In The Name Of God

HW02

Advanced Neuroscience

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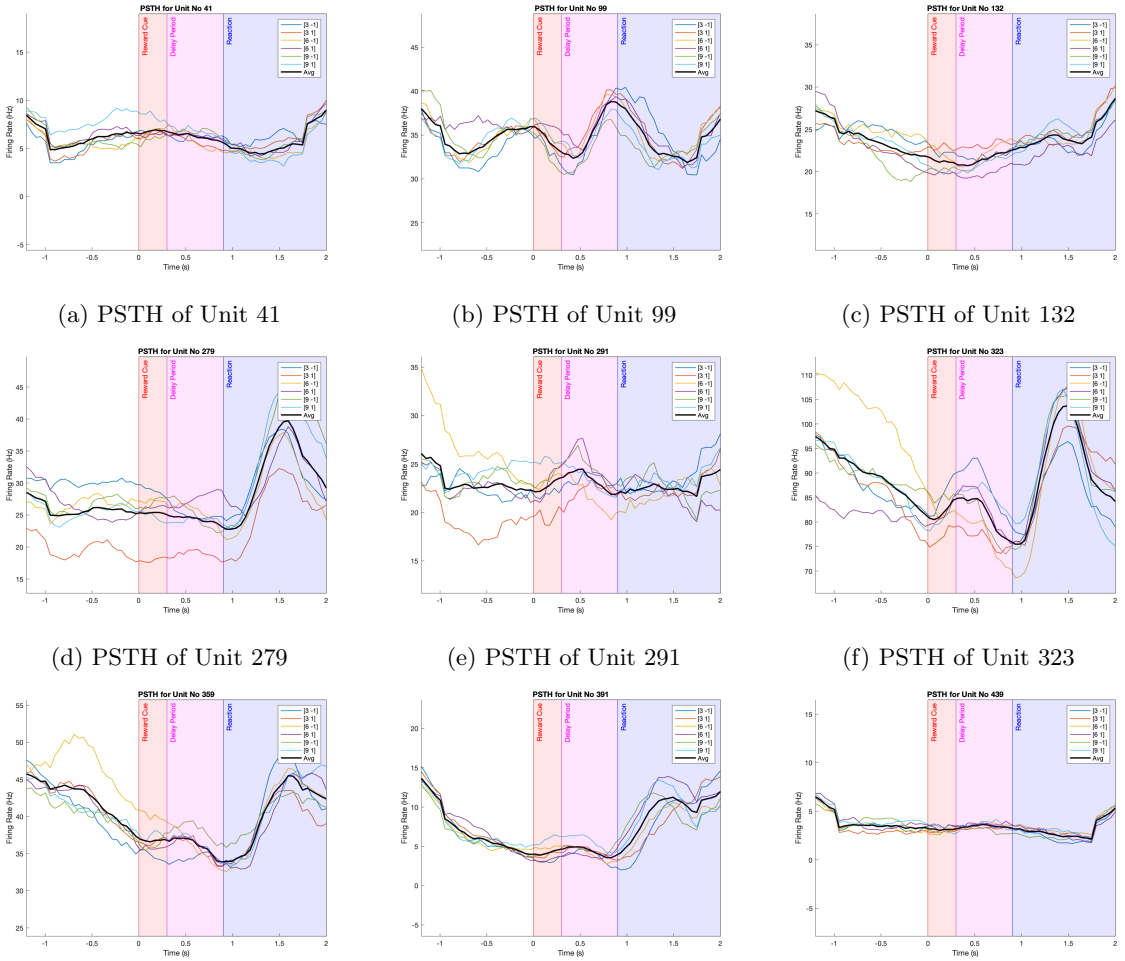
■ Step 1

□ Q1



(a) PSTH of Unit 41 (b) PSTH of Unit 99 (c) PSTH of Unit 132

(d) PSTH of Unit 279 (e) PSTH of Unit 291 (f) PSTH of Unit 323

(g) PSTH of Unit 359 (h) PSTH of Unit 391 (i) PSTH of Unit 439

Figure 1: PSTH of Different Units

According to Figure 1, some units have similar PSTH plot shapes, but their firing rates vary.

