Instructions on Data and Code Usage

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Figure 2e,h, Figure 3a and **Extended Data Figure 4, 5**

1. Code and data preparation

1.Unzip the code folder. It is recommended to use ***VS-code(***Visual Studio Code - Code Editing. Redefined***)*** open as a project with ***Python 3.12*** interpreter (You need to install python packages *pandas*, etc).

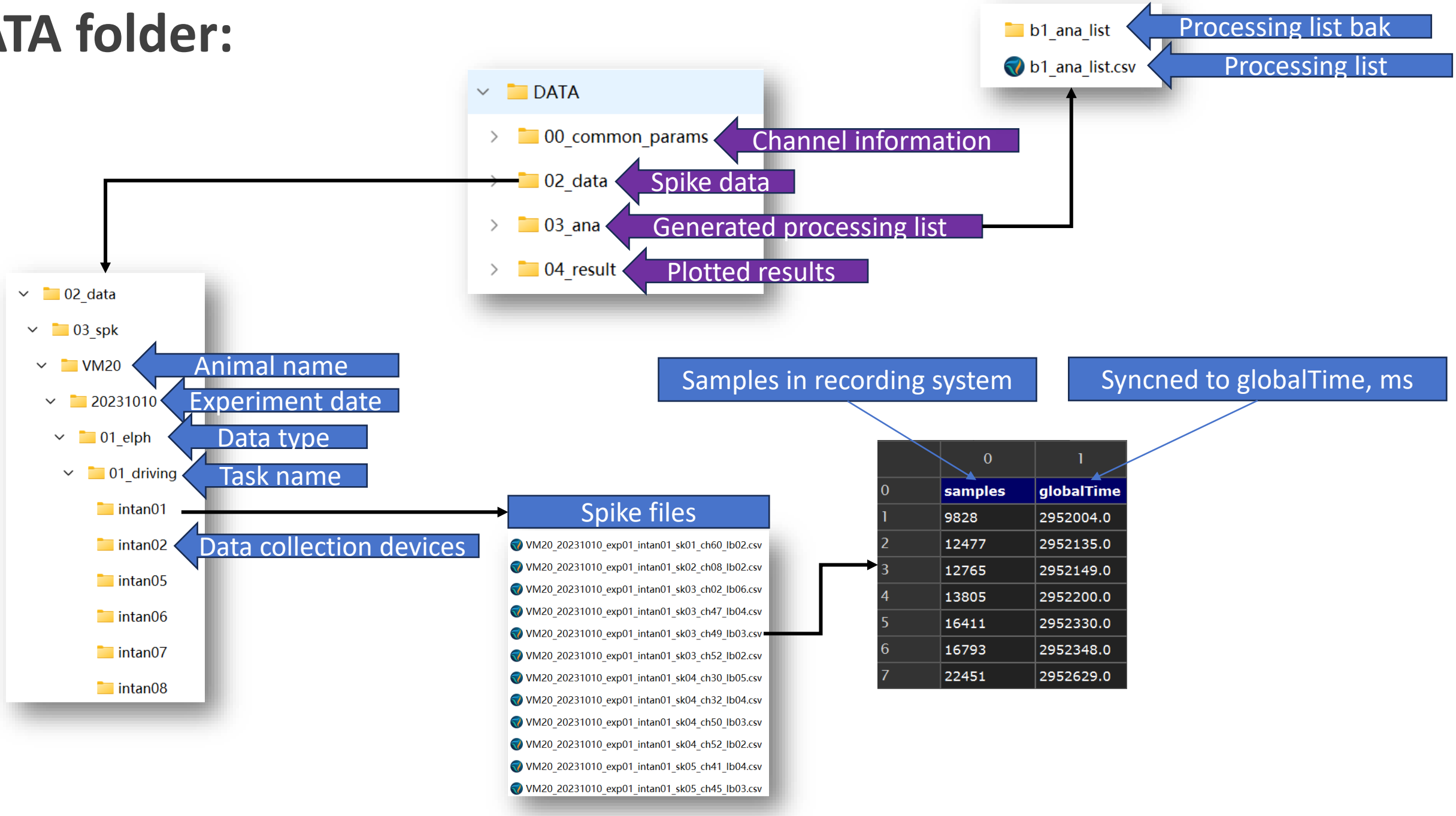
2.Place the code in an appropriate directory.

3.Place the **DATA** folder in your desired path **($DATA_PATH**).

4.Open the **CODE** folder as a project in ***VS-code***.

5. Replace the **pn_root** variable in each script to your **$DATA_PATH**.

DATA folder:



	0	1
0	samples	globalTime
1	9828	2952004.0
2	12477	2952135.0
3	12765	2952149.0
4	13805	2952200.0
5	16411	2952330.0
6	16793	2952348.0
7	22451	2952629.0

2. Generate data processing list

Run b1_gen_ana_list.py:

1. Open the file and modify the **DATA** folder path **pn_root** :

```
pn_root = r"\\NJJK-NAS\visual\66_paper\MANUSCRIPT\20250610-v6-submit\figShare_upload\DATA"
```

Replace it with your local path **($DATA_PATH**).

