Sharif University of Technology
Electrical Engineering School

Advanced Neuroscience HW2

SINGLE UNIT ANALYSIS & POPULATION RESPONSE STRUCTURE

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Part.1 - PSTH Analysis

First, I've calculated the PSTH with a window length of 40 samples for each trial of each neuron which means I have a $481 \times 19 \times 80$. The sampling rate is 0.001 which means each window has a length of 0.04s. Then I calculated the averaged PSTH for each condition using this matrix. Here are the results for some neurons:
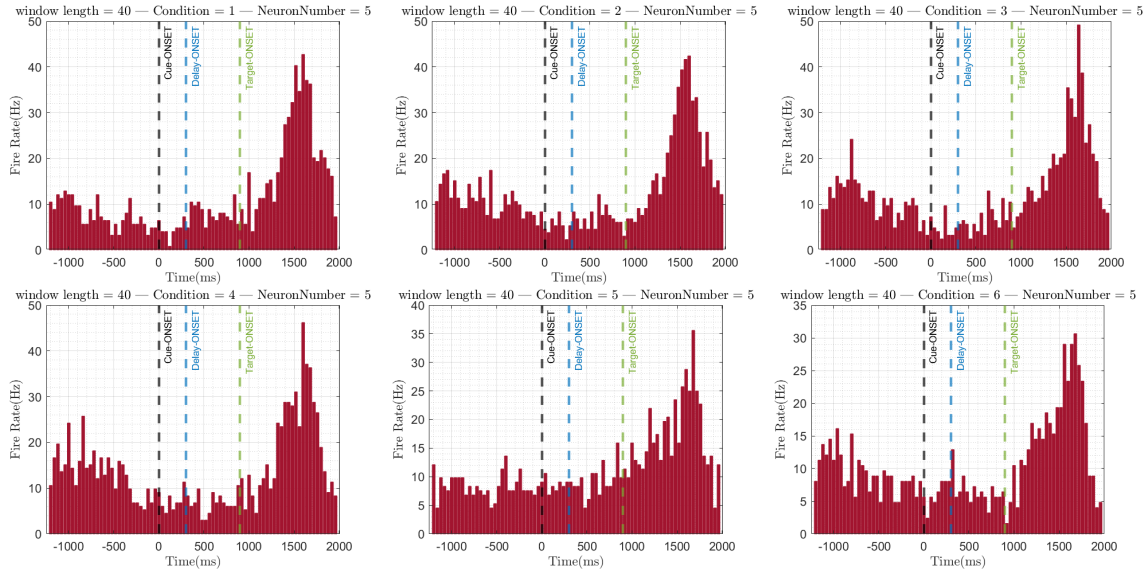

Figure 1: PSTH for unit 5

As you can see, unit number 5 seems to be sensitive to target-ONSET on all conditions and will have an increased firing rate after the monkey saccade to target.
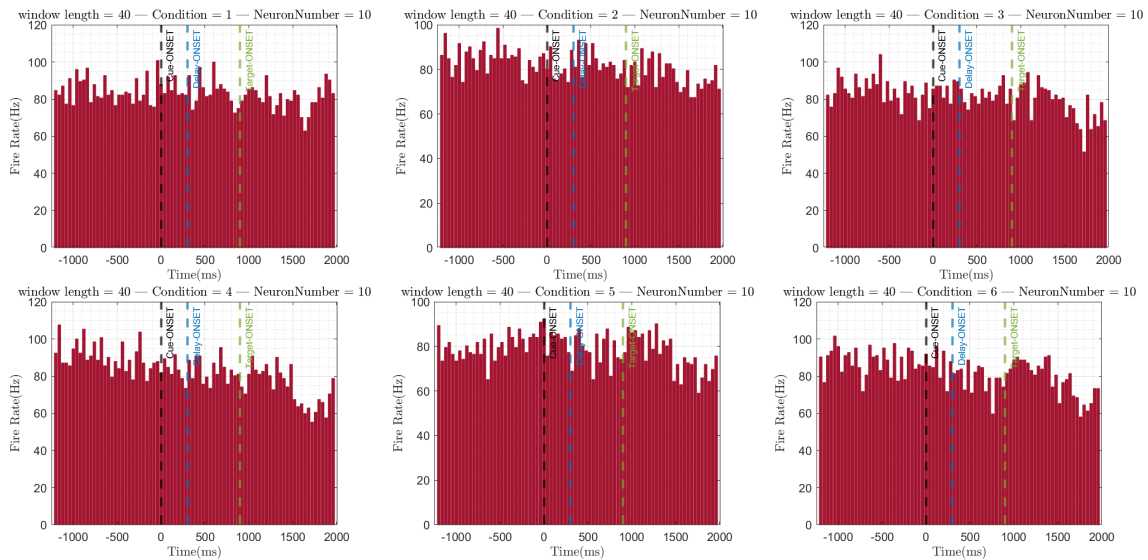