□ Q2

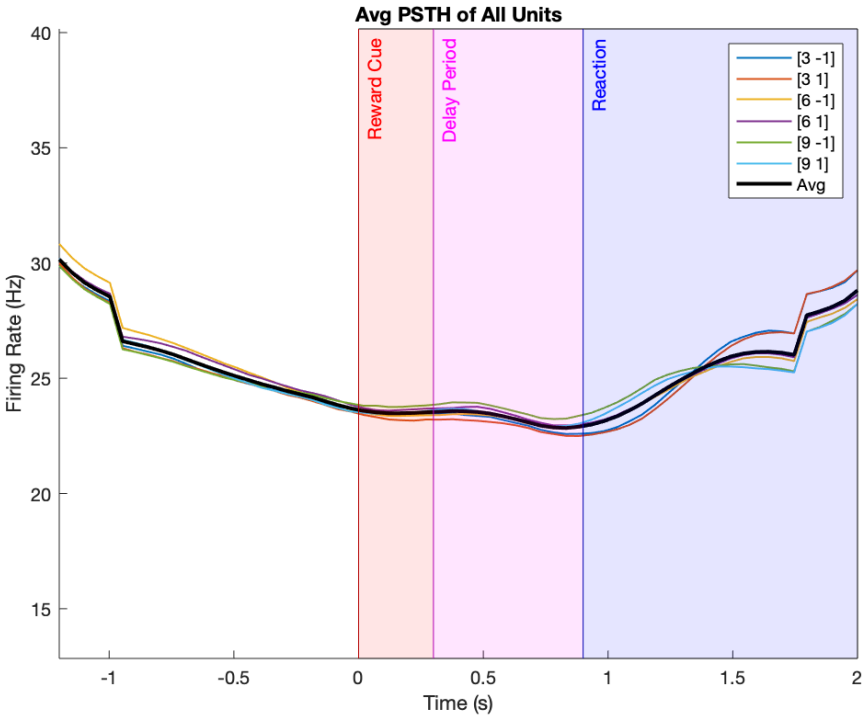


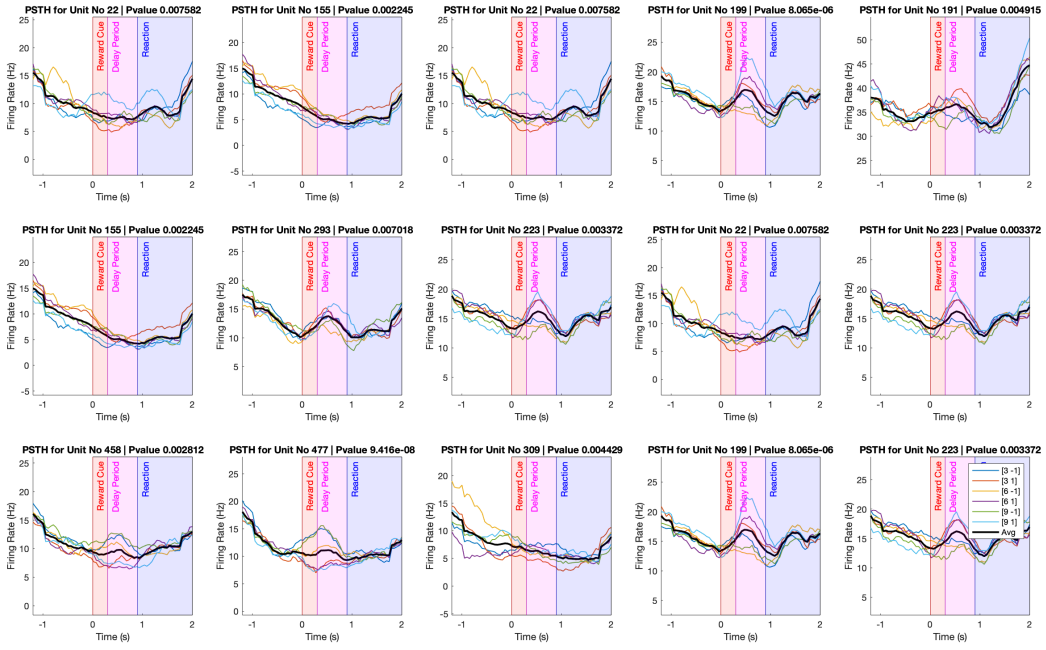
Figure 2: PSTH of Average of all Units

As can be seen in Figure 2, the average PSTH of all the units differ from the PSTH of some units which are likely to encode the neural activity with their firing rate. So, I think that maybe just a few of the units are encoding the neural activity with their firing rate.