2. Running this script will generate a data processing list (**b1_ana_list.csv**) at:

$PATH_DATA\03_ana\00_list\b1_ana_list.csv

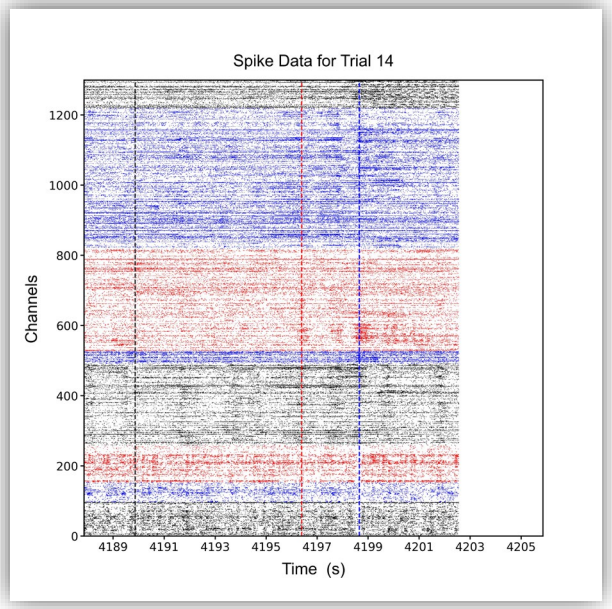
This file contains all ***unit*** information, file paths, and result storage locations, which will be used in subsequent steps.

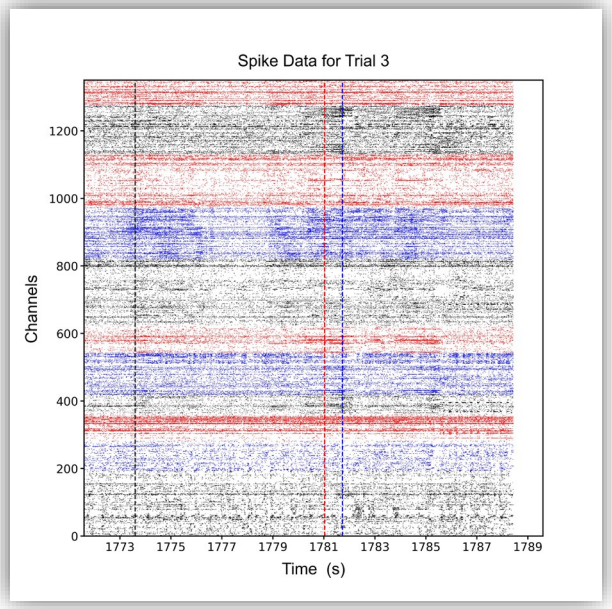
3. Plot Trial Raster:

1. After the previous step, open **$CODE_PATH**/b2_plot_raster.py.
2. Replace **pn_root** with your **$DATA_PATH**
3. Results will be saved in: **$DATA_ PATH**\04_result\b2_raster, (e.g., ***VM20*** and ***VM23*** are animal names.)
4. Customizing Brain Region Colors:
   - Modify the color scheme by changing: color = processing_row['color_bak']
   - Replace **'color_bak'** with any of the following fields in **b1_ana_list.csv**: *color, color_VM20, color_VM23, color@20230315, color_bak,* or other colors you defined

4. You will get figures like:

in several minutes.

