



In The Name Of God
HW02
Advanced Neuroscience

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■ Step 1

□ Q1

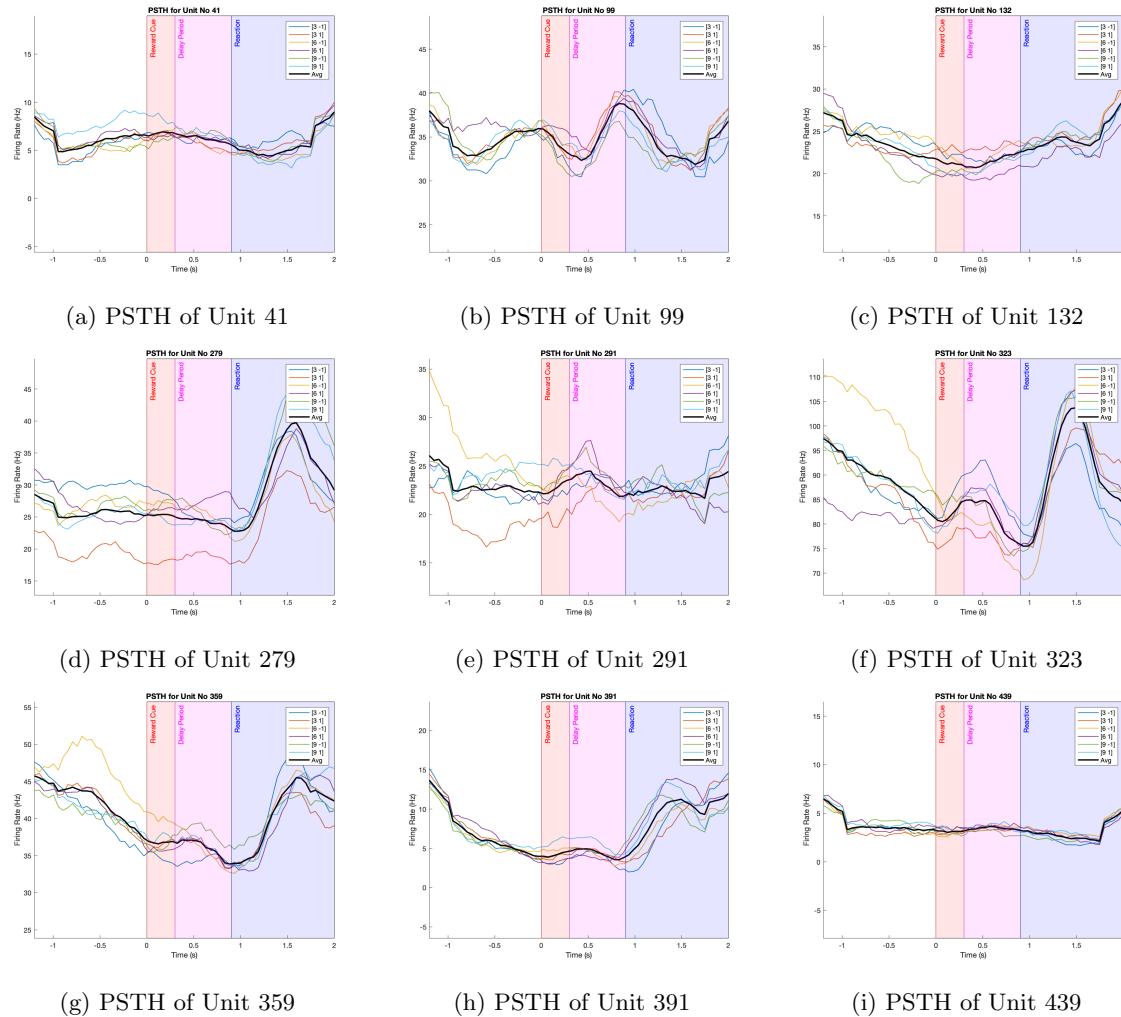


Figure 1: PSTH of Different Units

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



□ Q2

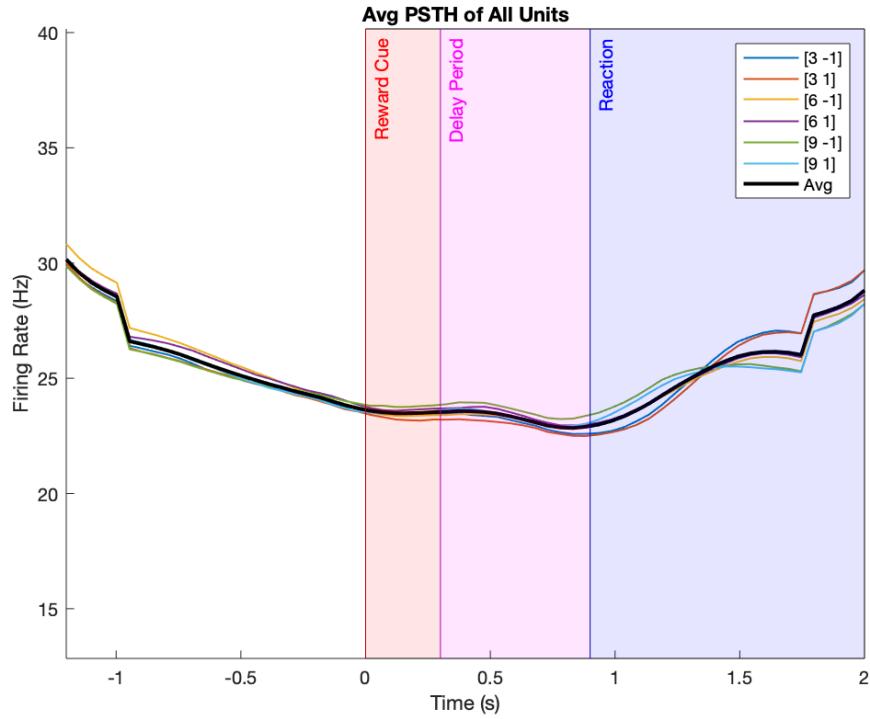


Figure 2: PSTH of Average of all Units