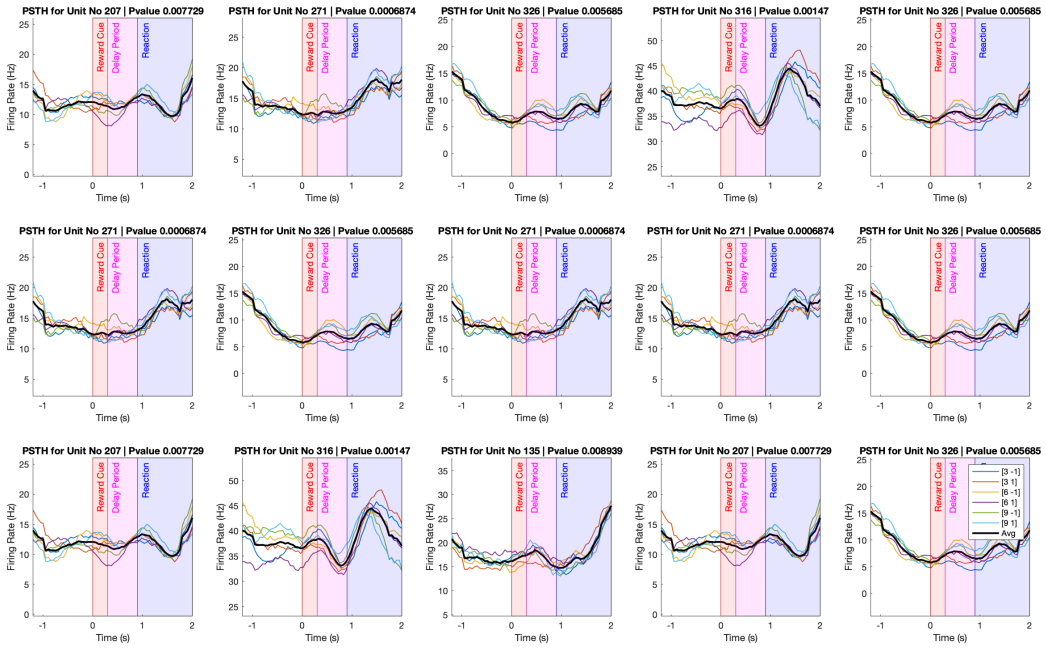
■ Step 2

□ Single Units

Left and Right Cue

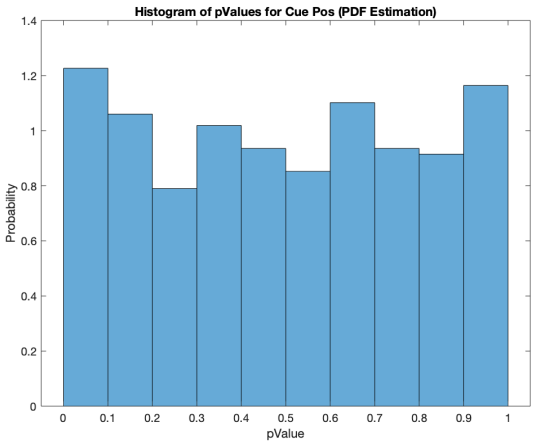


(a) No Shuffling

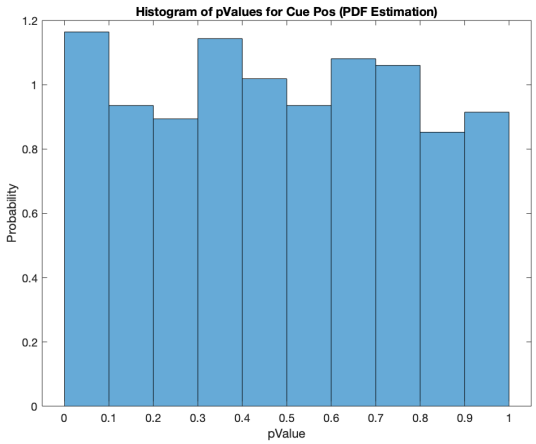


(b) Shuffled

Figure 3: PSTH of Some Units with pValue < 0.01

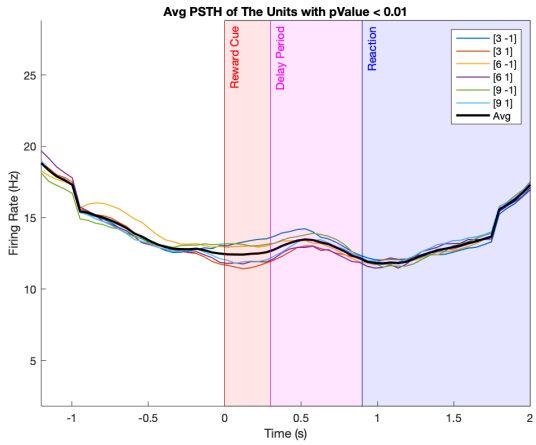


(a) No Shuffling

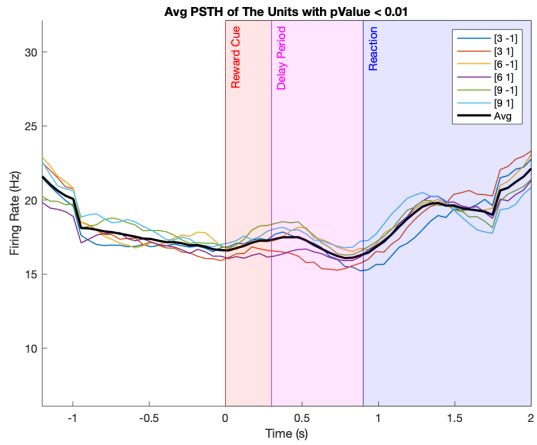


(b) Shuffled

Figure 4: Histogram (PDF) of pValues for Cue Locations



(a) No Shuffling



(b) Shuffled

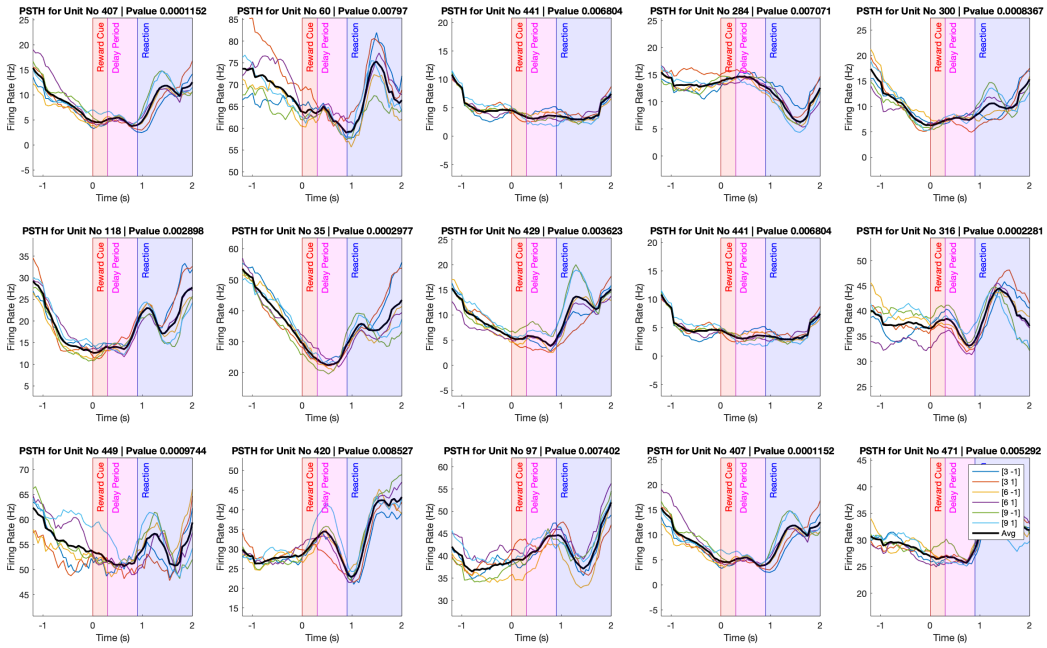
Figure 5: Average PSTH of The Units with pValue < 0.01

Table 1: Average pValue of all Units

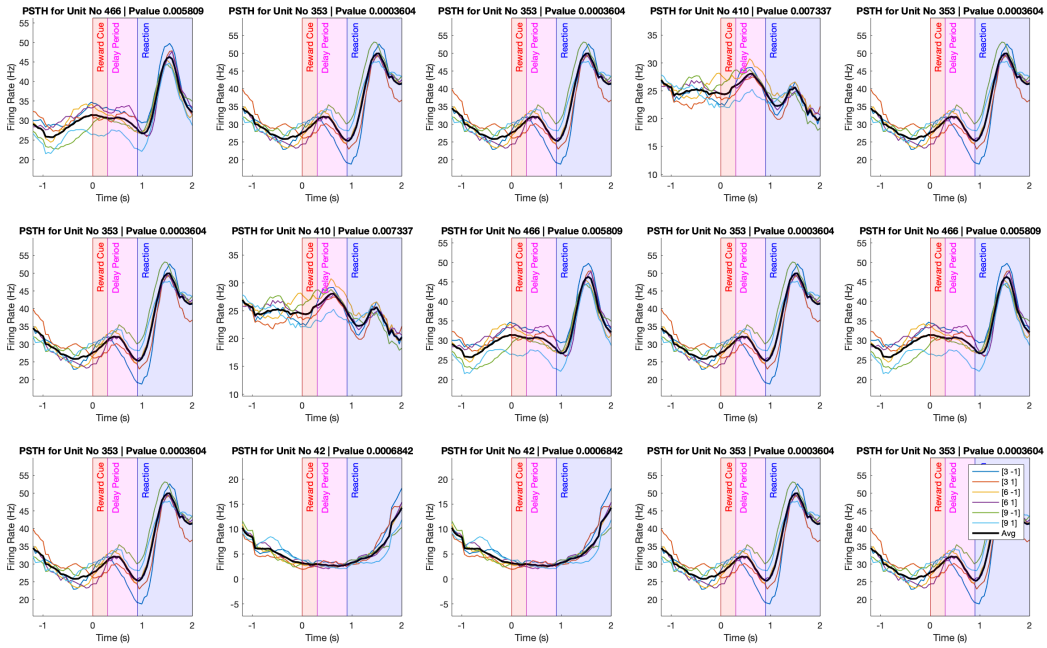
No Shuffling	Shuffled
0.4944	0.4880

As can be seen in Figure 4, the distribution of the pValues doesn't have any peaks in small pValues and the average PSTH of all the units with pValue ¡ 0.01 doesn't indicate any difference between different cue locations.