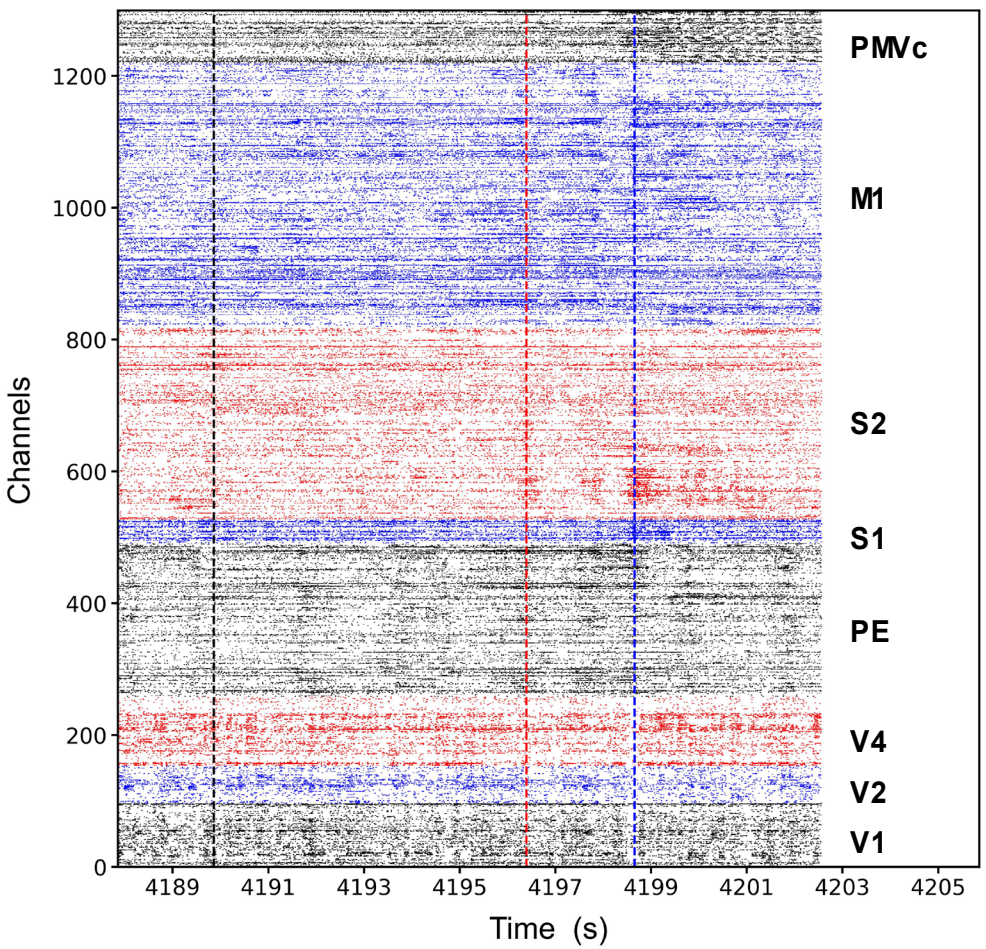




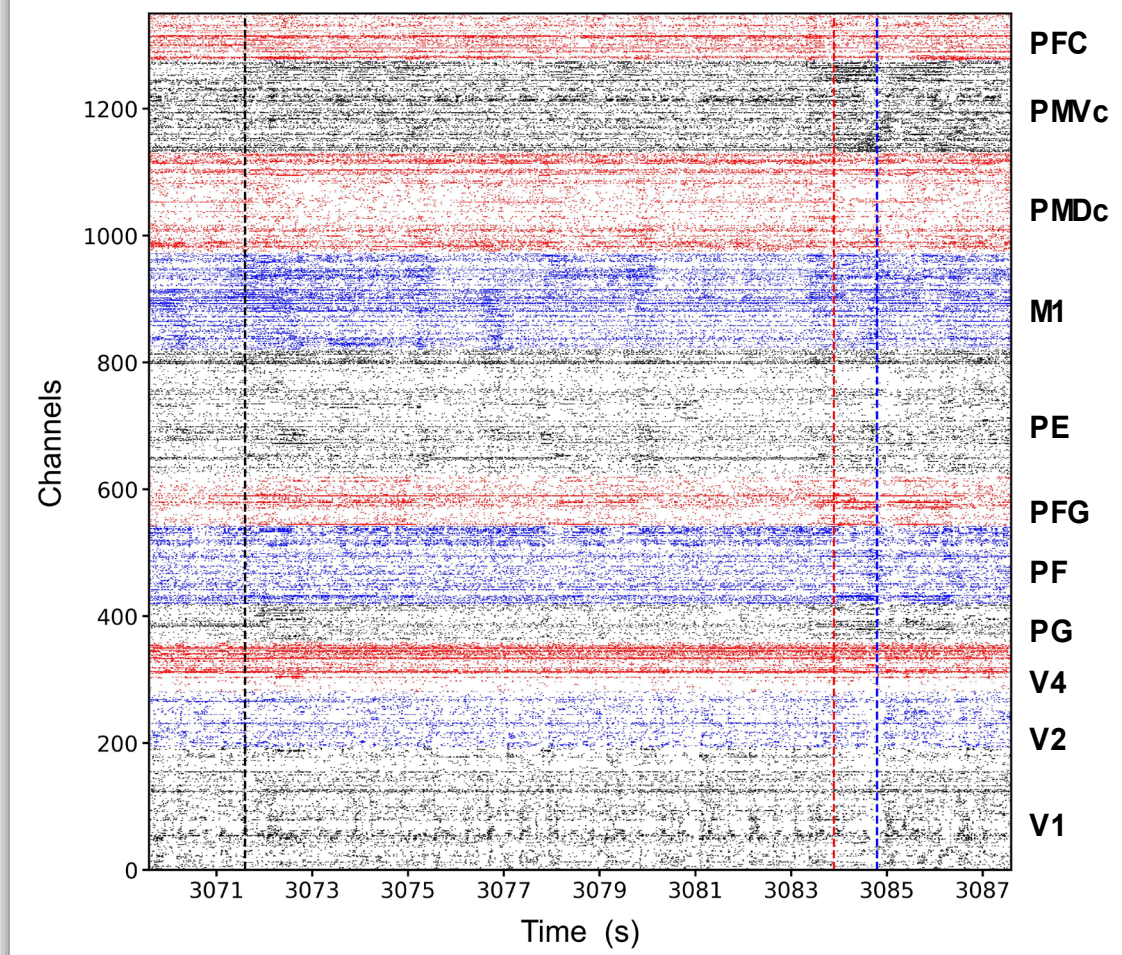
3. Plot Trial Raster: result figures

Events: ***reach_start, touch_fruit, touch_mouth***

Animal *VM20*



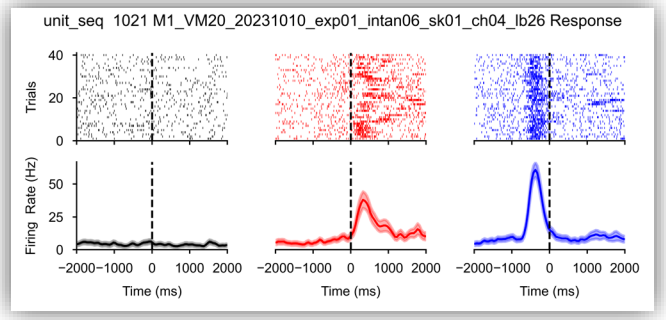
Animal *VM23*

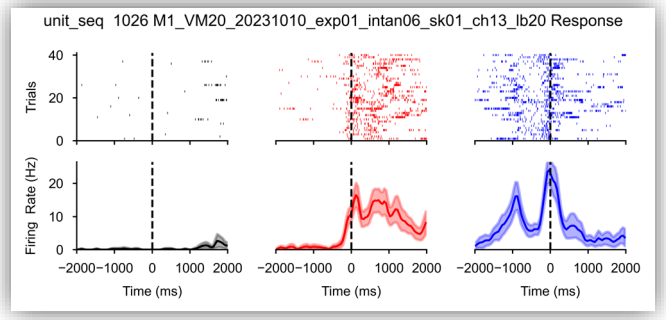


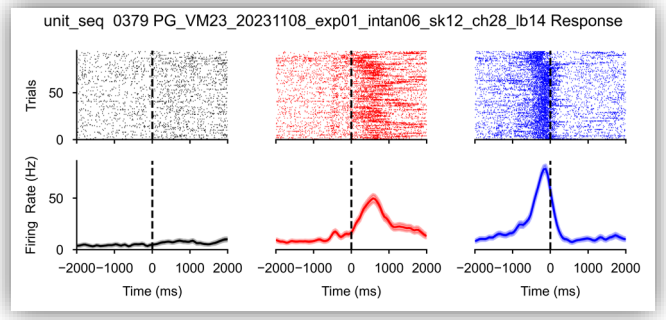
4. Plot Task Raster by Unit:

1. Open **$CODE_PATH/b3_plot_task_raster.py**
2. Replace **pn_root** with your **$DATA_PATH**
3. The script will load ***b1_ana_list.csv*** and generate plots for each unit.
4. Color Scheme in Plots:
   - **Black** = reach_start
   - **Red** = touch_fruit
   - **Blue** = touch_mouth

