

# Neuroscience Term Project

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## Introduction

In this paper we have used the electrophysiological dataset recorded in motor cortex of two macaque monkey(N) during an instructed delayed reach-to-grasp task to create numerous plots. Meanwhile the data is recorded with a  $10 \times 10$  electrode array. The area under control includes: central sulcus, M1, Premotor Cortex Dorsal (PMD) and Premotor Cortex Ventral (PMV). 96 electrodes out of 100 have the data we need. We'll be clarifying the type of the process, whether the neurons are sensitive to a particle event or not, studying the firing rate based on different events, and etc.

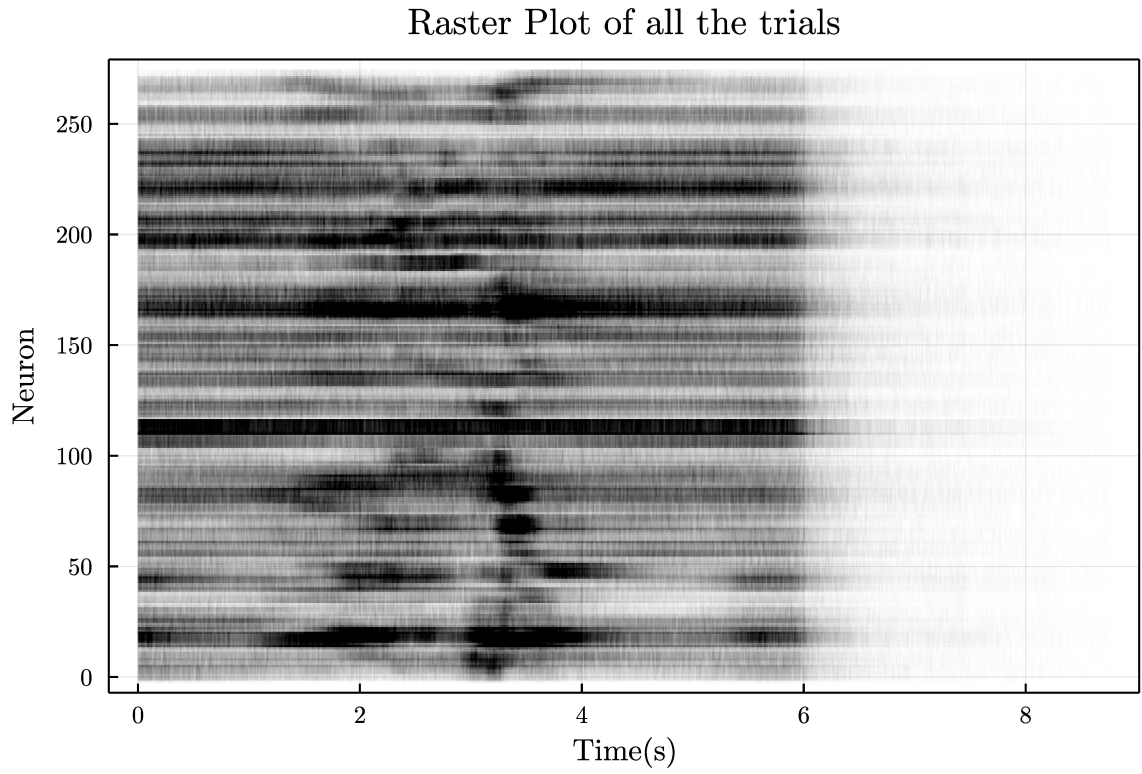
## Behavioural Task

The task is done by Monkey (N) and recorded during the trials. TS\_ON set signals when the task begins. After 400 ms, the yellow LED turns on, a signal that the start of the trial (WS\_ON). CUE\_ON set is the representation of how the monkey should grasp the object; Whether it is a side grip (SG) and the two left LEDs turn on, or it's a precision grip (PG) and the two right LEDs turn on. After 300 ms CUE.OFF happens and the LEDs turn off. During the following 1000 ms, if something out of order happens, the trial leads to an error; and if