Reward Expected Value

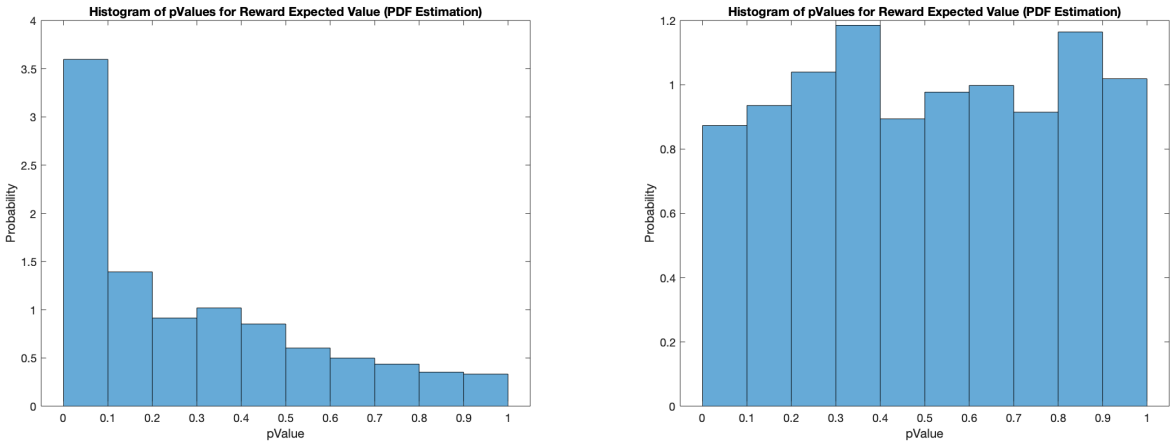


(a) No Shuffling



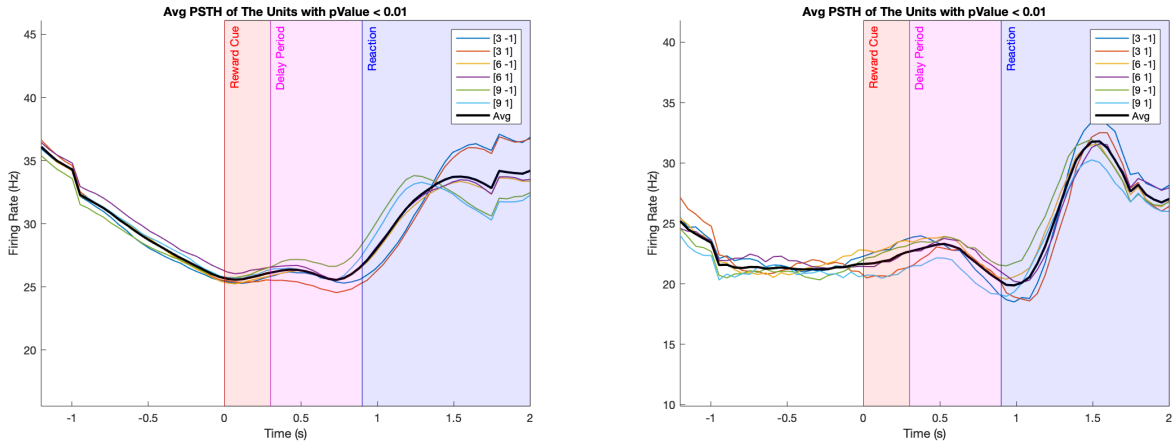
(b) Shuffled

Figure 6: PSTH of Some Units with pValue < 0.01



(a) No Shuffling (b) Shuffled

Figure 7: Histogram (PDF) of pValues for Reward Expected Value



(a) No Shuffling (b) Shuffled

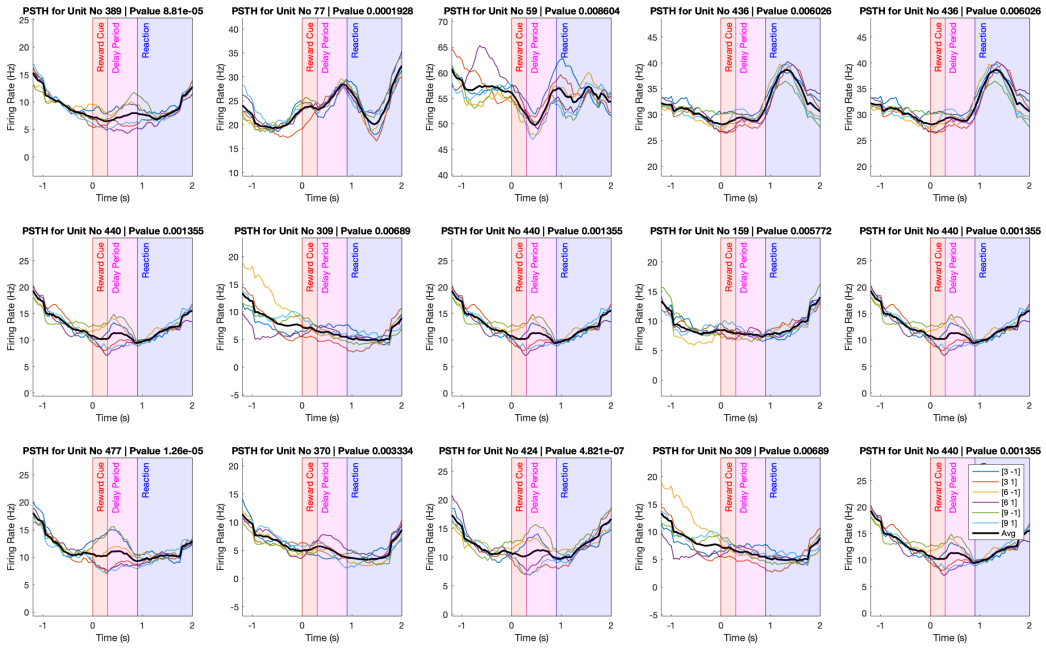
Figure 8: Average PSTH of The Units with pValue < 0.01