4. You will get figures like the following figures in 10-20 minutes, depends on your CPU.







4. Plot Task Raster by Unit: result figures

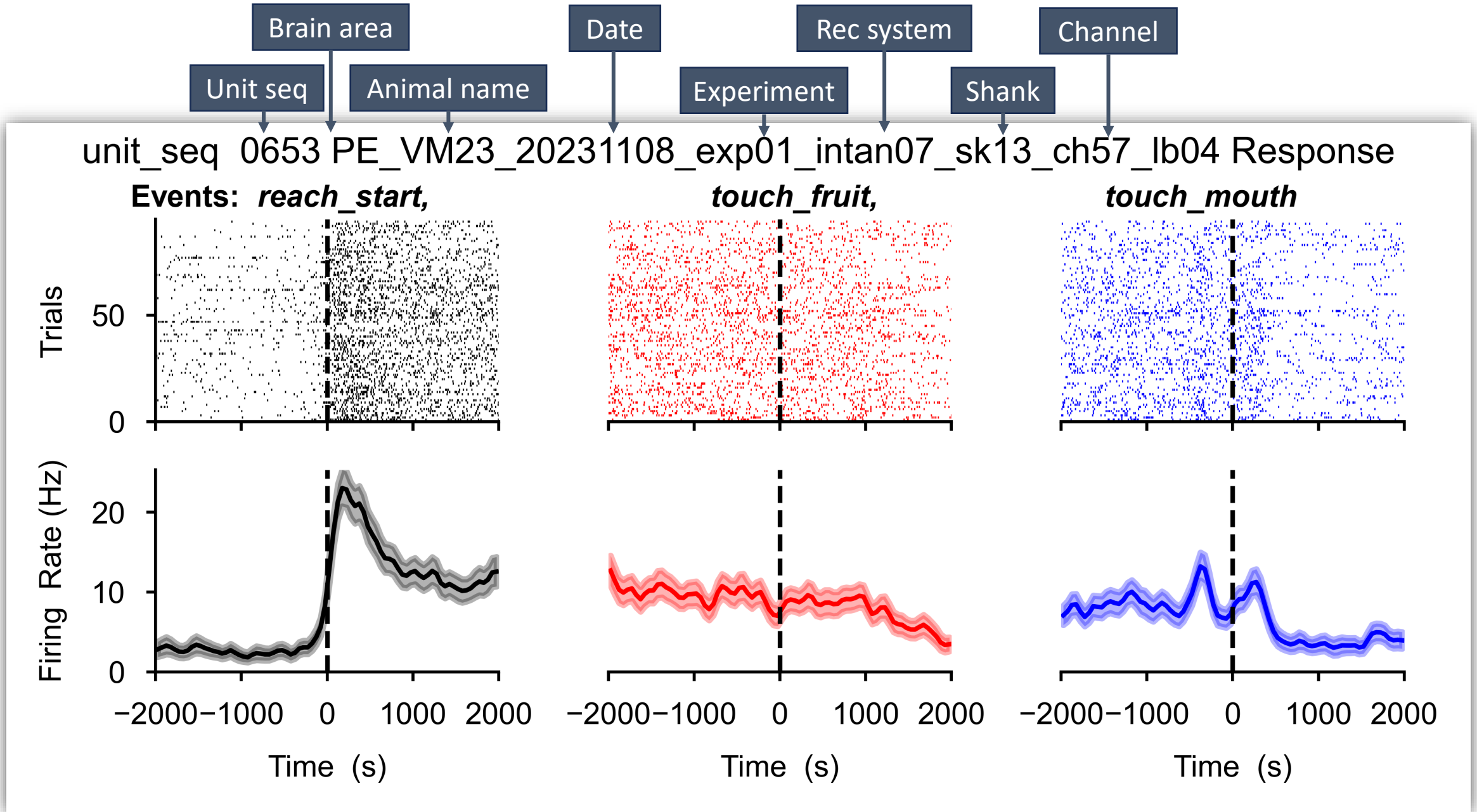
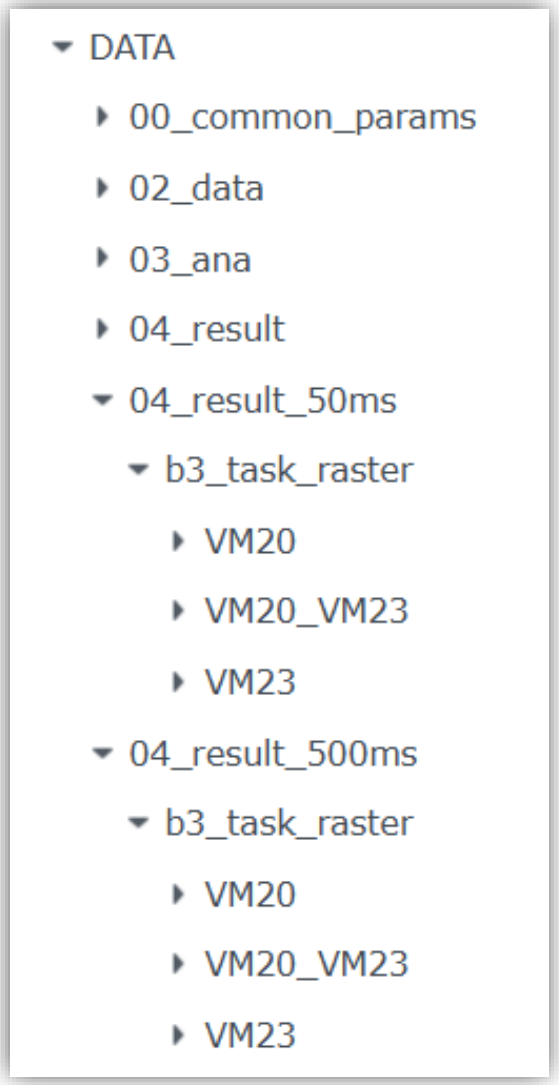


Figure 3c and **Extended Data Figure 6**

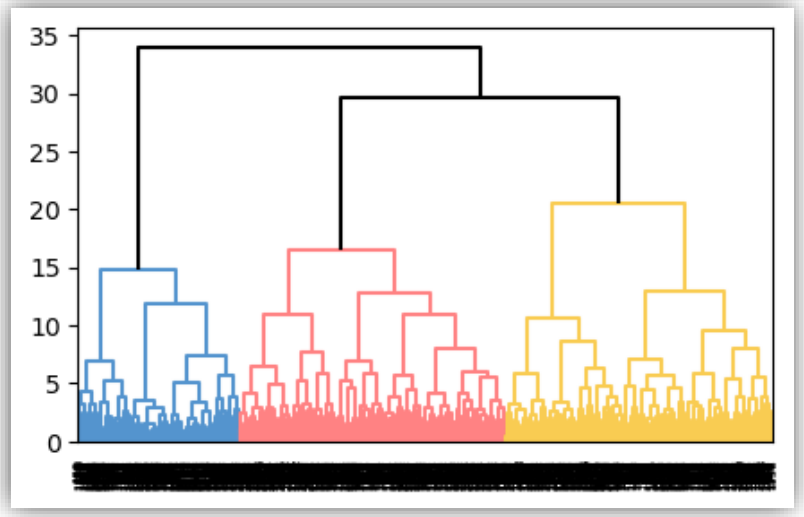
1. Calculate Firing Rates per Unit:

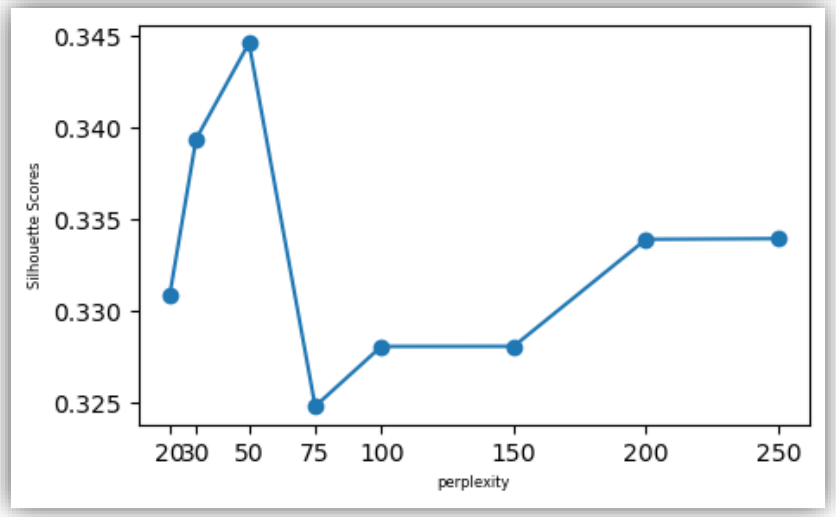
1. Open **$CODE_PATH/b4_extract_fr.py**.
   - Replace **pn_root** with your **$DATA_PATH**
   - Modify variable **bin_size** to get **50ms** bin FR and **500ms** bin FR respectively for later use.
   - Run twice at 50ms, and 500ms bin_size, respectively.
2. The script will load ***b1_ana_list.csv*** and save the mean firing rates for each unit to **$PATH_DATA/04_result_{bin_size}ms**.
3. Run **$CODE_PATH/b4_merge_data.py** to merge the data from **VM20** and **VM23** into a new folder named **VM20_VM23**.

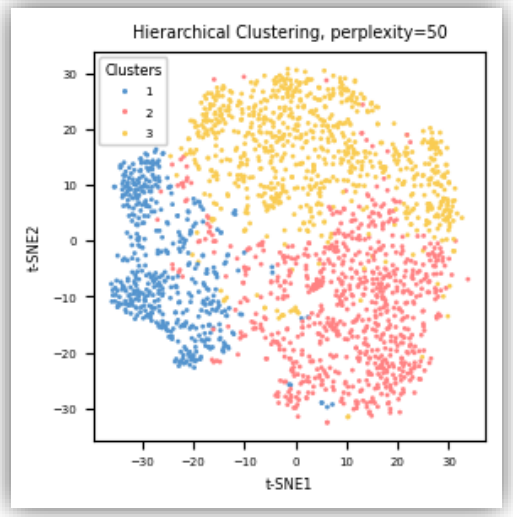


2. Hierarchical Clustering:

1. ***.ipynb** files are Jupiter notebook file type. You need to install Jupiter along with VS-code.
2. Run **$CODE_PATH/Figure_3c.ipynb** step by step. This notebook is used to generate the following plots (**Figure 3c** and **Extended Data Figure 6**):
   - Replace **pn_root** with your **$DATA_PATH** and run the code.
   - Perform **hierarchical clustering** by *Ward's* method: Units were classified into three clusters.
   - Visualization of neuronal firing rates on a low dimensional space: dimension reduction were performed using **t-distributed stochastic neighbor embedding** (t-SNE), and the optimal perplexity value for t-SNE analysis were determined by finding the highest silhouette score.