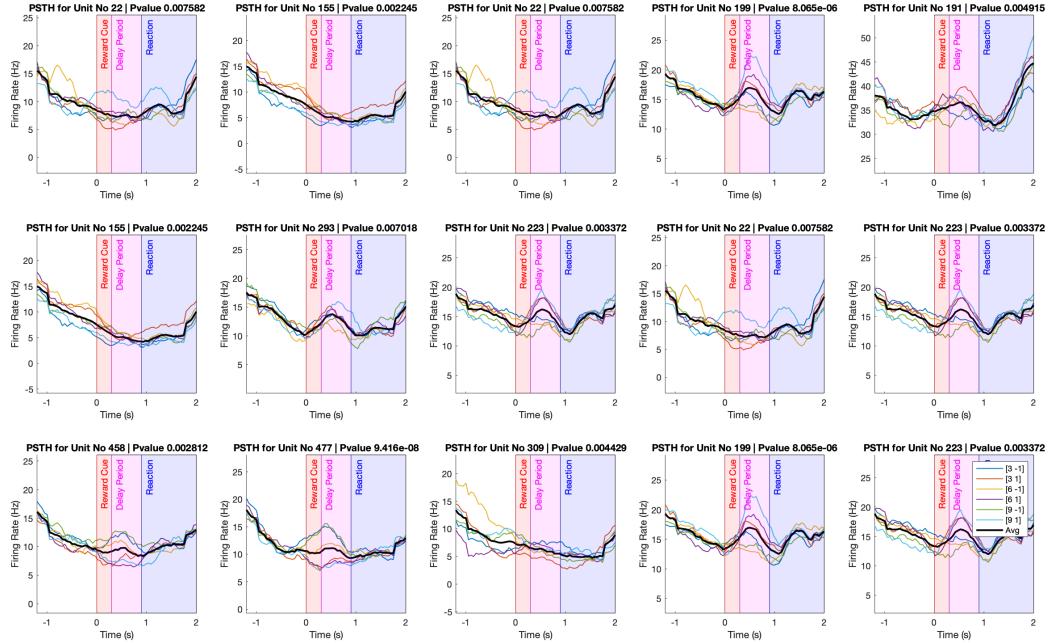
As can be seen in Figure 2, average PSTH of all the units differ from the PSTH of some units which are likely to encode the neural activity with their firing rate. So, I think that maybe just a few of the units are encoding the neural activity with their firing rate.



