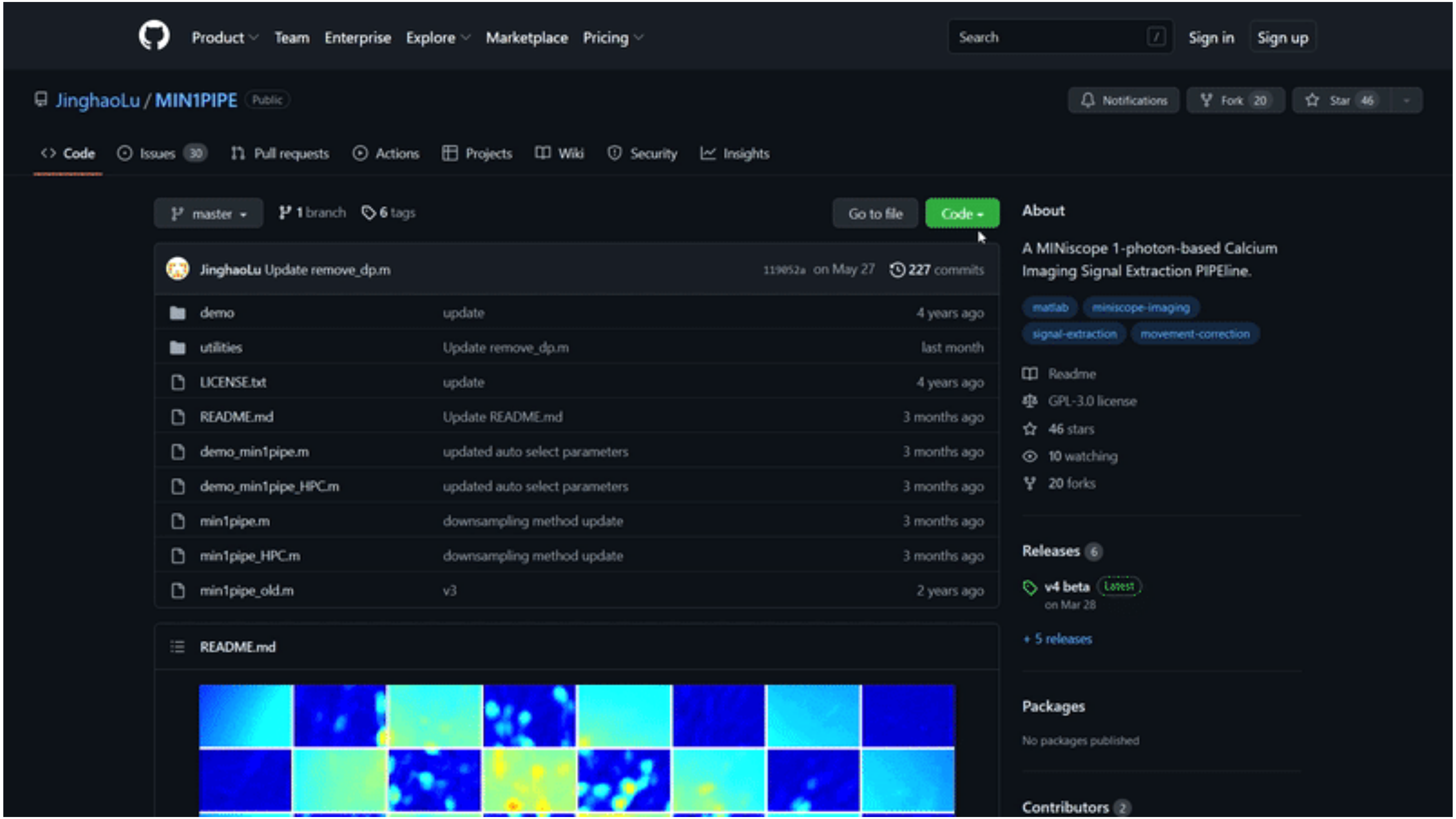



AAV-Syn-GCaMP7f
DAQ
ACC

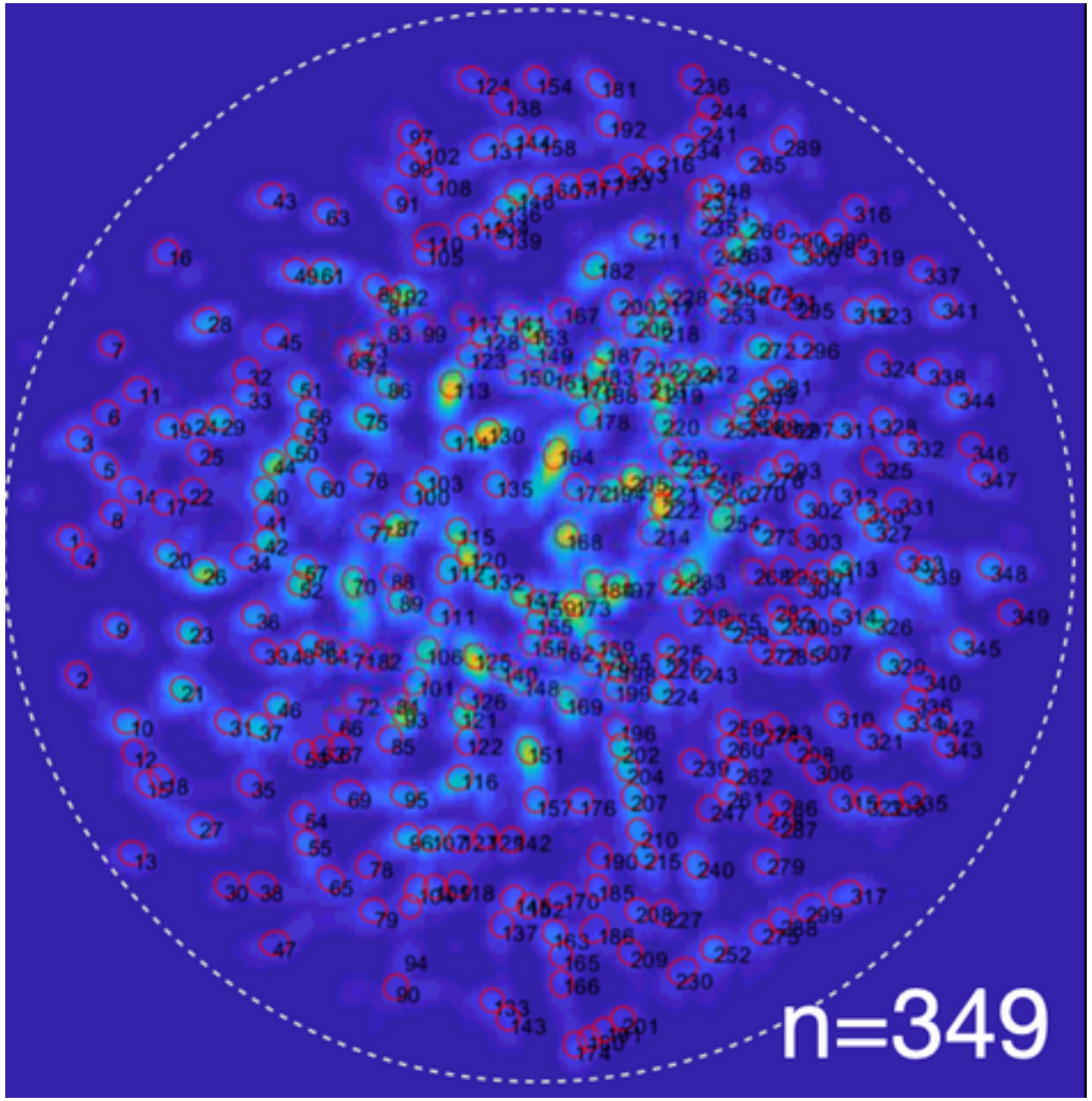