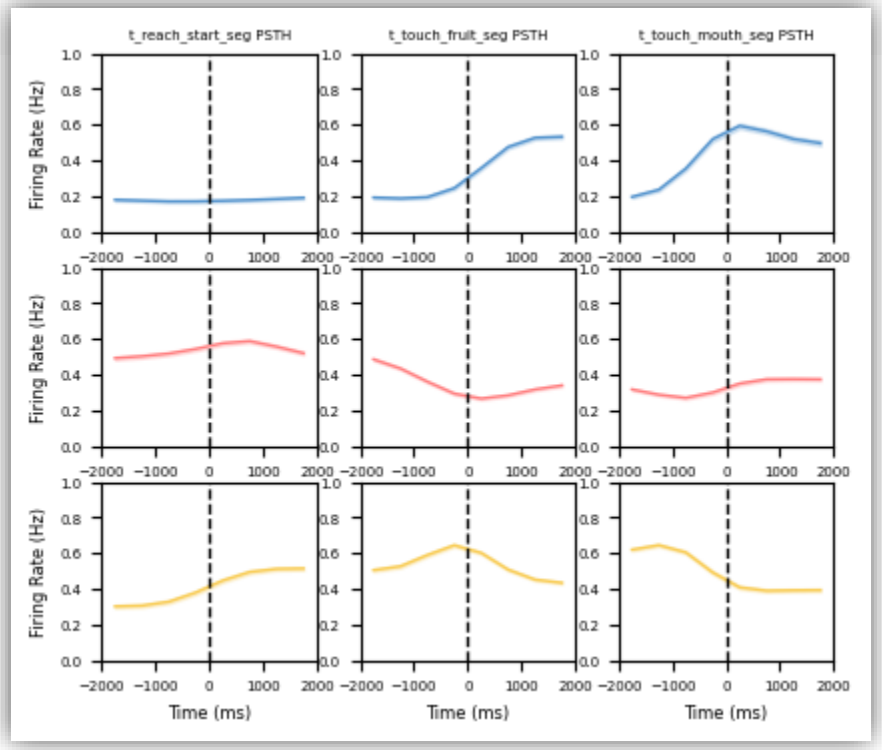






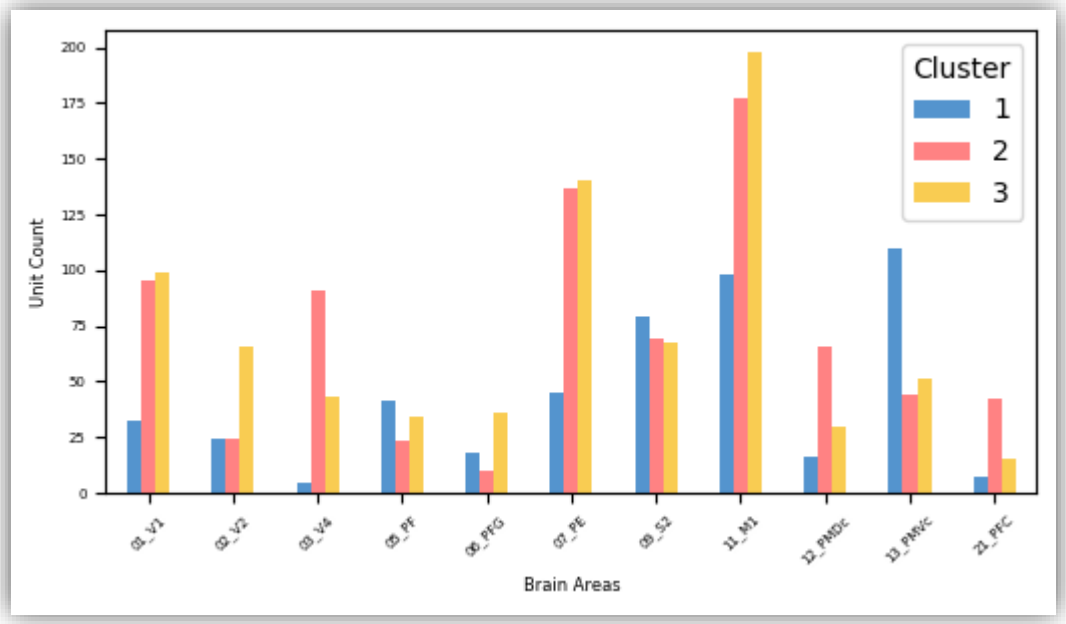
3. Normalized Average Firing Rate:

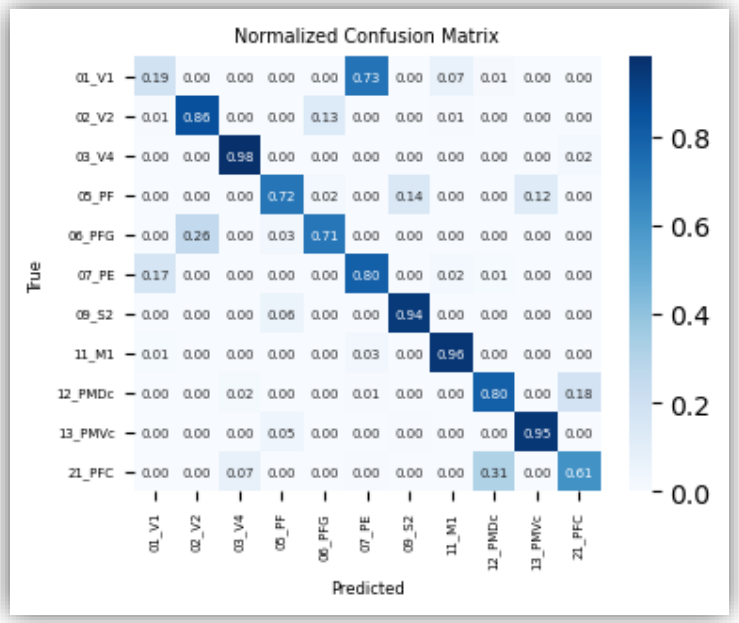
1. Run **$CODE_PATH/Figure_3d.ipynb** step by step. This notebook is used to generate the following plot, showing the normalized average firing rate for three clusters aligned to the onset of three behavioral epochs (Figure 3d):
   - Replace **pn_root** with your **$DATA_PATH** and run the code.
   - The firing rates for each unit during three behavioral epochs were **Min-max normalized** to the range (0, 1).