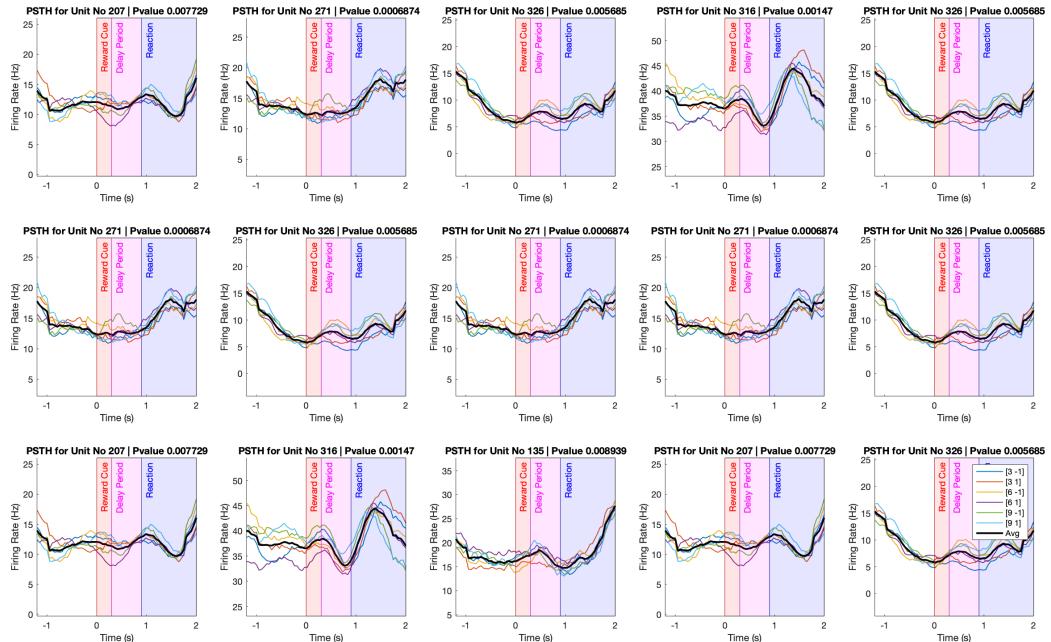
■ Step 2

□ Single Units

Left and Right Cue



(a) No Shuffling



(b) Shuffled

Figure 3: PSTH of Some Units with pValue < 0.01

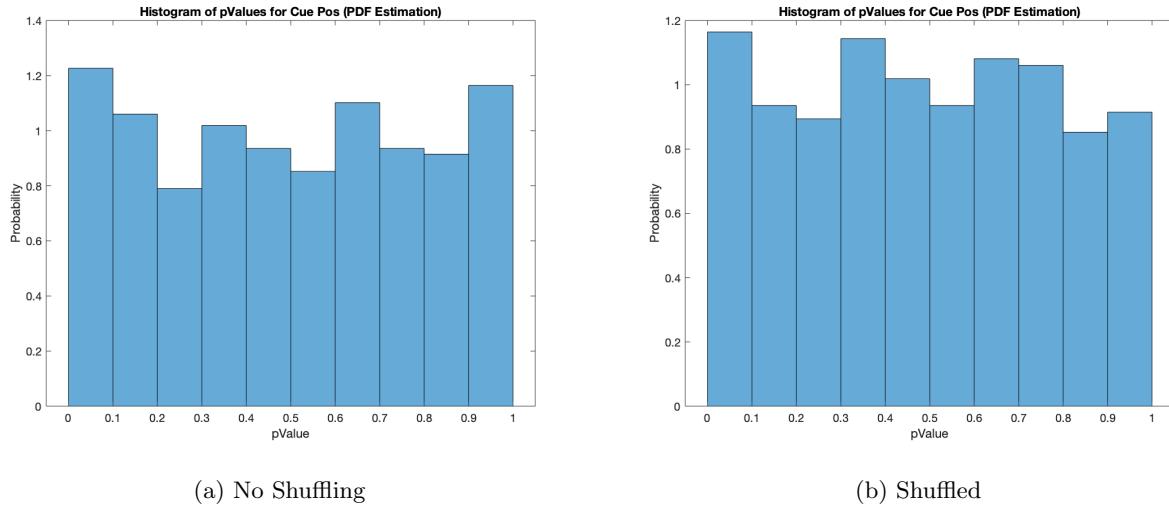


Figure 4: Histogram (PDF) of pValues for Cue Locations