Procedure

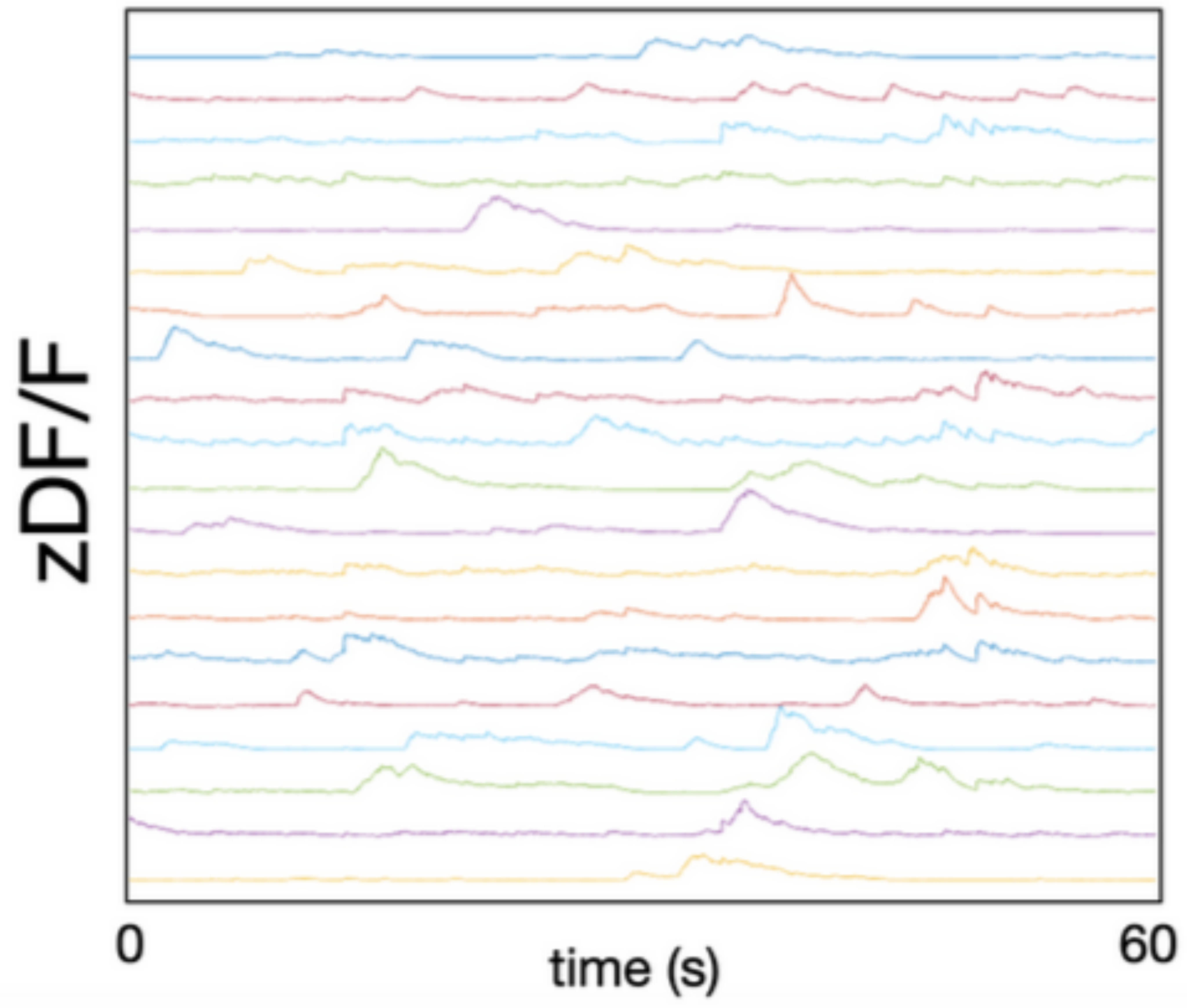
- Run Miniscope mice through maze
- Run video through MIN1PIPE