4. SVM Classification:

1. Run **$CODE_PATH/Figure_3ef.ipynb** step by step. This notebook is used to generate the following plots (Figure 3e and Figure 3f):
   - Replace **pn_root** with your **$DATA_PATH** and run the code.
   - The polynomial kernel for the classifier is selected based on its high accuracy.
   - The confusion matrix was normalized per class by dividing each element in the matrix by the sum of elements in the corresponding row.



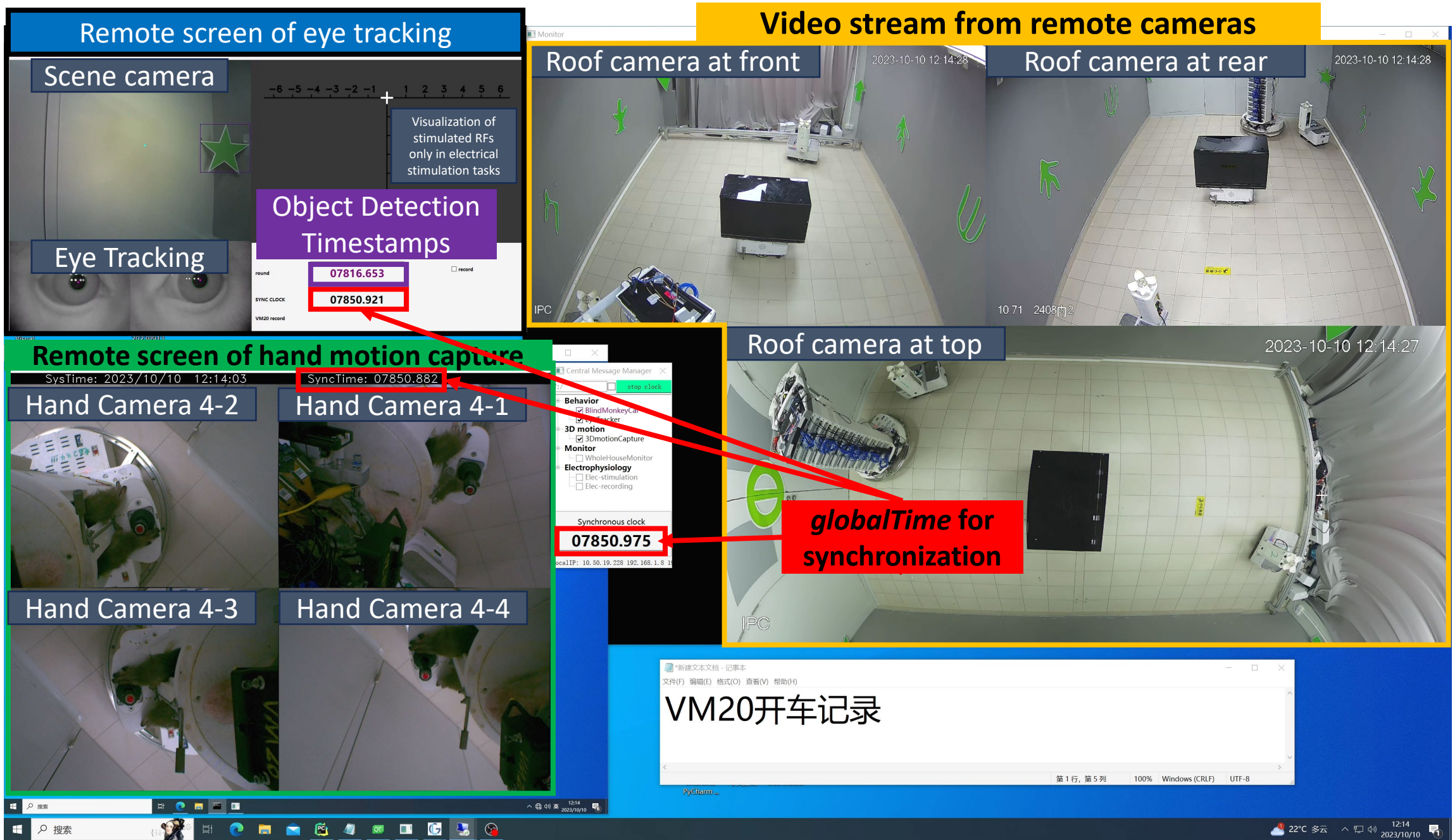


Instructions on Behavior Recording Videos

The videos were recorded with OBS Studio at 3840×2160@30Hz framerate

- VM20@20231010.mkv was animal *VM20* performed task at 20231010
- VM23@20231108.mkv was animal *VM23* performed task at 20231108

1. Remote screen and video stream recording simultaneously (VM20@20231010.mkv)



2. Remote screen and video stream recording simultaneously (VM23@20231108.mkv)