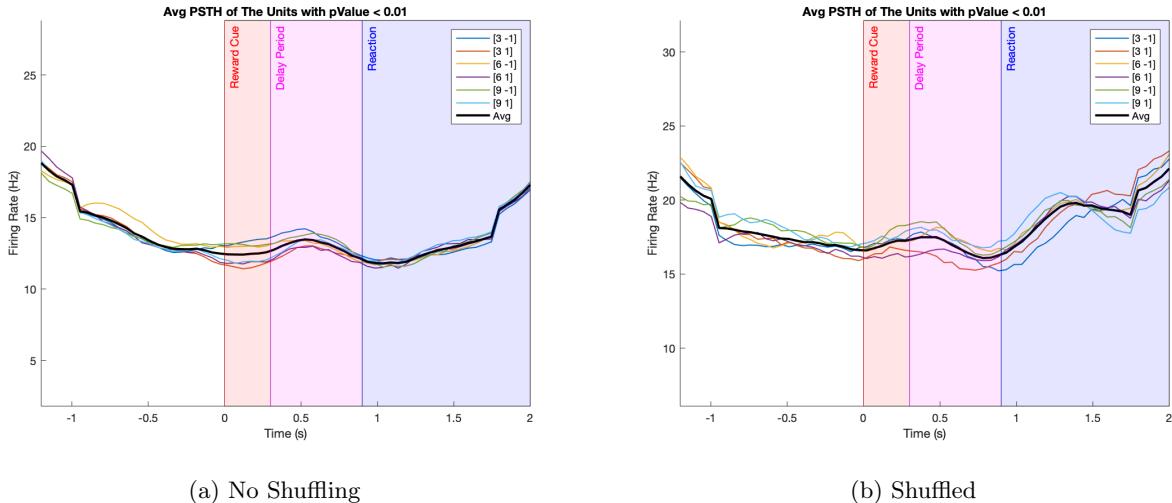


Figure 5: Average PSTH of The Units with $pValue < 0.01$

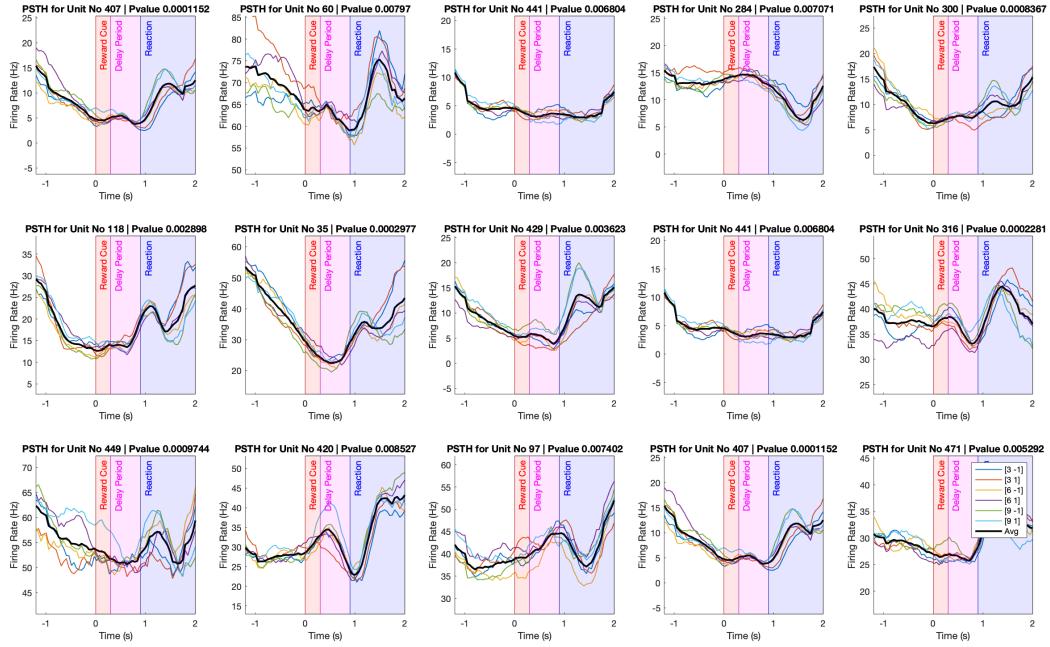
Table 1: Average pValue of all Units

No Shuffling	Shuffled
0.4944	0.4880