Table 2: Average pValue of all Units

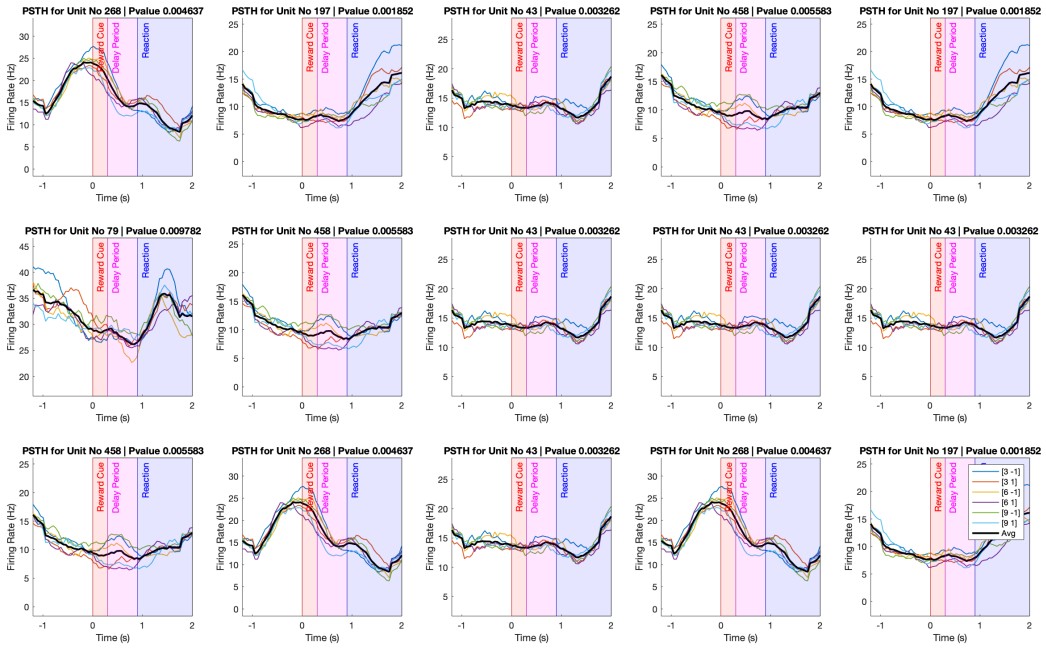
No Shuffling	Shuffled
0.2883	0.4976

As can be seen in Figure 10, the distribution of the pValues has a peak in pValues smaller than 0.1 and the average PSTH of all the units with pValue ¡ 0.01 indicates the noticeable difference between different reward expected values.

All 6 Conditions

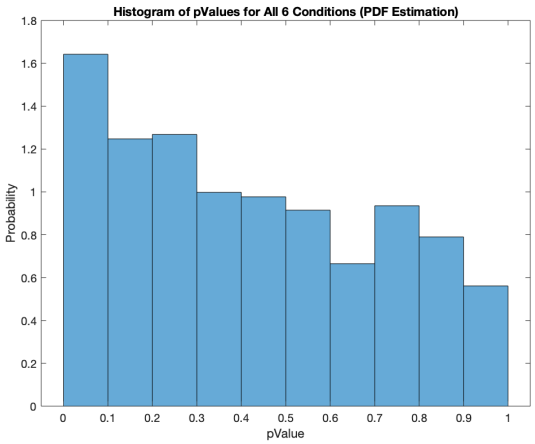


(a) No Shuffling

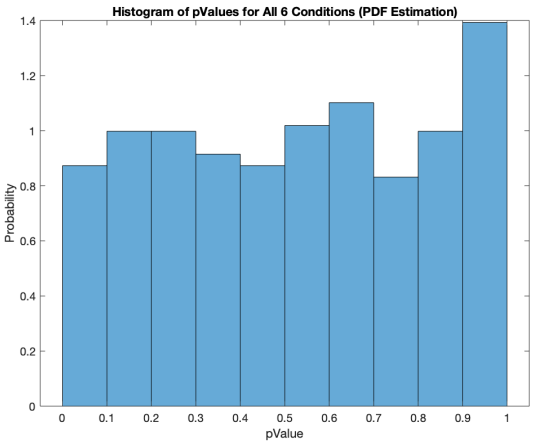


(b) Shuffled

Figure 9: PSTH of Some Units with pValue < 0.01

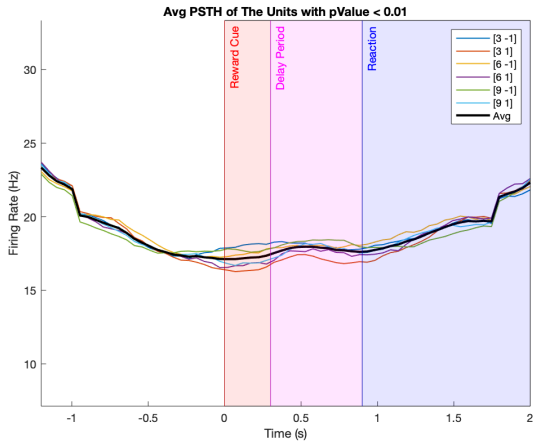


(a) No Shuffling

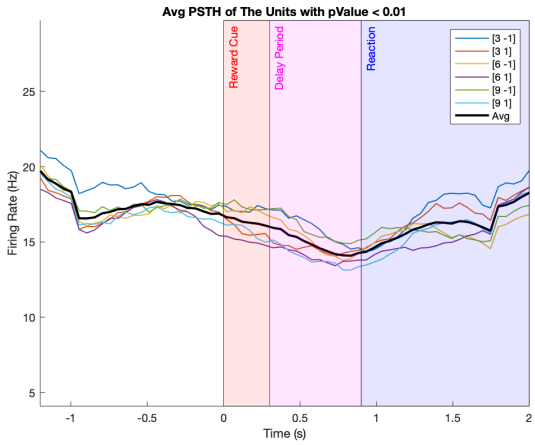


(b) Shuffled

Figure 10: Histogram (PDF) of pValues for All 6 Conditions



(a) No Shuffling



(b) Shuffled

Figure 11: Average PSTH of The Units with pValue < 0.01

Table 3: Average pValue of all Units

No Shuffling	Shuffled
0.4215	0.5060

As I expect, pValues for modeling all the conditions is smaller than pValues for modeling cue locations and bigger than pValue for reward expected value but it can not model the different conditions well.

□ Population

For a population, there is just a number as pValue so I have not any figures but I will compare average pValues of single units with pValue of the population in different conditions.

Table 4: Average pValue of all Units (for Single Units) and pValue for Populations

Conditions Type	Cue Left/Right			Reward Expected Value			All Conditions		
Shuffling	No	Yes	Ratio	No	Yes	Ratio	No	Yes	Ratio
Single Units	0.4944	0.4880	1.0131	0.2883	0.4976	0.5793	0.4215	0.5060	0.8330
Population	0.8162	0.0343	23.7959	2e-08	0.1608	1e-09	0.0935	0.2047	0.4567

As can be seen in Table 4, both single units and population code reward expected value better than all conditions or left/right cue. Also, cue left/right has the worst average pValue.
It is noteworthy to mention that Population codes the reward expected value far better than single neurons. I can suggest two reasons for it:

- In population coding, the basis functions are much larger than basis functions in single unit coding, so perhaps the reason for population superiority in coding the conditions is its larger basis functions set.
- Populations can code conditions better because a single unit does not have enough information to code them.