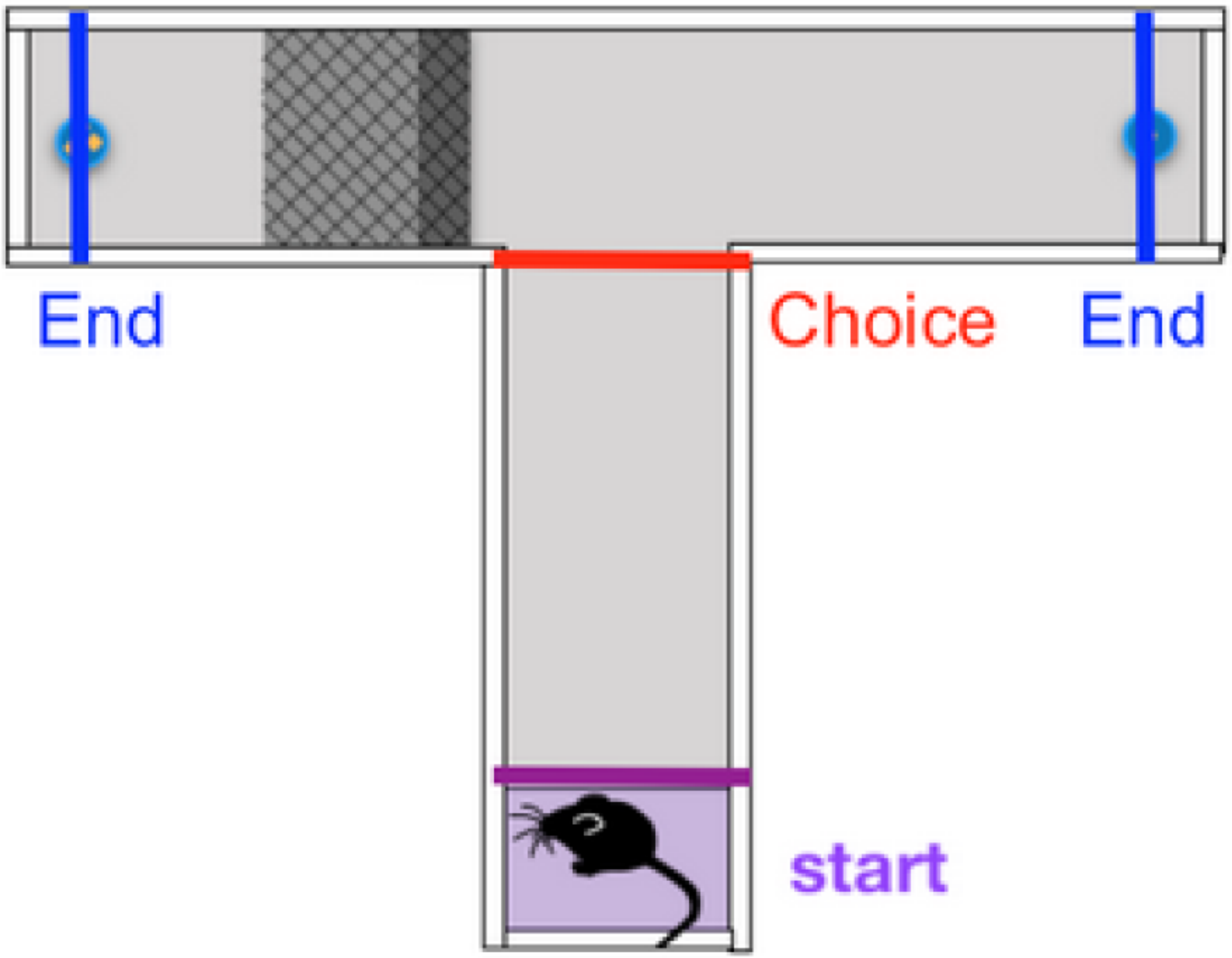
https://github.com/JinghaoLu/MIN1PIPE


n=349


zDF/F
0
time (s)
60

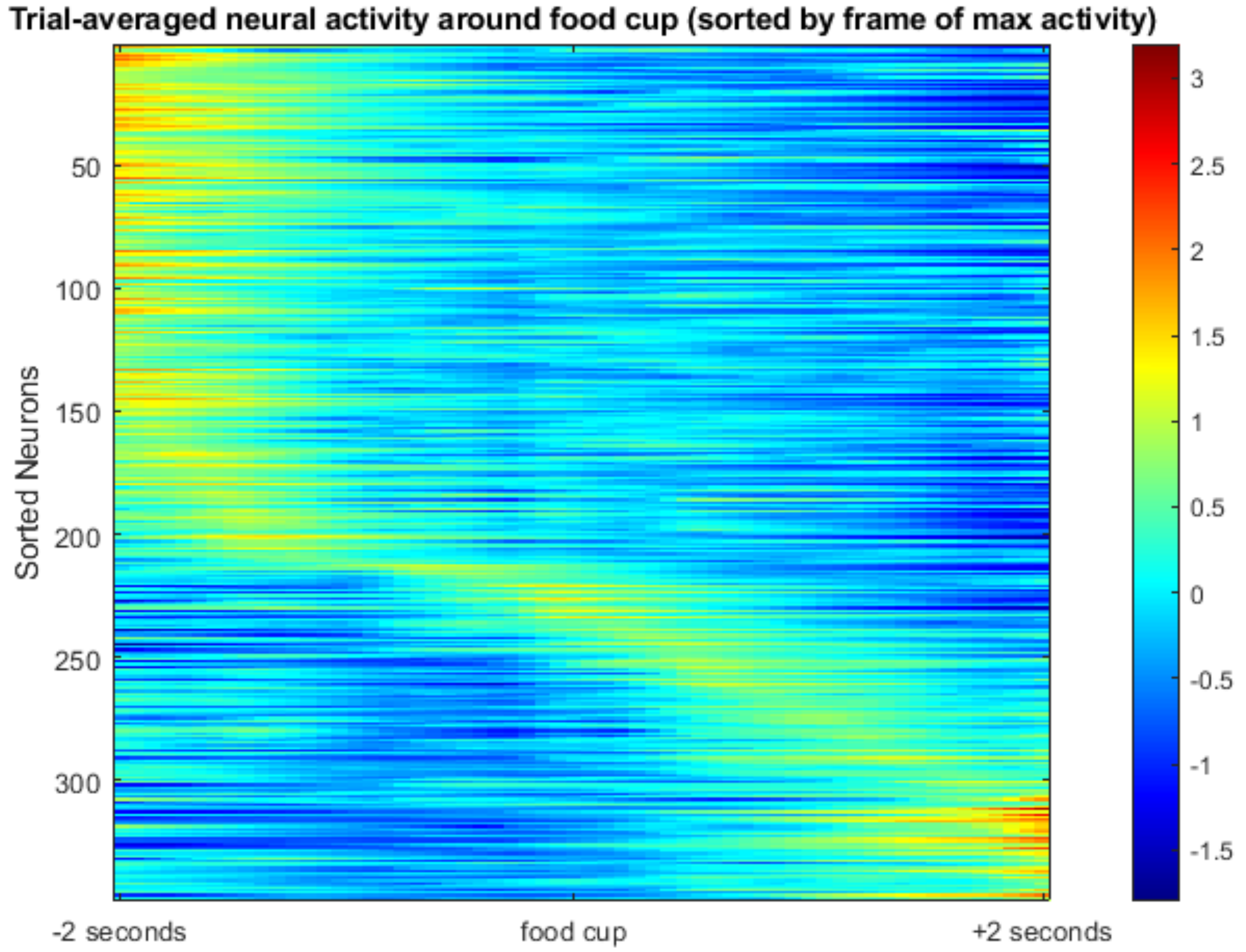
Analysis

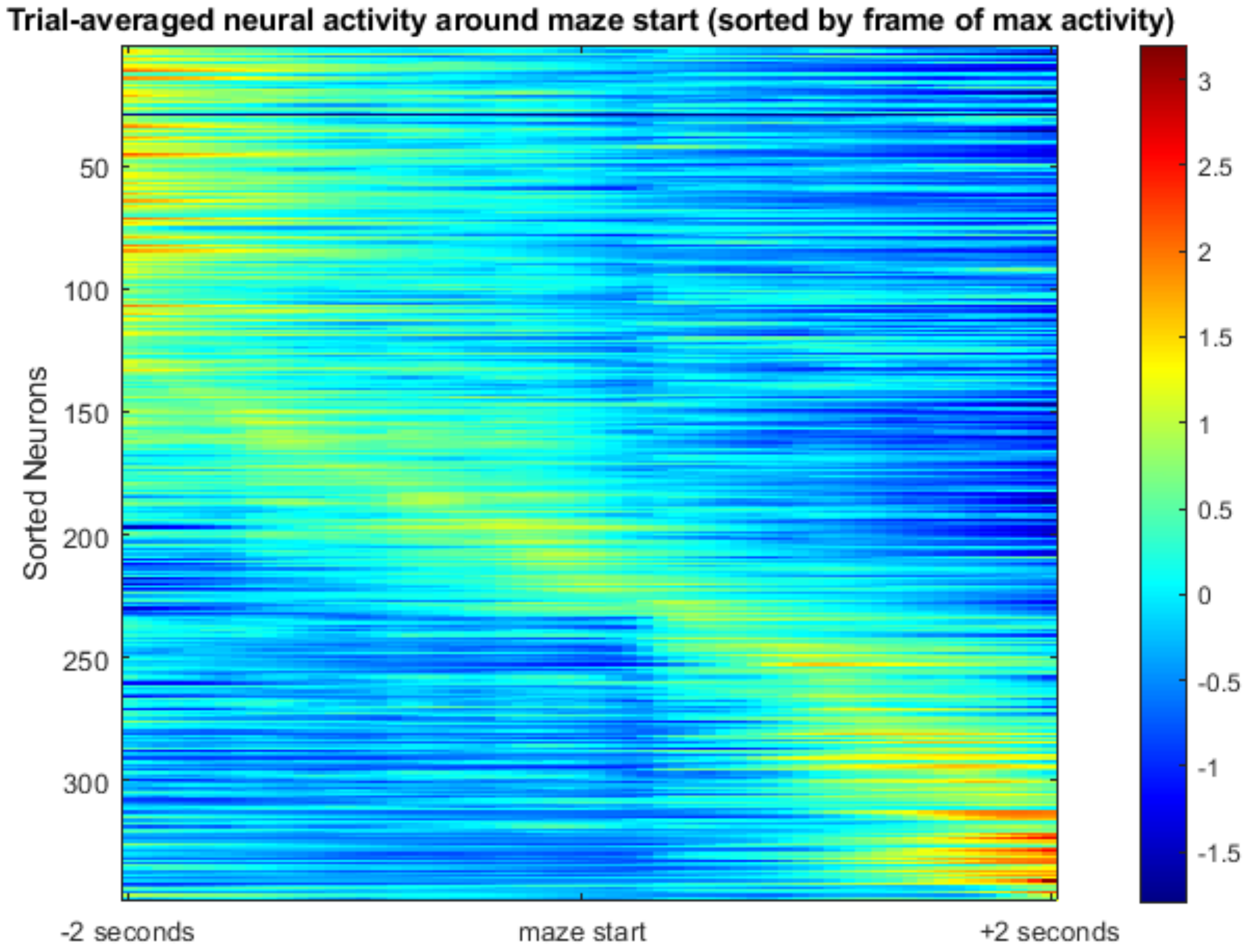
1. Synchronize overhead video with Miniscope video
2. Find frames for events of interest (i.e. start, choice, and end of each trial) and partition signals into individual trials
3. Center each trial around event of interest
4. Normalize signal, average across trials, and sort neurons by frame of maximum activity