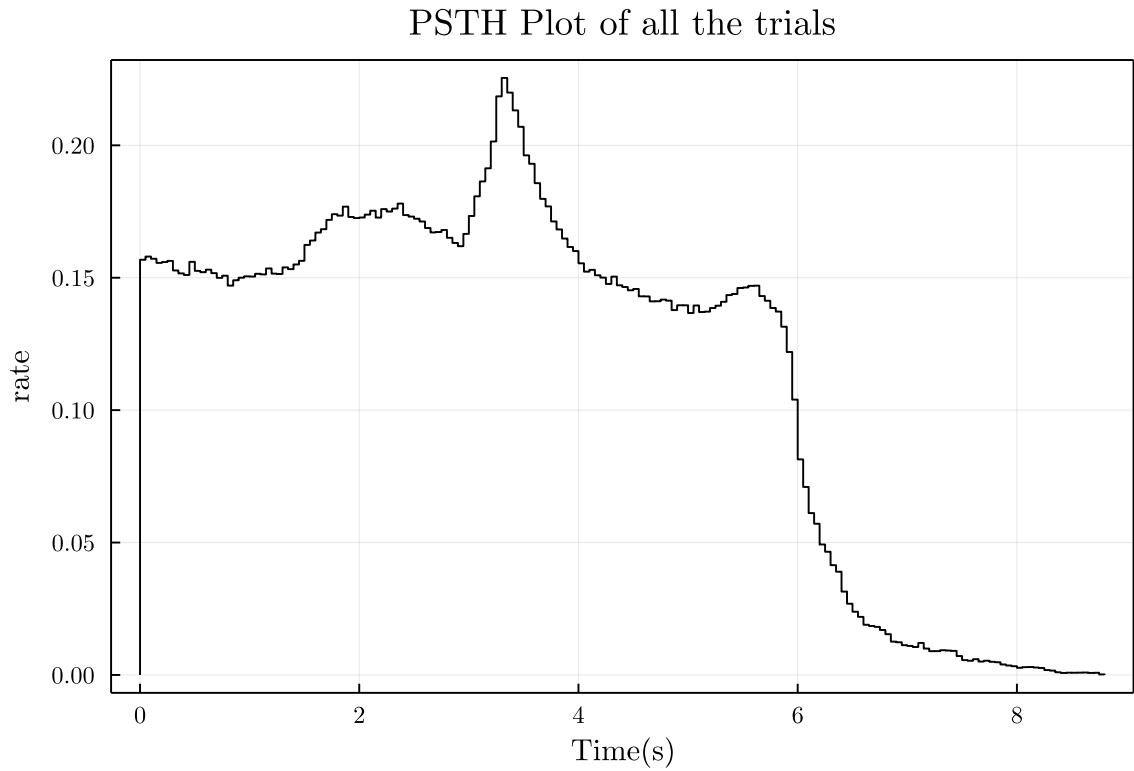
not, at GO\_ON set, signal to the monkey to move its hand and grip the object divides into two kinds: Low force (LF) and high force (HF). After some delay, depending on the monkey's own behaviour, SR\_ON signals the start of the monkey's hand's motion. If no error happens, it should hold on the object for 500 ms, and then it receives the reward (RW\_ON). At last, WS.OFF signals the end of the trial. These events are saved as bit numbers in dataset.

## Materials and Methods

We used the data associated with the neurons' spike trains and the events during the trials. In order to have the raster plot, each trial has been separated from other trials, and its starting time shifted to zero. This way the behaviour of neurons can be seen during each trial. PSTH figure is the density of spikes over time, and is plotted with the same data sorting procedure (Fig. 1(b)). Because the events were not altogether ordered and collected over time, showing the events as vertical line in Fig. 1(a) would cause unnecessary confusion. So, instead, a histogram of events for all the trials is provided, implementing which events have happened at which time during the trial (Fig. 2).



(a)



(b)

Figure 1: Raster Plot and PSTH. In order to use the dataset properly, the time shifting mentioned in the **Materials and Methods** section is applied. a) The rasters show multiple trials during which a neuron responds to the stimulus. b) Firing rates, shown under the raster plot, were constructed from the multiple trials by counting spikes within discrete time bins and averaging over trials.