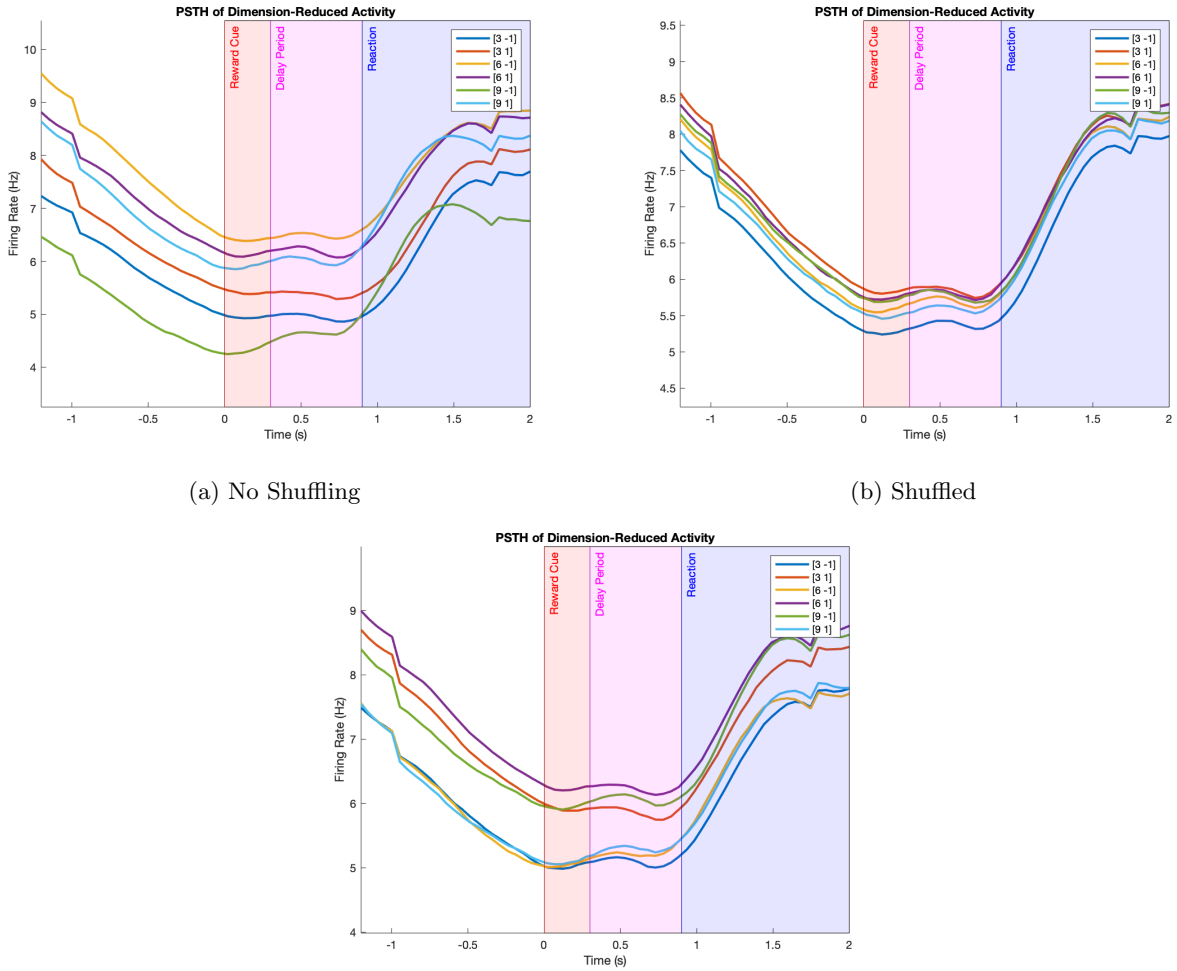
For analyzing the mentioned reasons, I have shuffled the data and fitted GLM on them and as have been mentioned in Table 4, the ratio of pValue of not shuffled data to pValue of shuffled data is minimum when the population is coding the conditions. So I infer that this area can code the reward expected value so good.

* I don't report R^2 values because the modeled data (conditions) has a small variance.

■ Steps 3 and 4

□ All 6 Conditions

Reducing num of Units to 1 using PCA



(a) No Shuffling

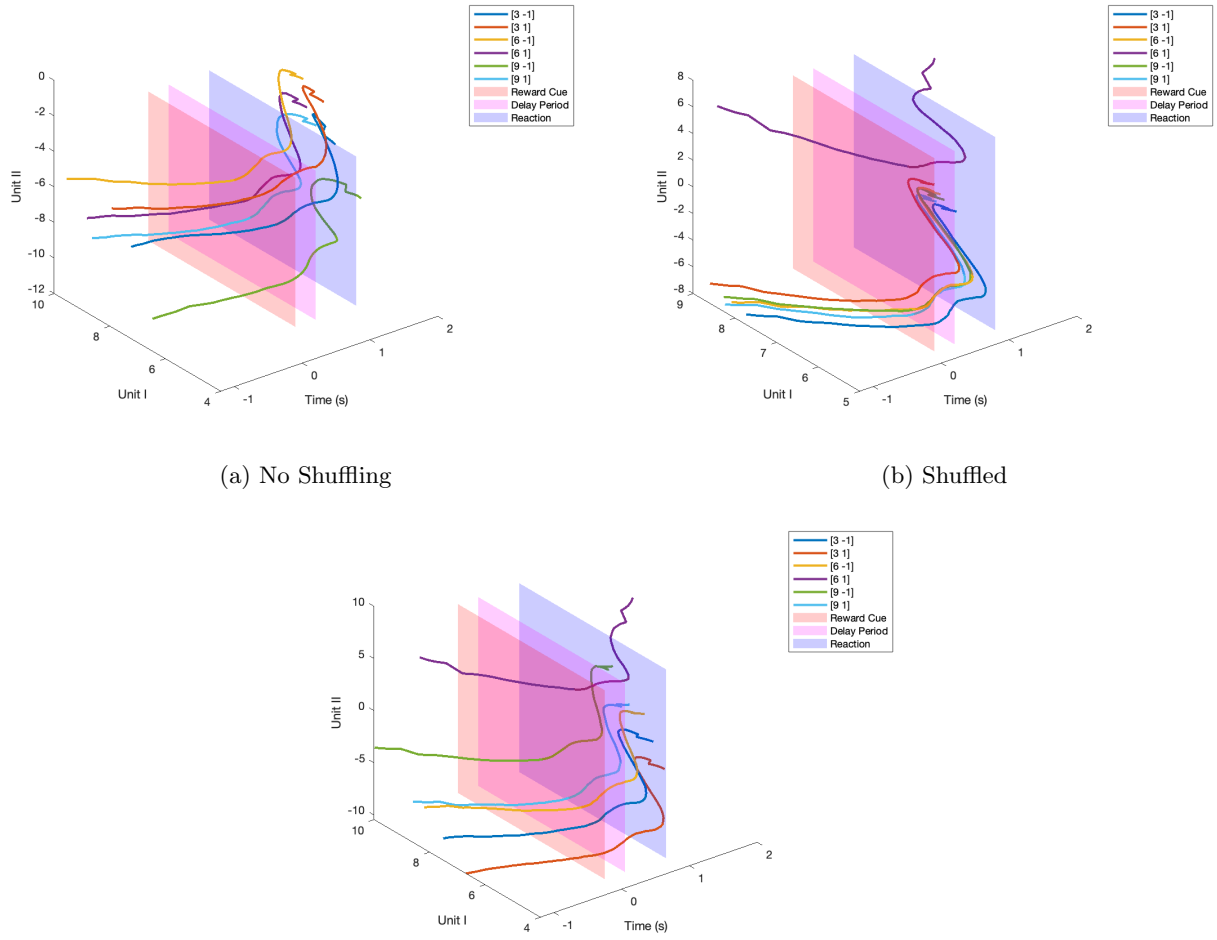
(b) Shuffled

(c) CFR Shuffled

Figure 12: PSTH Plot

Note that I have not plotted Principal component in Figures 12 and 15. I have picked the first eigenvector and reconstructed the whitened data in the time domain using only that eigenvector. However, there is not a meaningful difference between different conditions as can be seen in the Figures above.