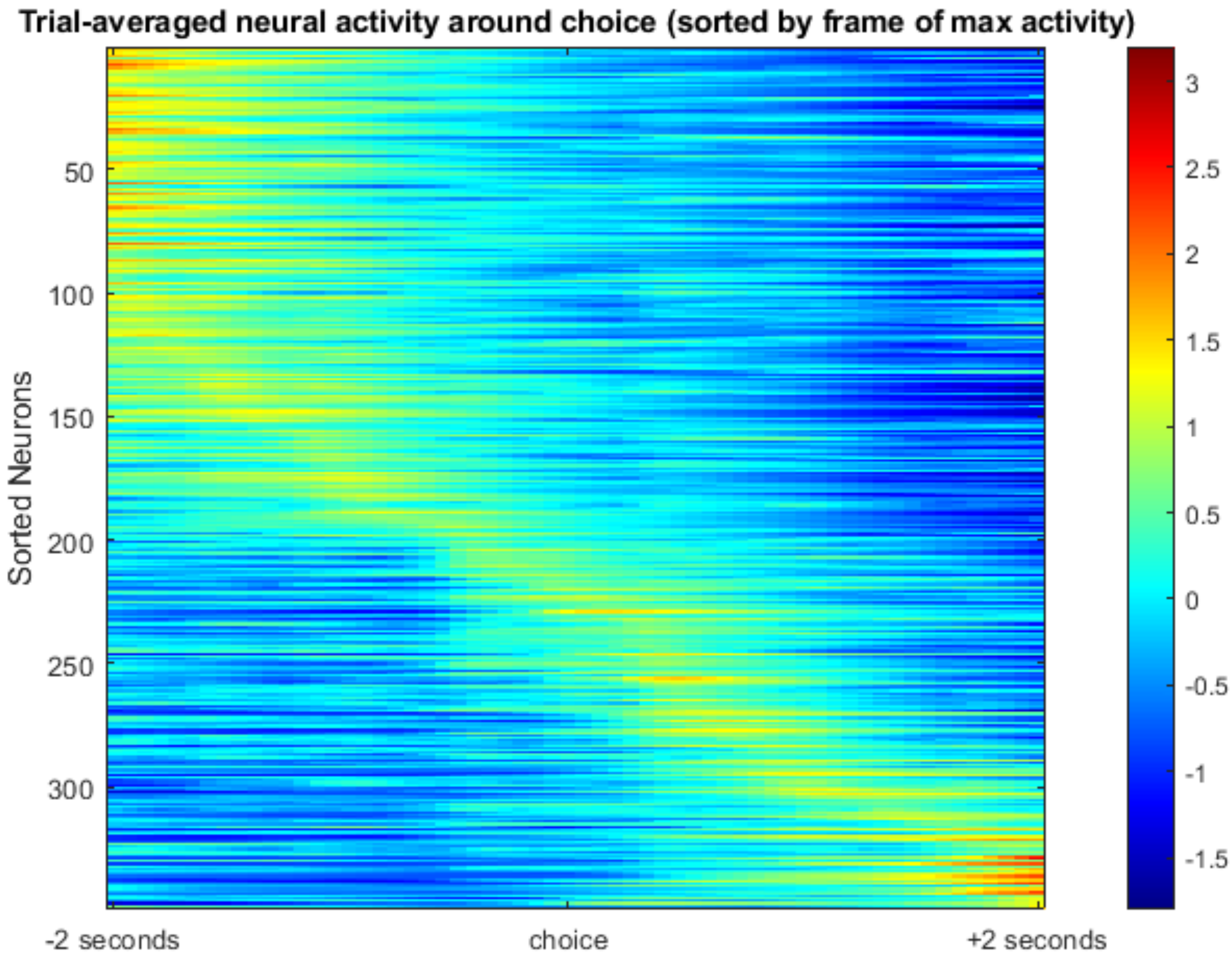


```
%loop through each neuron
for neuron = 1:size(dff,1)
    % for one neuron
    % number trials x event length
    one_neuron = zeros([length(start_frame), seconds*frames_per_sec*2]);

    % loop through each trial, normalize neuron signal
    for trial = 1:length(start_frame)
        one_neuron(trial,:) = normalize(dff(neuron, beginning(trial):endi
    end

    % take average of single neuron across all trials
    neuron_activity(neuron,:) = mean(one_neuron);
end
```

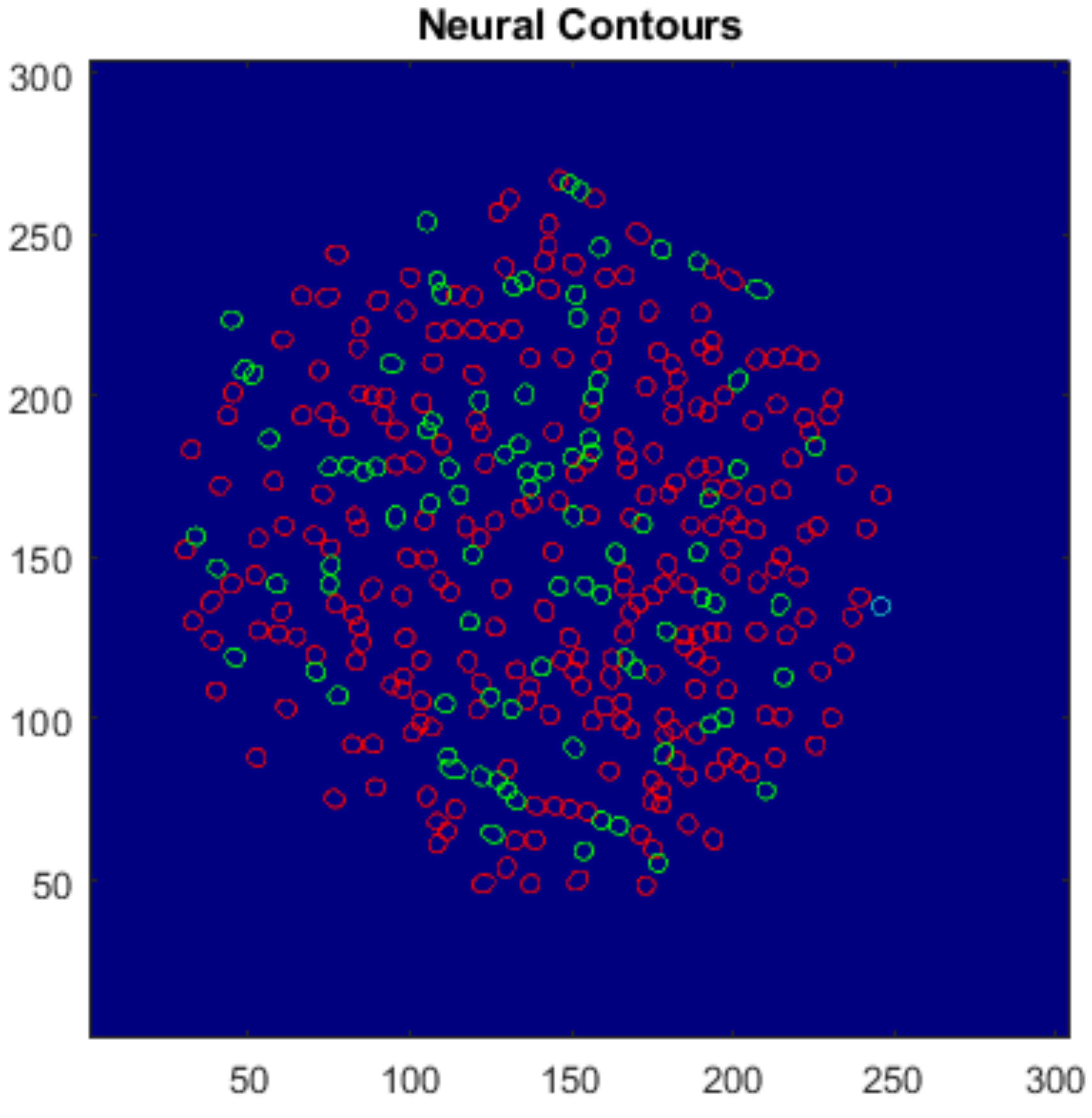
```
% sort neurons by peak activity
[~, max_pos] = max(neuron_activity, [], 2);
[~, max_order] = sort(max_pos);
nas2 = neuron_activity(max_order, :);
```