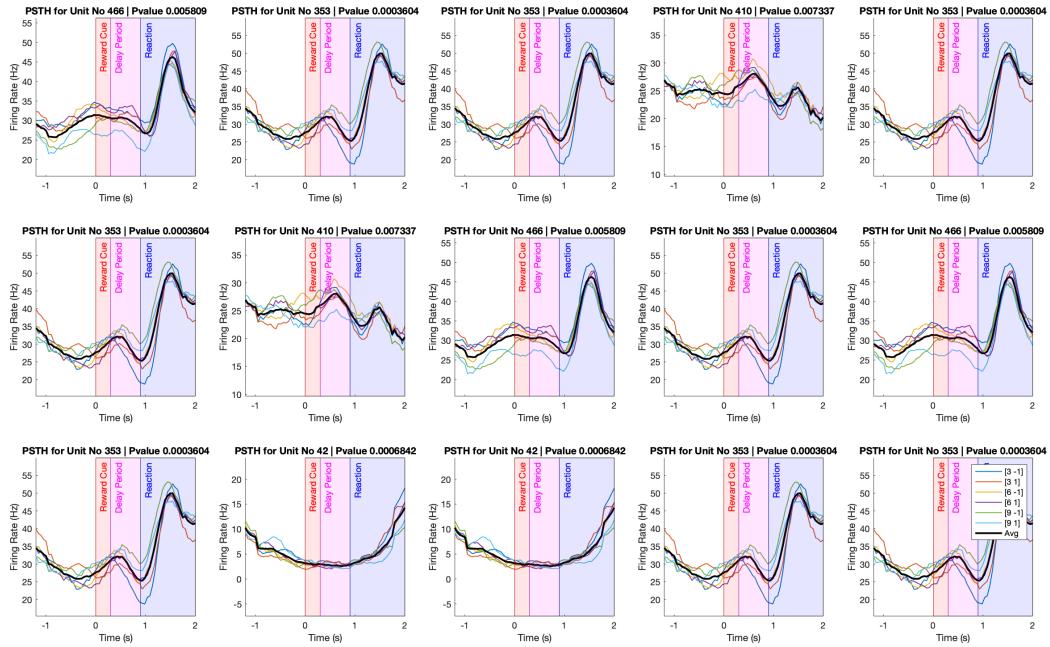
As can be seen in Figure 4, distribution of the pValues doesn't have any peaks in small pValues and average PSTH of all the units with $pValue < 0.01$ doesn't indicate any difference between different cue locations.