Reducing num of Units to 2 using PCA



(a) No Shuffling

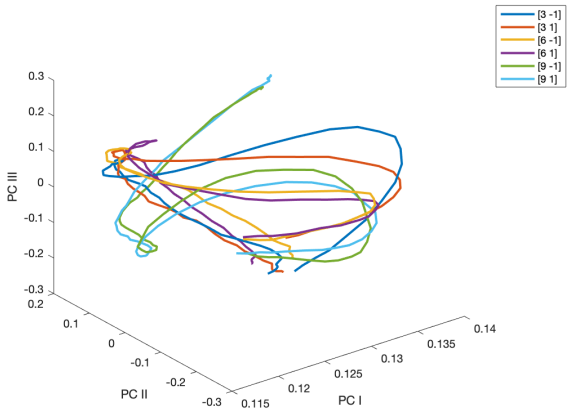
(b) Shuffled

(c) CFR Shuffled

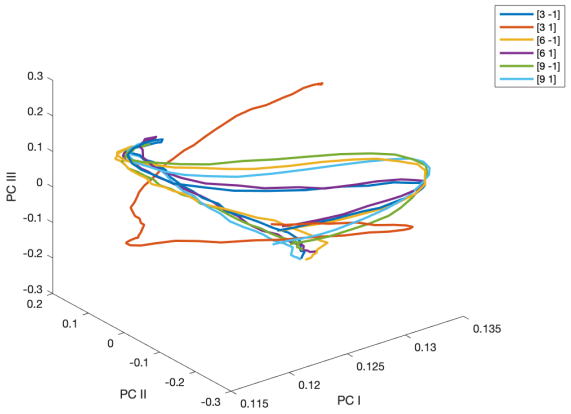
Figure 13: Unit I vs Unit II vs Time

In the Figures 13 and 16, I have the first and second eigenvectors and reconstructed the data in the time domain using these two eigenvectors.

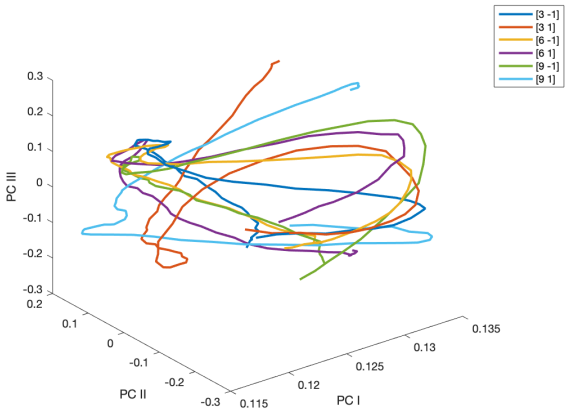
Plotting PCs instead of Dimension Reduced Data



(a) No Shuffling



(b) Shuffled



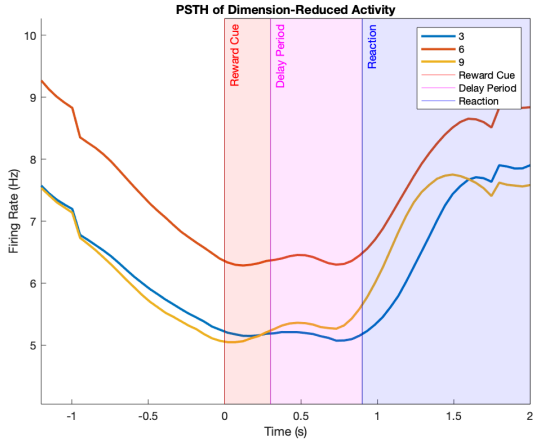
(c) CFR Shuffled

Figure 14: PC I vs PC II vs PC III

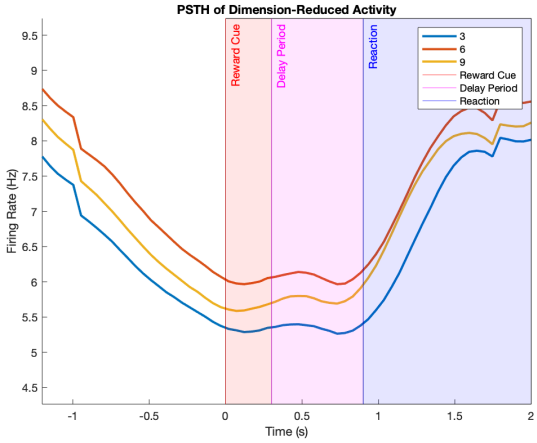
In the Figures 14 and 17, I have plotted the first 3 eigenvectors vs together. As can be seen in the Figures above, conditions with high reward expected values (cyan and green trajectories) have a different trajectory in comparison with the other conditions and when I shuffle the data, this difference goes away.