## Distribution of events

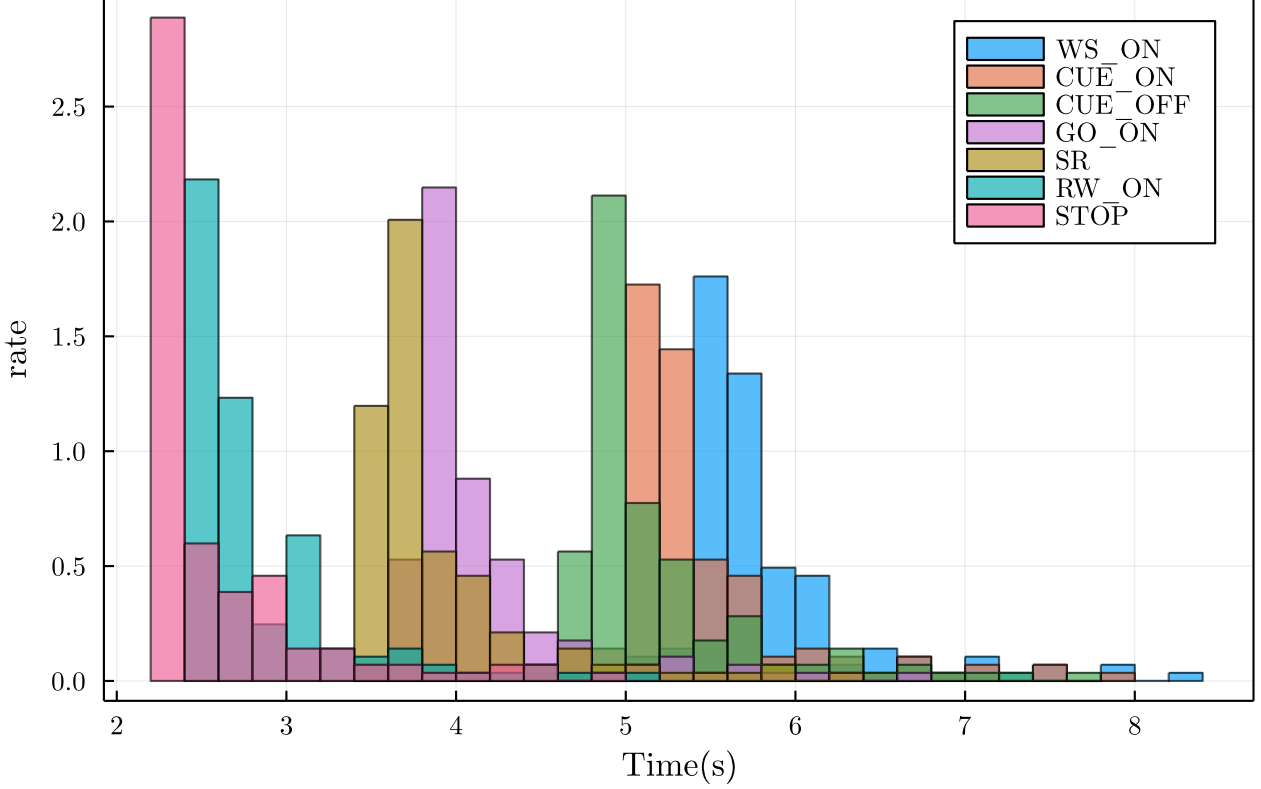


Figure 2: The density of events in all the trials over time

The histogram plot of the ISI of all the trials is shown in Fig. 3. Of course, the trials are gone through a filter to eliminate the outlier data.

## Discussion

A stochastic process that generates a sequence of events, such as action potentials, is called a **point process**. If the probability of an event occurring at any given time doesn't depend at all on the preceding events, so that the events themselves are statistically independent, we have a **Poisson process**. The **Homogeneous Pois-**

**son process**, which we are involved with here, causes the Poisson distribution:

$$P_T[n] = \frac{(rT)^n}{n!} \exp(-rT) \quad (I)$$

The probability density of time intervals between adjacent spikes is called the interspike interval distribution (ISI), and it is a useful statistic for characterizing spiking patterns. From equation (I), with  $n = 0$ , the probability of not firing a spike for period  $\tau$  is  $\exp(-r\tau)$ , so the probability of an interspike interval falling between  $\tau$  and  $\Delta t + \tau$  is:

$$P[\tau \leq t_{i+1} - t_i < \tau + \Delta t] = r\Delta t \exp(-r\tau) \quad II$$

We fit the data to the general exponential equation  $Ae^{Bt}$  with  $B = -2.24 \pm 0.14$