Figure 2: PSTH for unit 10

As you see, unit number 10's firing rate won't significantly change during time and it seem's it doesn't code anything in our task.
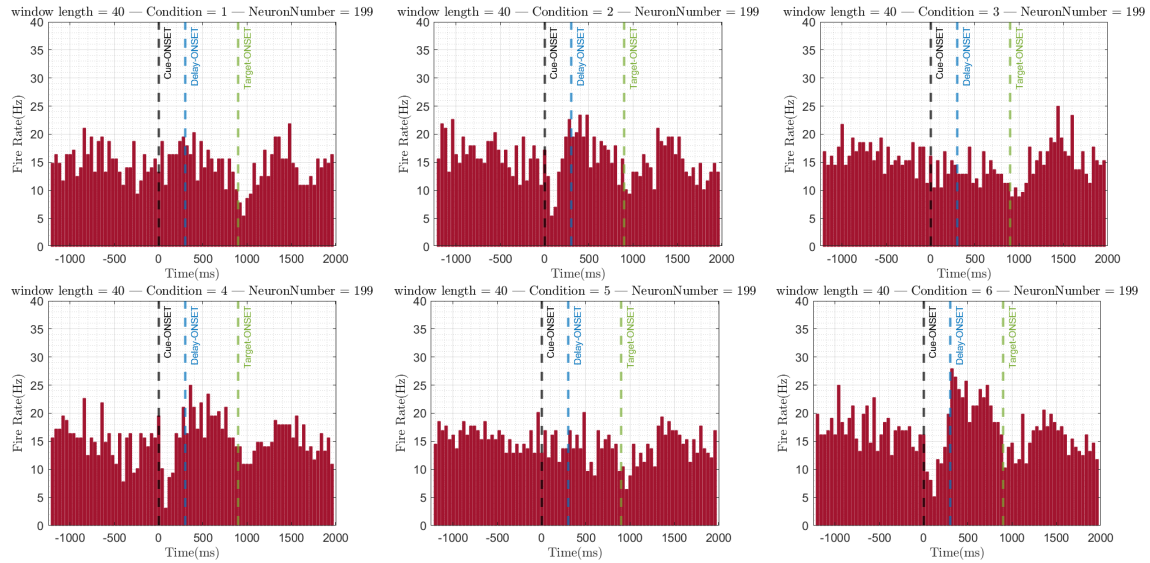
Figure 3: PSTH for unit 199

As you can see, unit number 199 seems to code the cue location between delay and target ONSET. Conditions with cue location of 1 have a higher average firing rate in this period than conditions with cue location of -1. Firing rate between cue and delay ONSET also encodes the cue location. Conditions with cue location of 1 has less average firing rate than conditions with cue location -1.

So it is obvious that different units, have different PSTHs; Some of them encode our task features and some of them don't.