Reward Expected Value



(a) No Shuffling



(b) Shuffled

Figure 6: PSTH of Some Units with pValue < 0.01

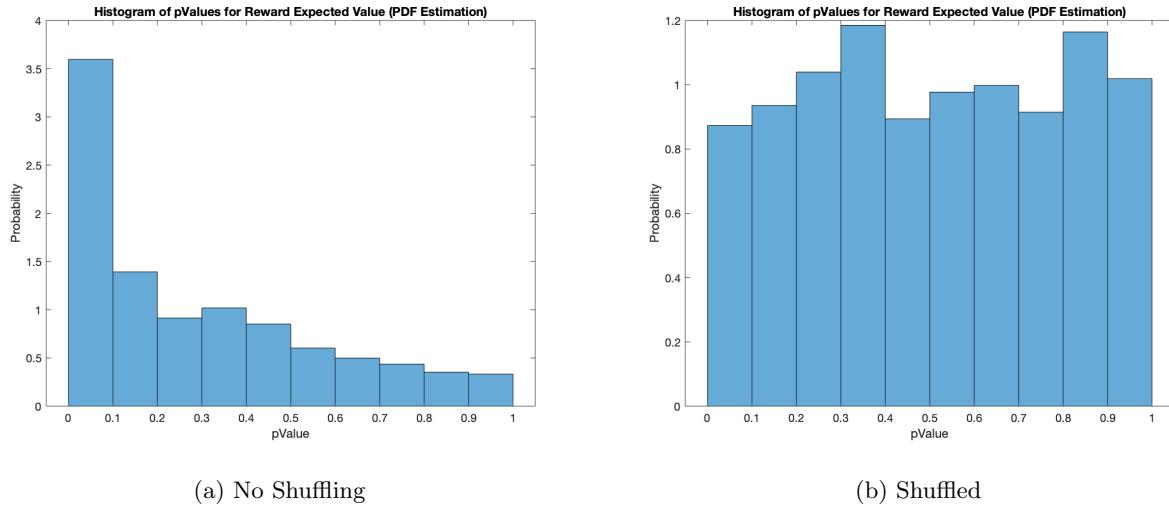


Figure 7: Histogram (PDF) of pValues for Reward Expected Value

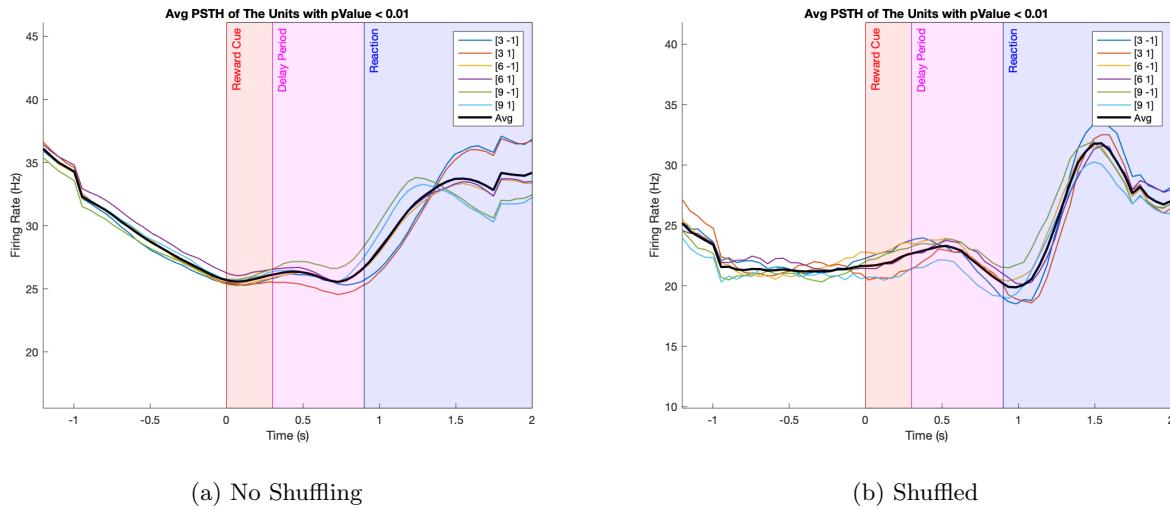


Figure 8: Average PSTH of The Units with pValue < 0.01

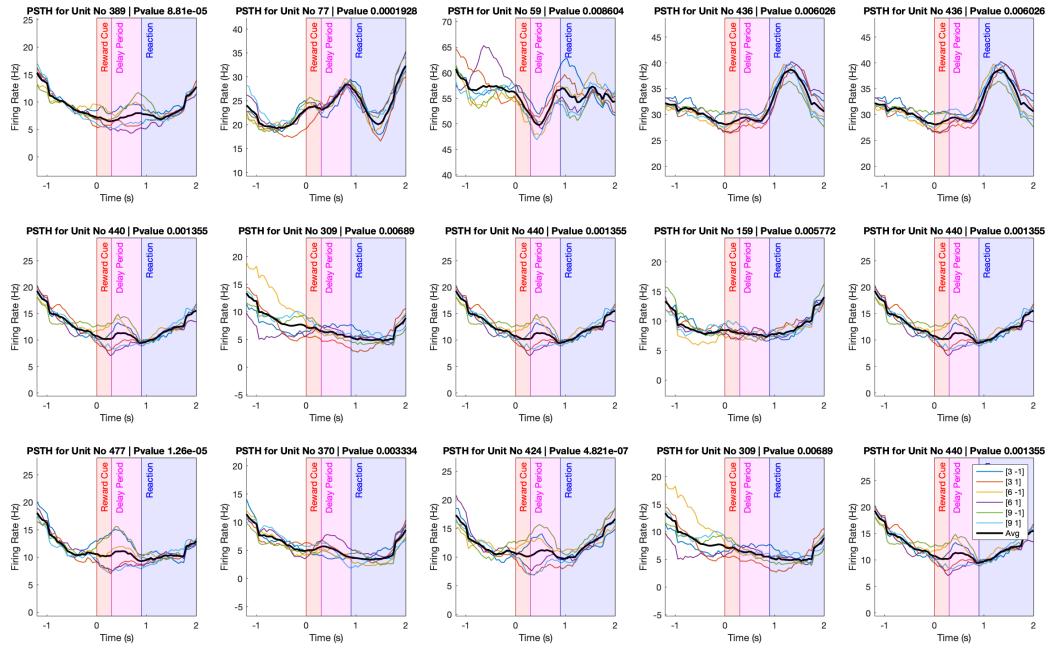