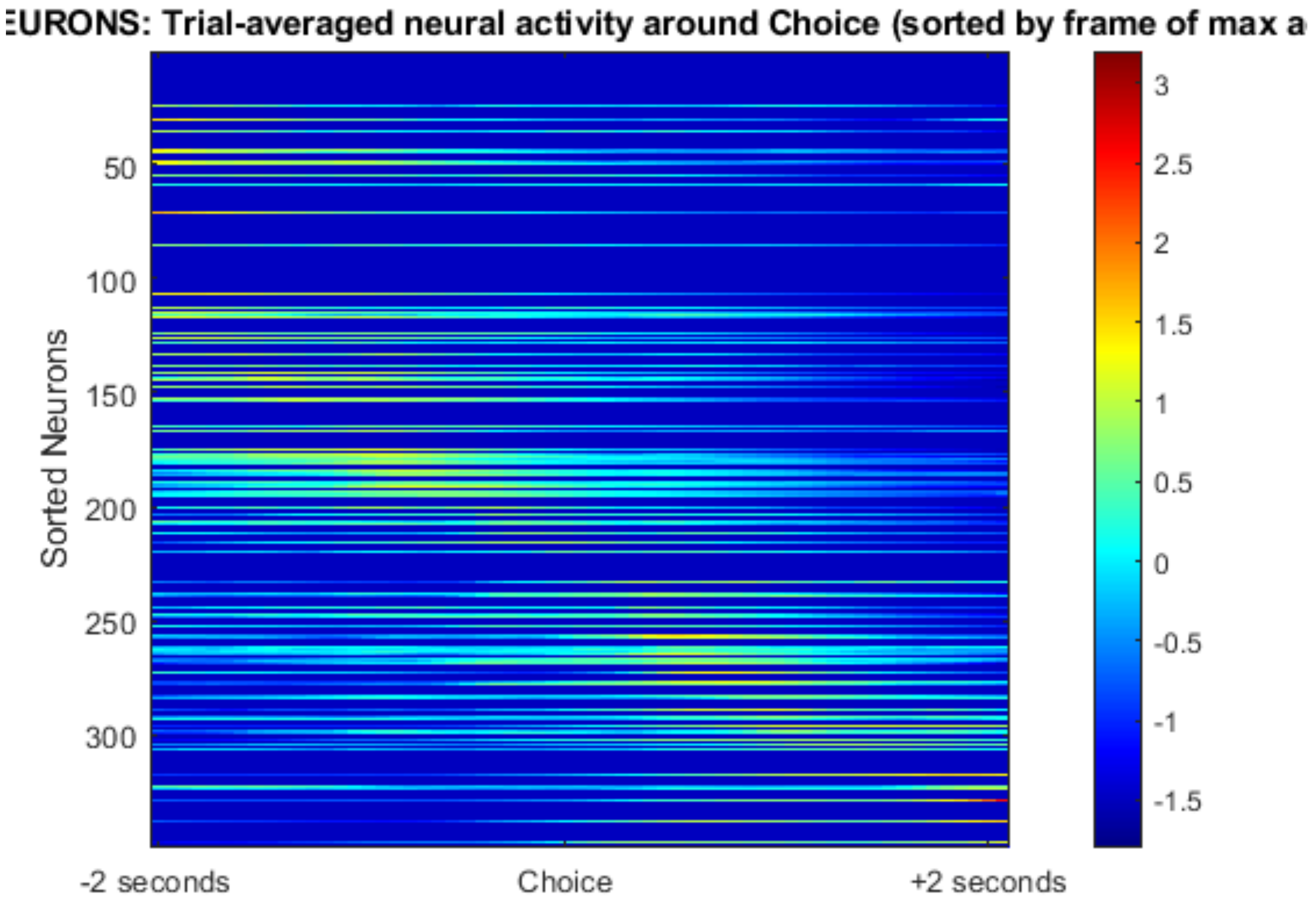

Trial-averaged neural activity around food cup (sorted by frame of max activity)
Sorted Neurons
50
100
150
200
250
300
-2 seconds
food cup
+2 seconds
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5


Trial-averaged neural activity around maze start (sorted by frame of max activity)
Sorted Neurons
50
100
150
200
250
300
-2 seconds
maze start
+2 seconds
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5


Trial-averaged neural activity around choice (sorted by frame of max activity)
Sorted Neurons
50
100
150
200
250
300
-2 seconds
choice
+2 seconds
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5

Permutation Test





PCA

This view is capturing what the *neural population* activity is doing! Each trajectory combines the activity from all neurons into a lower dimensional subspace, and each neuron contributes to this overall trajectory. We call this trajectory the “neural state.”