☐ Just Expected Value

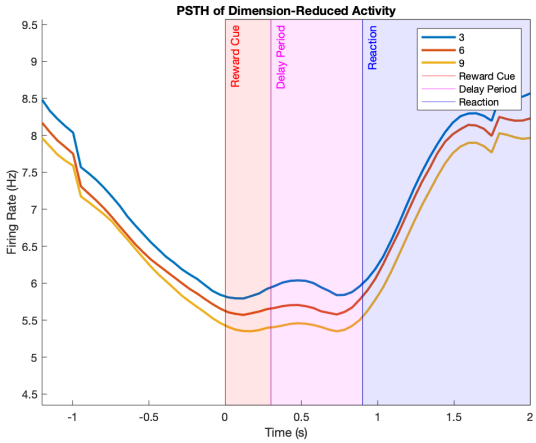
Reducing num of Units to 1 using PCA



(a) No Shuffling



(b) Shuffled

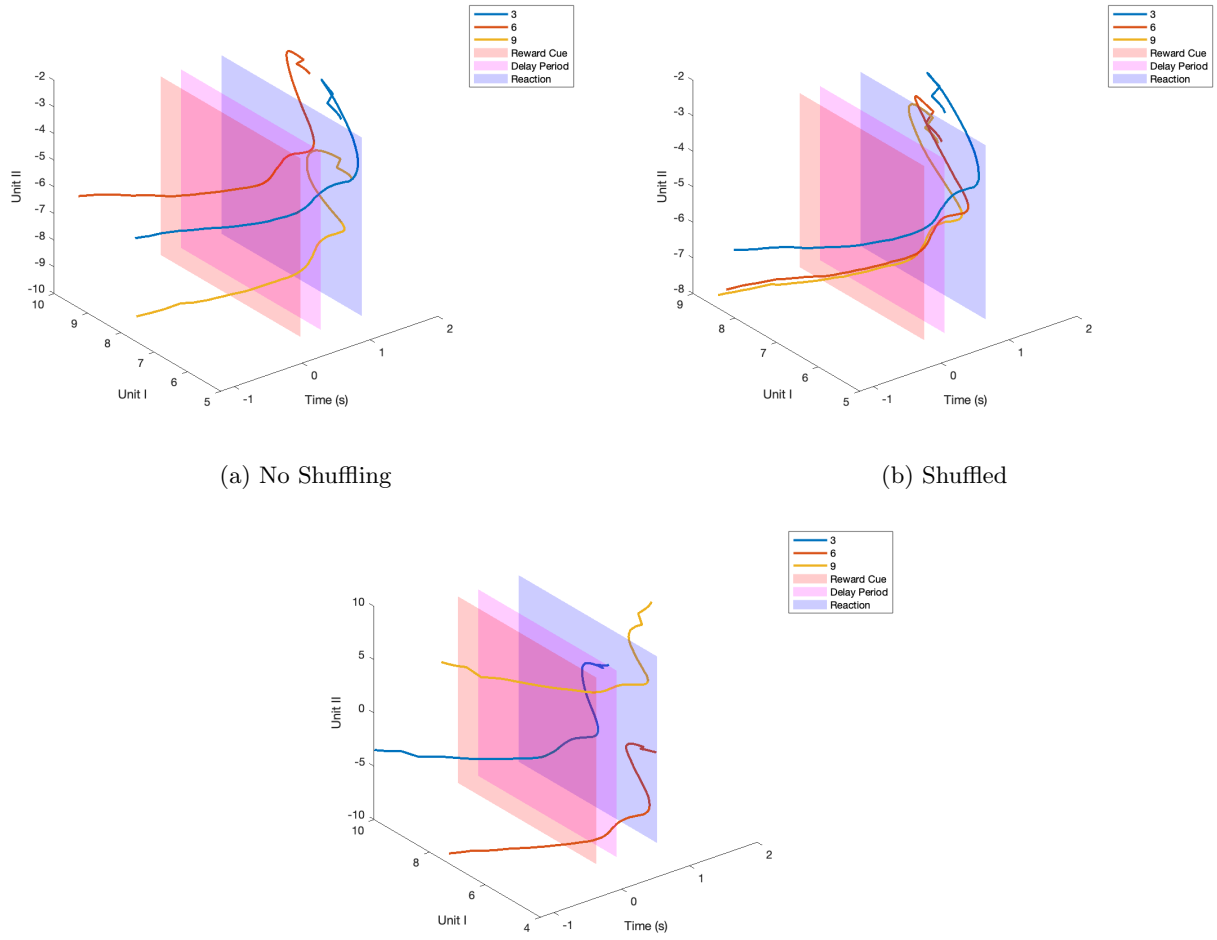


(c) CFR Shuffled

Figure 15: PSTH Plot

As I expect, there is no noticeable difference for different expected values as same as Figure 12.

Reducing num of Units to 2 using PCA



(a) No Shuffling

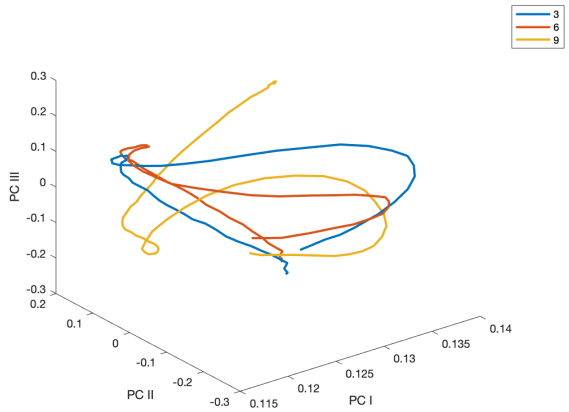
(b) Shuffled

(c) CFR Shuffled

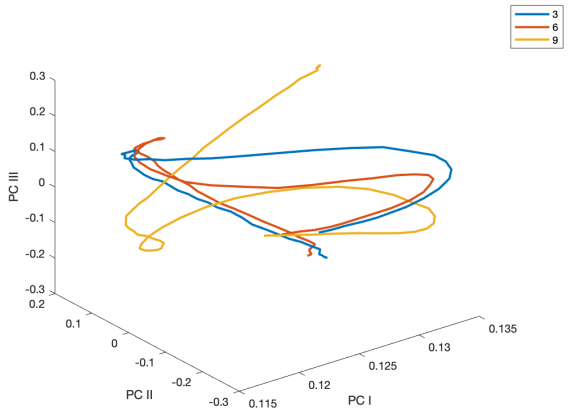
Figure 16: Unit I vs Unit II vs Time

Same as the last part.

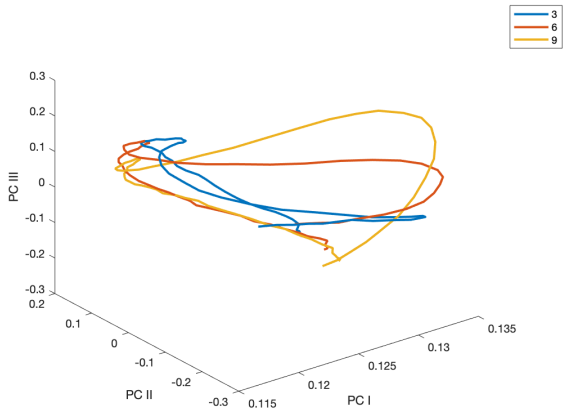
Plotting PCs instead of Dimension Reduced Data



(a) No Shuffling



(b) Shuffled



(c) CFR Shuffled

Figure 17: PC I vs PC II vs PC III

As mentioned before in Figure 14, the High reward expected value has a completely different trajectory in comparison with the other reward expected values. I have shuffled the data by randomly changing the reward expected values in Figure 17 b, but it doesn't have much difference with Figure 17 a. but using CFR shuffling method in Figure 17 c, we can see that almost all the conditions are following the same pattern in their trajectories.