If we average over all units, the PSTHs can't tell us anything since not all the neurons acts the same and this cause PSTHs with some how no information as you can see:
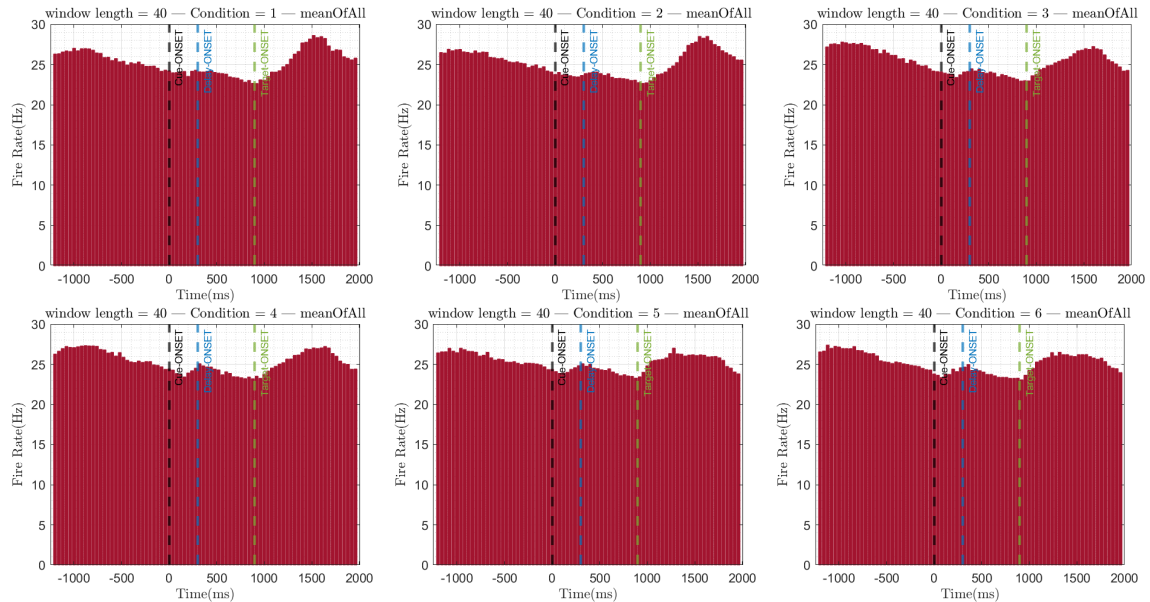

Figure 4: Average PSTH over all units

Part.2 - Single Unit Analysis Using Regression

Here, We fit the average firing rate of each trial in a specific time window for each neuron to the cue locations and reward values. The specific time window that I have chosen starts from delay-ONSET(0.3s) and ends 0.1s after target-ONSET(1s). The reason behind this choice is that the trained monkey will probably choose which direction to saccade after the cue is shown in the delay period. So the monkey is making a decision and gathering attention on its choice and our data shows this before the saccade in the delay period since the data is recorded from parietal cortex. Here are units numbers with P-Value less then 0.05, 0.01 and 0.001 of their regression:

P-Value < 0.05: (83 units) 6 12 21 28 49 54 56 57 59 65 69 74 82 84 90 106 120 127 130 136 141 177 178 193 197 199 206 222 223 225 238 240 242 251 253 267 289 293 294 296 314 319 326 329 335 342 343 346 353 356 365 372 373 376 380 389 390 395 396 400 403 404 409 413 414 416 420 424 426 429 430 437 440 441 443 446 458 459 463 467 477 478 481

P-Value < 0.01: (46 units) 12 49 65 90 120 127 141 193 199 223 238 240 242 267 293 294 296 319 342 343 346 353 356 365 372 373 376 380 389 390 400 403 404 413 416 424 426 429 430 437 440 441 458 459 477 478

P-Value < 0.001: (23 units) 199 223 240 242 293 342 343 372 389 400 403 404 413 424 429 430 437 440 441 458 477

