**Aim**:

Studying the population response structure

**Task description**:

Uncertainty is a ubiquitous component of our environment, such that humans and animals are regularly confronted with conditions that vary in degrees of uncertainty. It is therefore a fundamental requirement of our brain systems to accurately process uncertain information so that we may function appropriately, both in our mundane day-to-day activities and in more profound moments. Many brain regions including the frontal cortex, basal ganglia, amygdala, parietal cortex, cingulate cortex, and insular cortex have been identified as key areas in processing information about uncertain rewards.

In this assignment we are going to analyze the activity of a population of single units recorded with multi-electrode array in Parietal cortex. The task (Figure 1) is designed to study the encoding of reward expected value in area 7a (Figure 2). This area encodes the spatial location of cue [2].

Here in this assignment the question is that is the units in area 7a encode the expected value of the reward or not? The other question is that whether population structure conveys more information than single units?

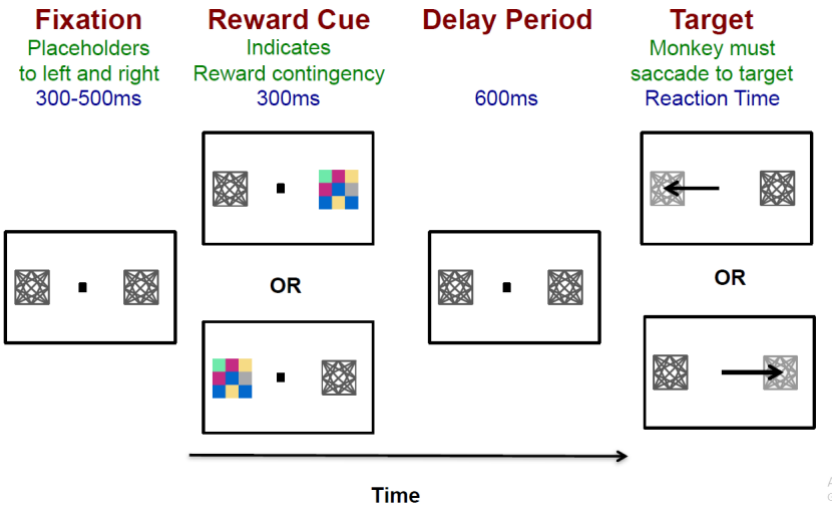


Figure 1: Task General Structure


a b

Figure 2: a) Anatomical location where the data is recorded
b) The multi-electrode array used for recording

**Data Description**:

When you load the data, a file named 'Unit' is added to the workspace. The file contains activities of 481 single units recorded from an array. In the subfield, 'Trls' there is spike times for 192 trials in each single unit which is aligned to 'Cue Onset'. Length of each trial is 3.2 second (1.2 sec before cue onset to 2 sec after cue onset). In the subfield 'Cnd', there are the trials in each group of the task conditions. The subfield 'Value' in 'Cnd' shows the expected value and the cue location in the task.

**Steps of the assignment**:

Step 1: Calculate the PSTH for the units and plot the average PSTH for each condition of the task.

Q1: Are the PSTH of different units act in the same way?

Q2: Could you infer the encoding of task parameters from the average PSTH?

Step 2: Single unit analysis using GLM: Use GLM analysis to find out which units significantly encode the task conditions which includes reward expected value and cue location (i.e. regress neural responses against these two parameters)

Step 3: According to [1], plot the population activity in lower dimension (2 or 3) by using suitable dimension reduction algorithm.

Step 4: Until now, we checked the encoding of reward expected value in single units and population space. But in order to verify the structure we see, we have to do some shuffling tests. Elsayed and Cunninghum in [3] proposed a method for shuffling and statistical testing that whether the activity of population is the byproduct of single units.

You can either do your own simple shuffling or do the more accurate shuffling proposed in [3] and explain the results (if you like to use their method download their shuffling algorithm from github). If you do your own shuffling explain your approach.

Based on your shuffling does the population data teach us more than what is expected from single unit analysis?

[1] Cunningham, J. P., & Byron, M. Y. (2014). Dimensionality reduction for large-scale neural recordings. *Nature neuroscience*, *17*(11), 1500.

[2] Constantinidis, C. and Steinmetz, M.A., 2001. Neuronal responses in area 7a to multiple-stimulus displays: I. Neurons encode the location of the salient stimulus. *Cerebral Cortex*, *11*(7), pp.581-591.

[3] Elsayed, G.F. and Cunningham, J.P., 2017. Structure in neural population recordings: an expected byproduct of simpler phenomena?. *Nature neuroscience*, *20*(9), p.1310.