Table 2: Average pValue of all Units

No Shuffling	Shuffled
0.2883	0.4976

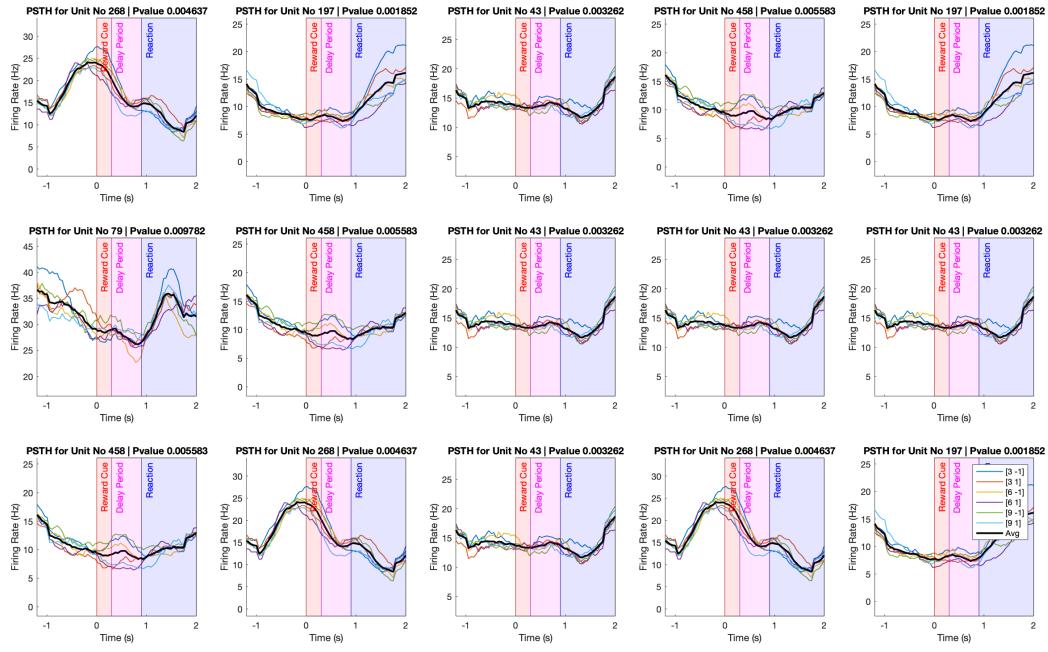
As can be seen in Figure 10, distribution of the pValues has a peak in pValues smaller than 0.1 and average PSTH of all the units with pValue < 0.01 indicates noticeable difference between different reward expected values.