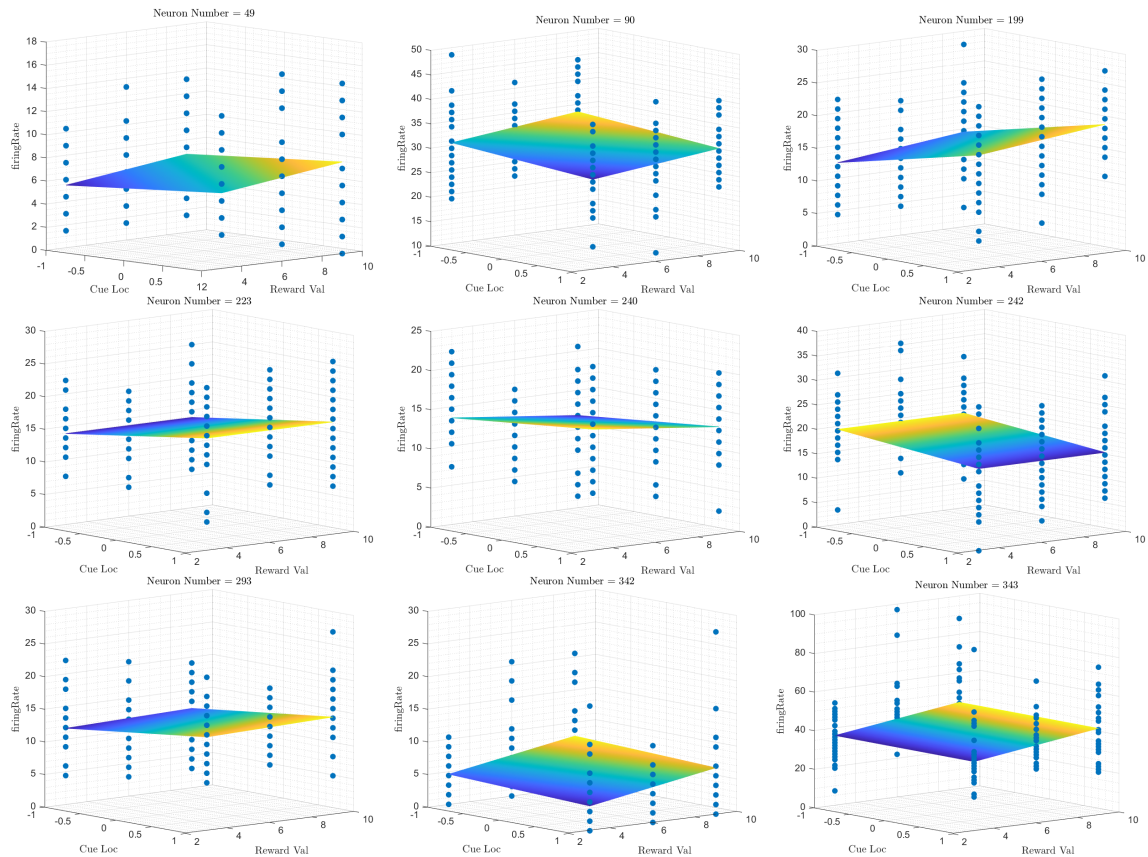Now we show the regressed data for units with P-Value less than 0.001:

Figure 5: Regressed average firing rate for each trial of each neuron on stimuli conditions - unit with P-Value less than 0.001
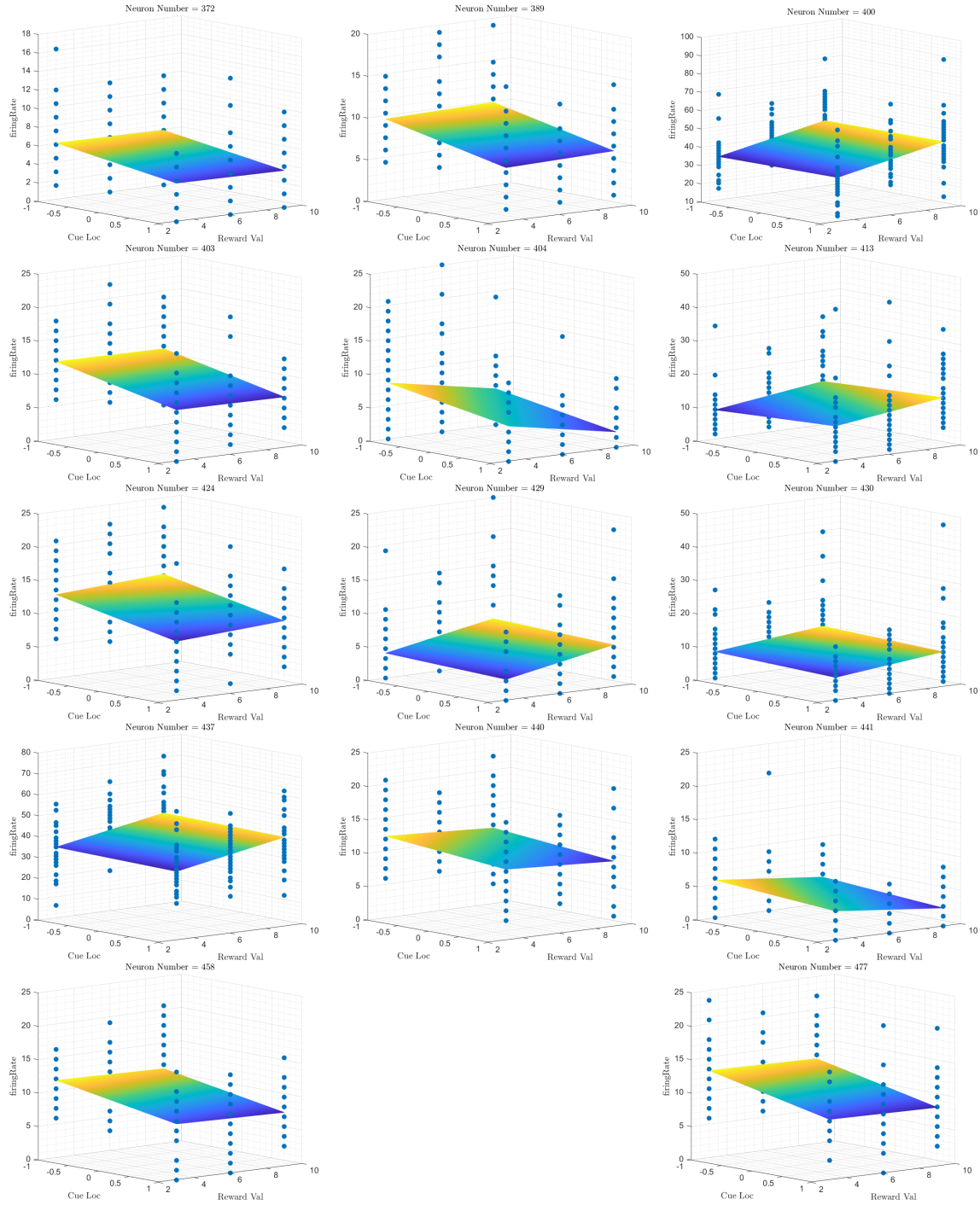
Figure 6: Regressed average firing rate for each trial of each neuron on stimuli conditions - unit with P-Value less than 0.001

As you can see, these 23 units, encode cue location and reward values. Some of them encodes one of the feature better than others. For example, when reward value increases, some of the neurons firing rate will decrease and some will increase. It is the same for the cue location. (Each dot is the value of average firing rate in the time window of interest based on its cue location and reward value)

So single unit analysis conveys information about both cue locations and reward values.