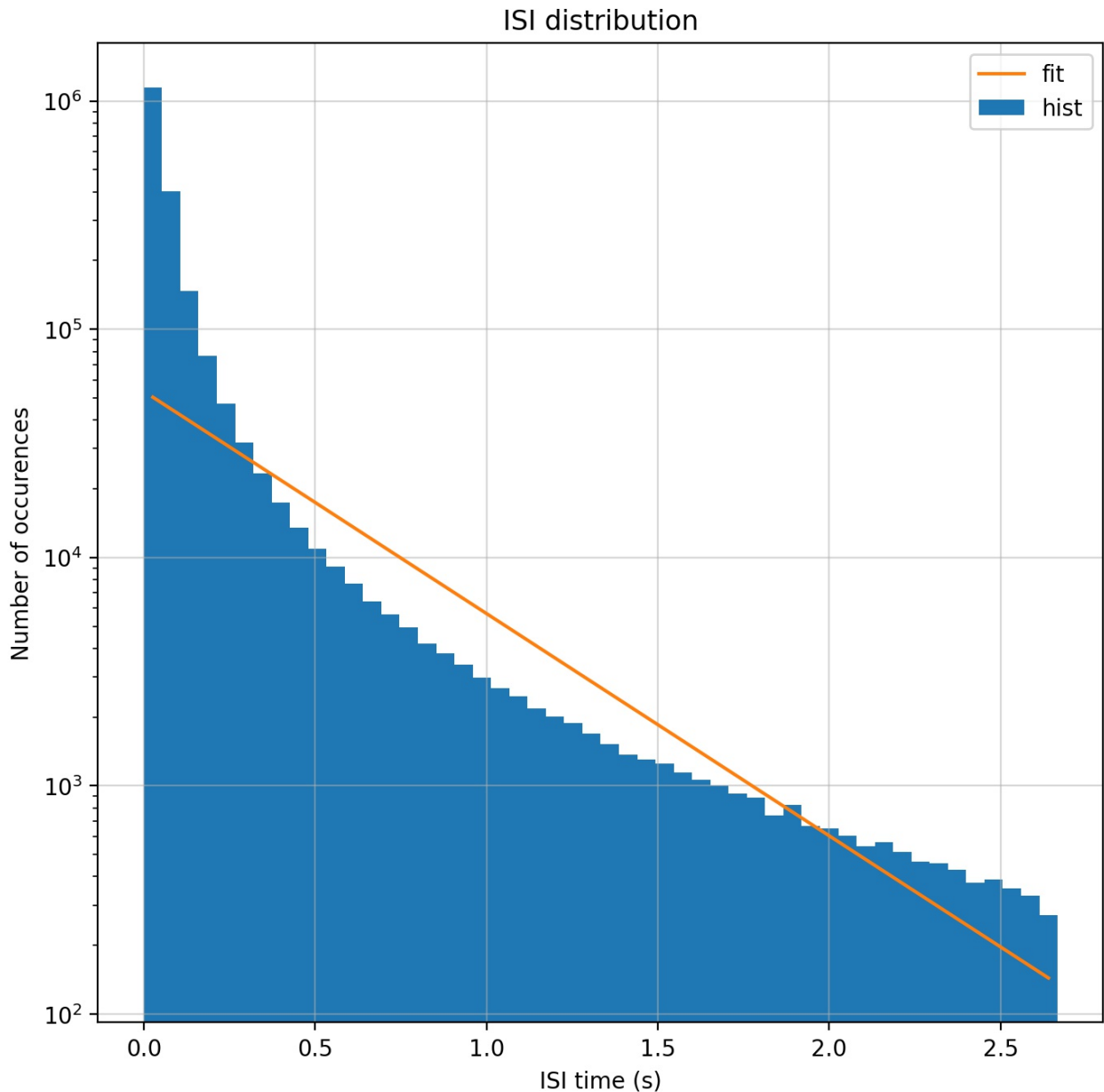


Figure 3: The ISI distribution for filtered data. The bin size is between 0 to 8000 indexes. The y- axis then became logarithmic to fit the exponential function.

## References

1. Mark M. Churchland<sup>1</sup>, John P. Cunningham, Matthew T. Kaufman, Justin D. Foster, Paul Nuyujukian, Stephen I. Ryu & Krishna V. Shenoy, Neural population dynamics during reaching, 10.1038/nature11129.
2. Thomas Brochier<sup>1</sup>, Lyuba Zehl, Yaoyao Hao, Margaux Duret, Julia Sprenger, Michael Denker, Sonja Grün & Alexa Riehle<sup>1</sup>, Massively parallel recordings in macaque motor cortex during an instructed delayed reach-to-grasp task, Brochier, T. et al. G-Node <http://dx.doi.org/10.12751/g-node.f83565> (2018).

3. Mark M. Churchland and Krishna V. Shenoy, Temporal Complexity and Hetero-

geneity of Single-Neuron Activity in Premotor and Motor Cortex.