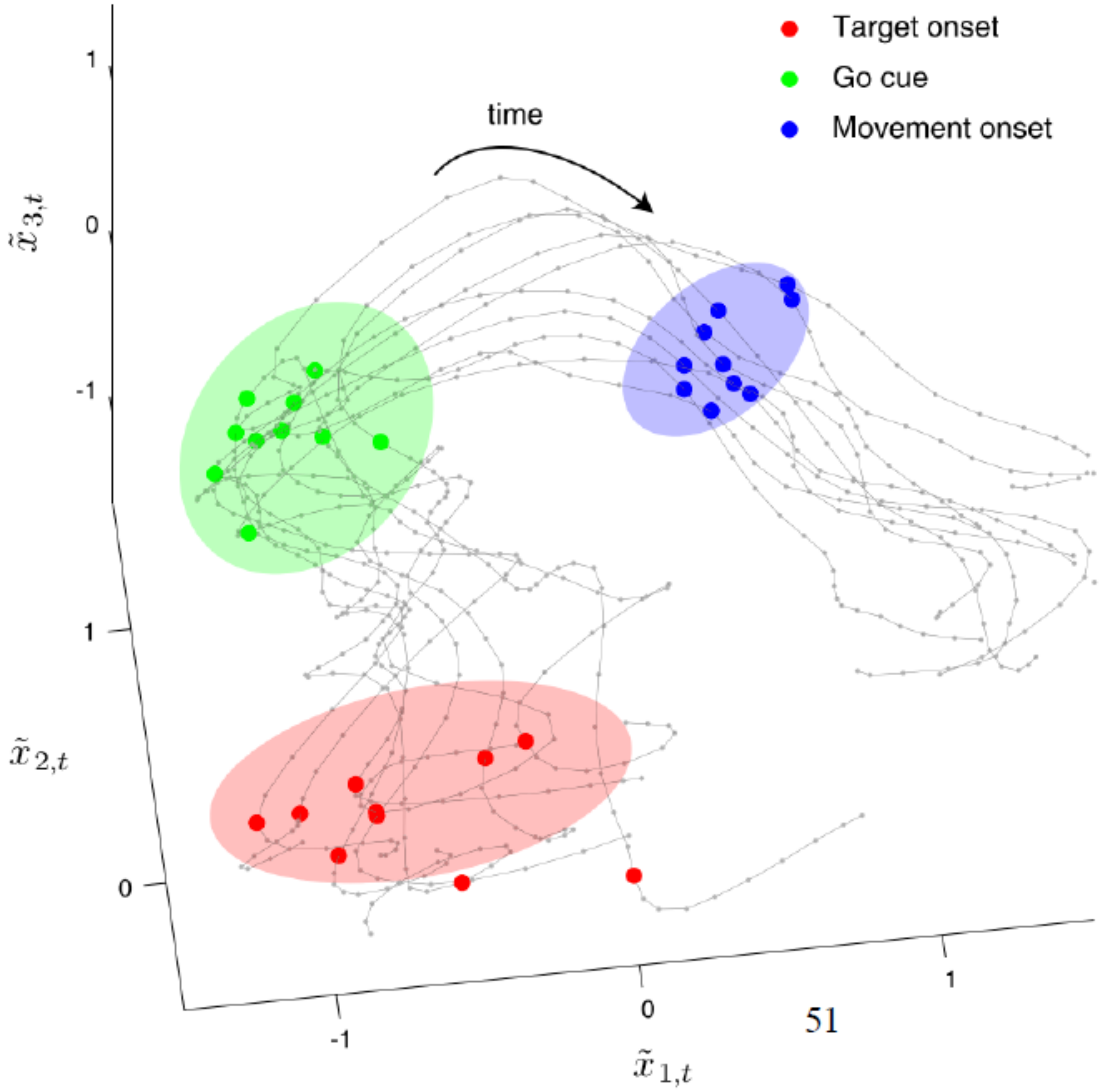
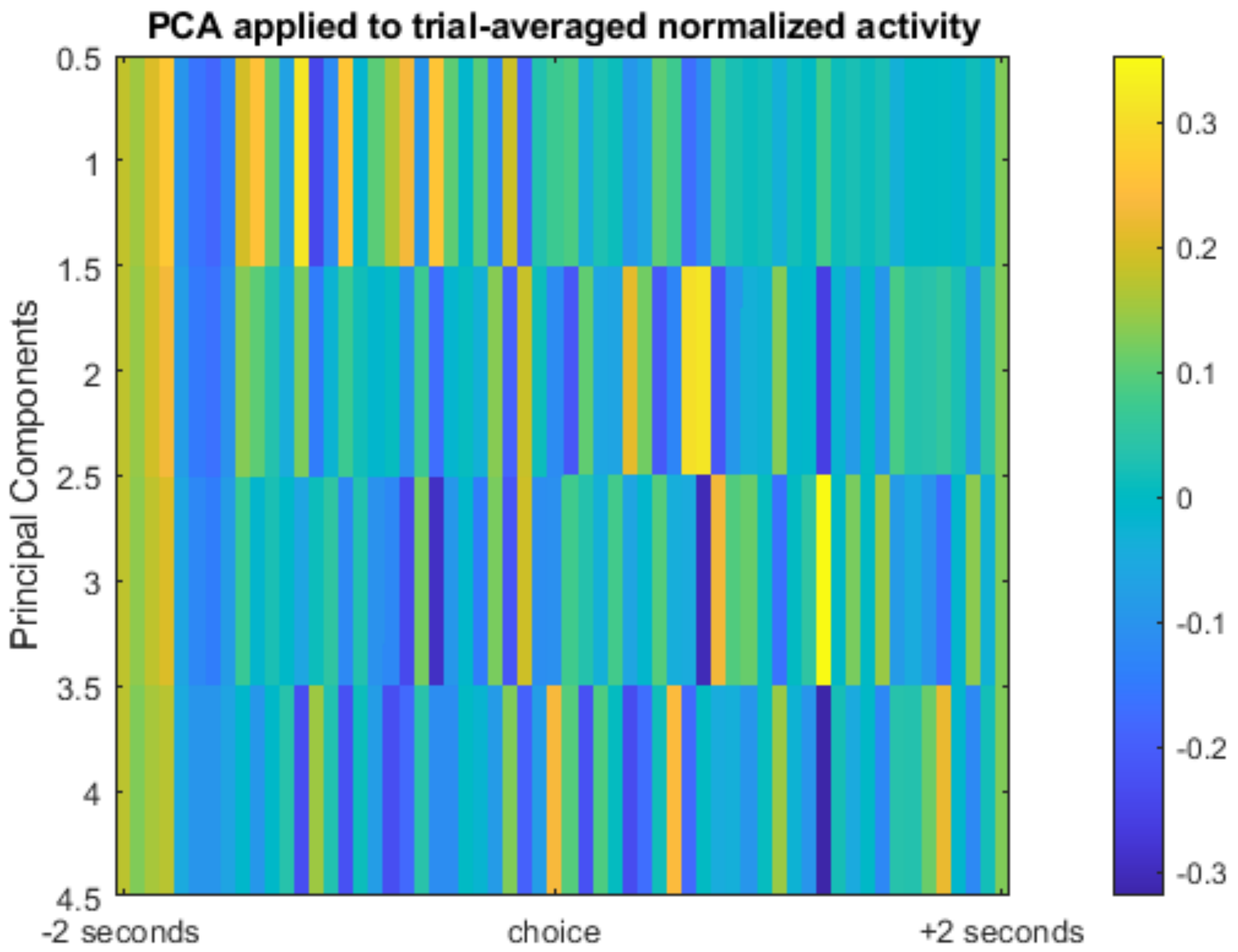