Part.3,4 - Population Activity in Lower Dimension

In this part, we calculate PSTH with a time window of 10 samples for more accurate results. We give the 481 × 320 matrix six times to PCA and plot the population activity. Here's the result:
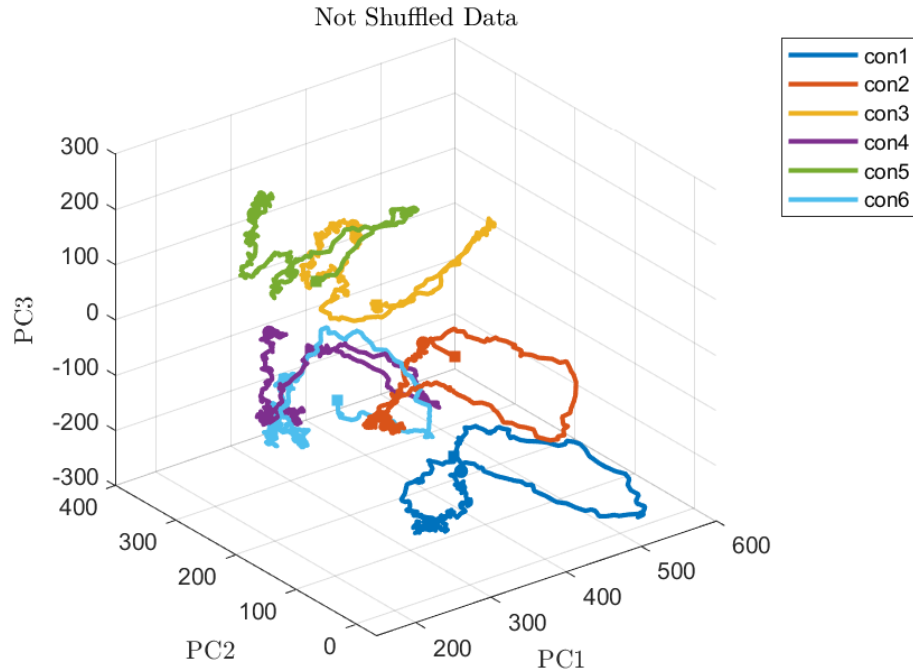

Figure 7: Population Activity across the most three significant PCs for each condition

Now we shuffle the data using CFR algorithm(100 times shuffled), and here's the result:
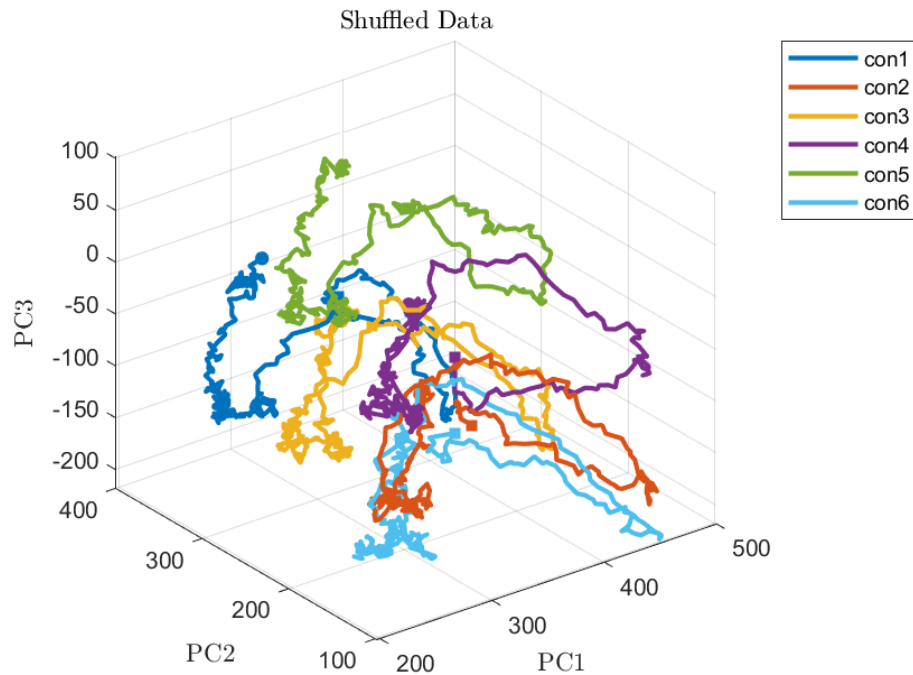

Figure 8: Population Activity across the most three significant PCs for each condition

As you can see, the not shuffled data is encoding different conditions with different patterns and locations, but after shuffling, all conditions will have the same pattern and they get very close to each other and they won't encode the conditions as good as when they were not shuffled (They don't do anymore!). So the population activity of all units conveys information about cue locations and reward values.