Photo Credit: Jonathan Kao, ECE C143A Lecture 18 Slides

PCA

- apply PCA on 349 x 61 matrix
- first principal component: high activity before choice
- second principal component: high activity after choice



Next Steps

- We need a more robust way of ID'ing "significant" neurons
- Use neural data in a neural network to predict binary outcome
- Read in more data with more animals
- Create computational model with various parameters such as perceived cost, velocity, etc.
- Optogenetic activation/silencing of ACC neuron subsets
- Project average population for different trial outcomes into lower-dimensional space

Neuron Projection

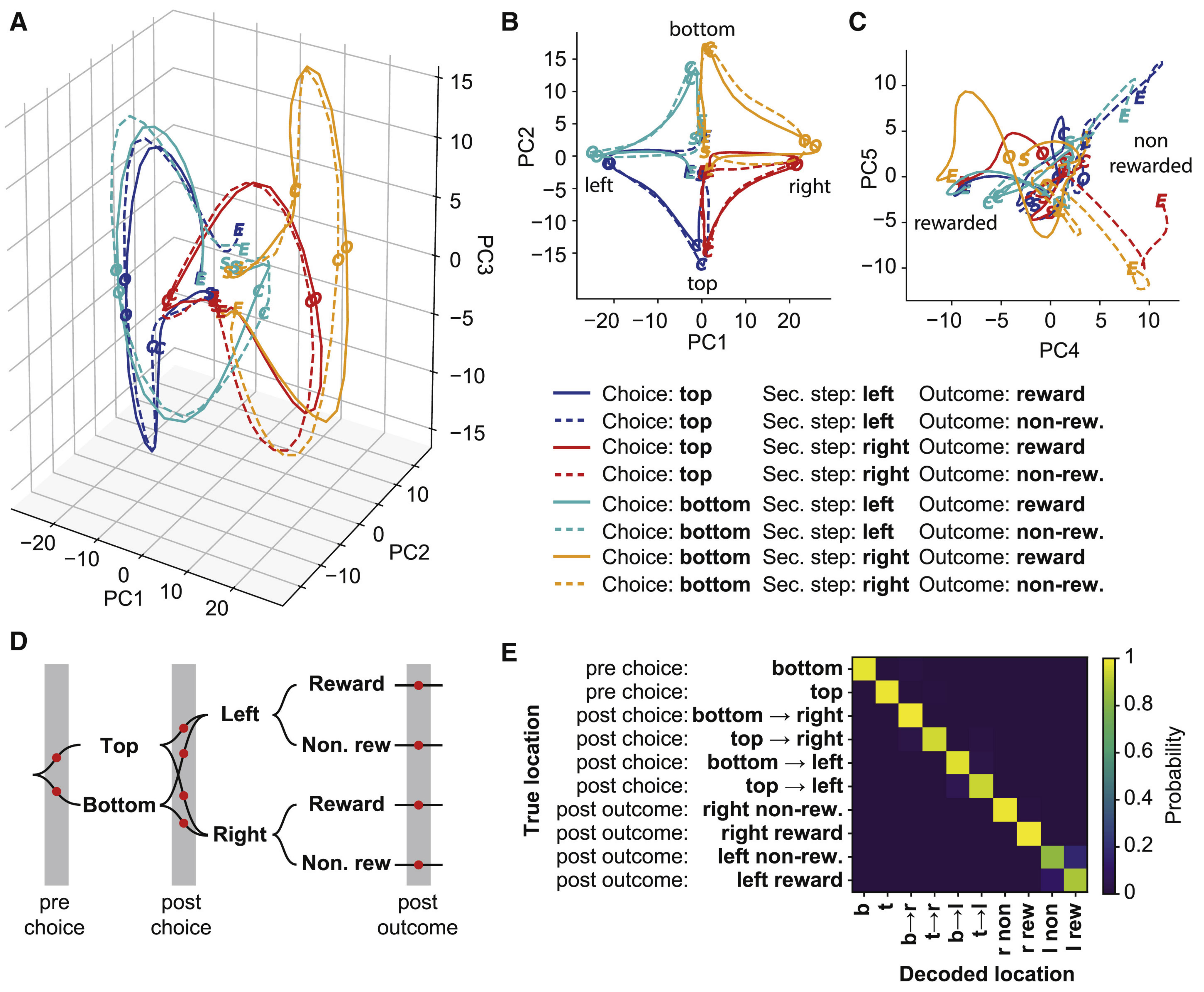


Photo Credit: Akam et al. 2021