All 6 Conditions



(a) No Shuffling



(b) Shuffled

Figure 9: PSTH of Some Units with pValue < 0.01

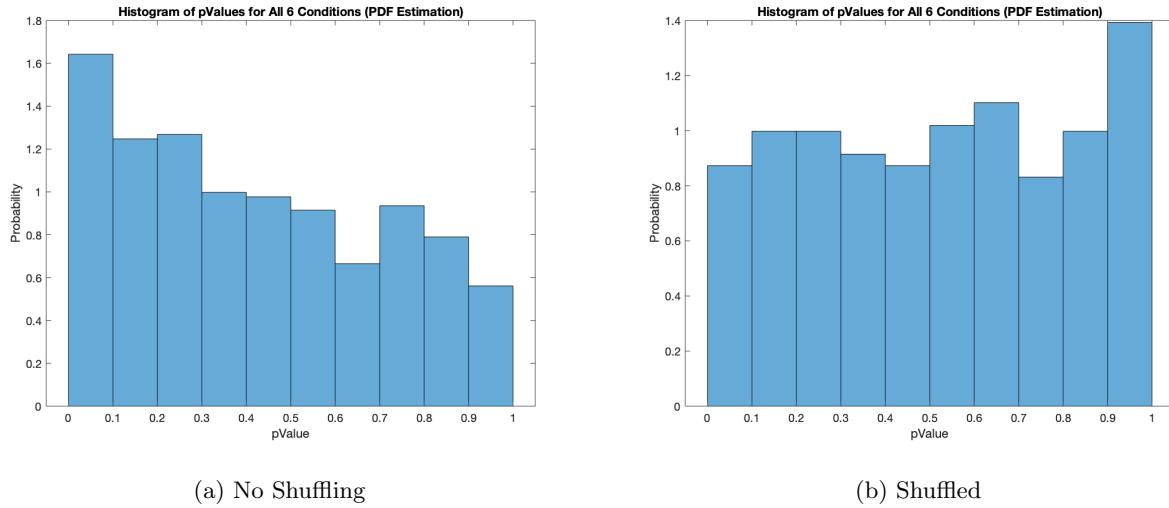


Figure 10: Histogram (PDF) of pValues for All 6 Conditions

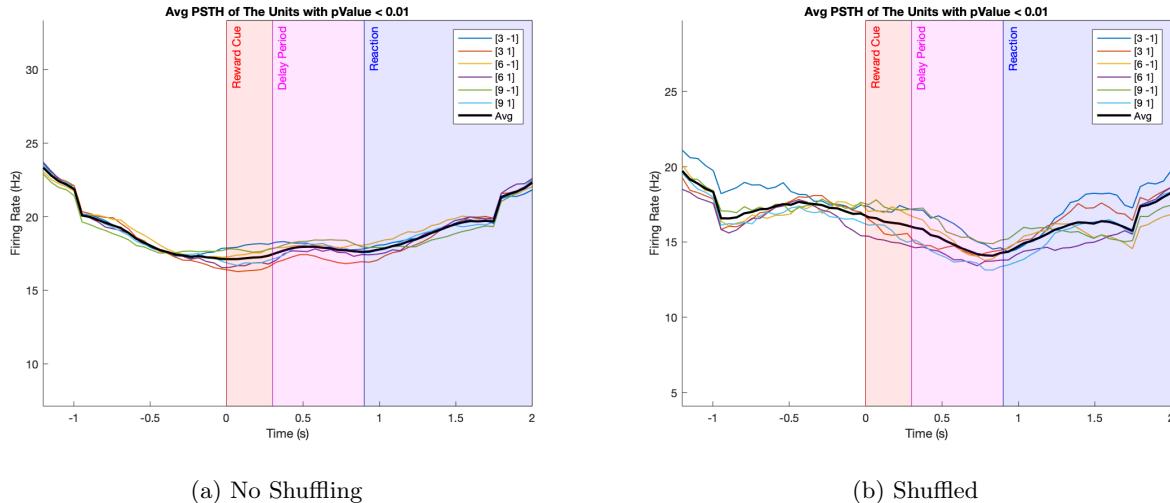


Figure 11: Average PSTH of The Units with pValue < 0.01

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 population in different conditions.

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

Conditions Type	Cue Left/Right			Reward Expected Value			All Conditions		
	No	Yes	Ratio	No	Yes	Ratio	No	Yes	Ratio
Shuffling									
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 of 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, ration 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.



■ Steps 3 and 4

□ All 6 Conditions

Reducing num of Units to 1 using PCA

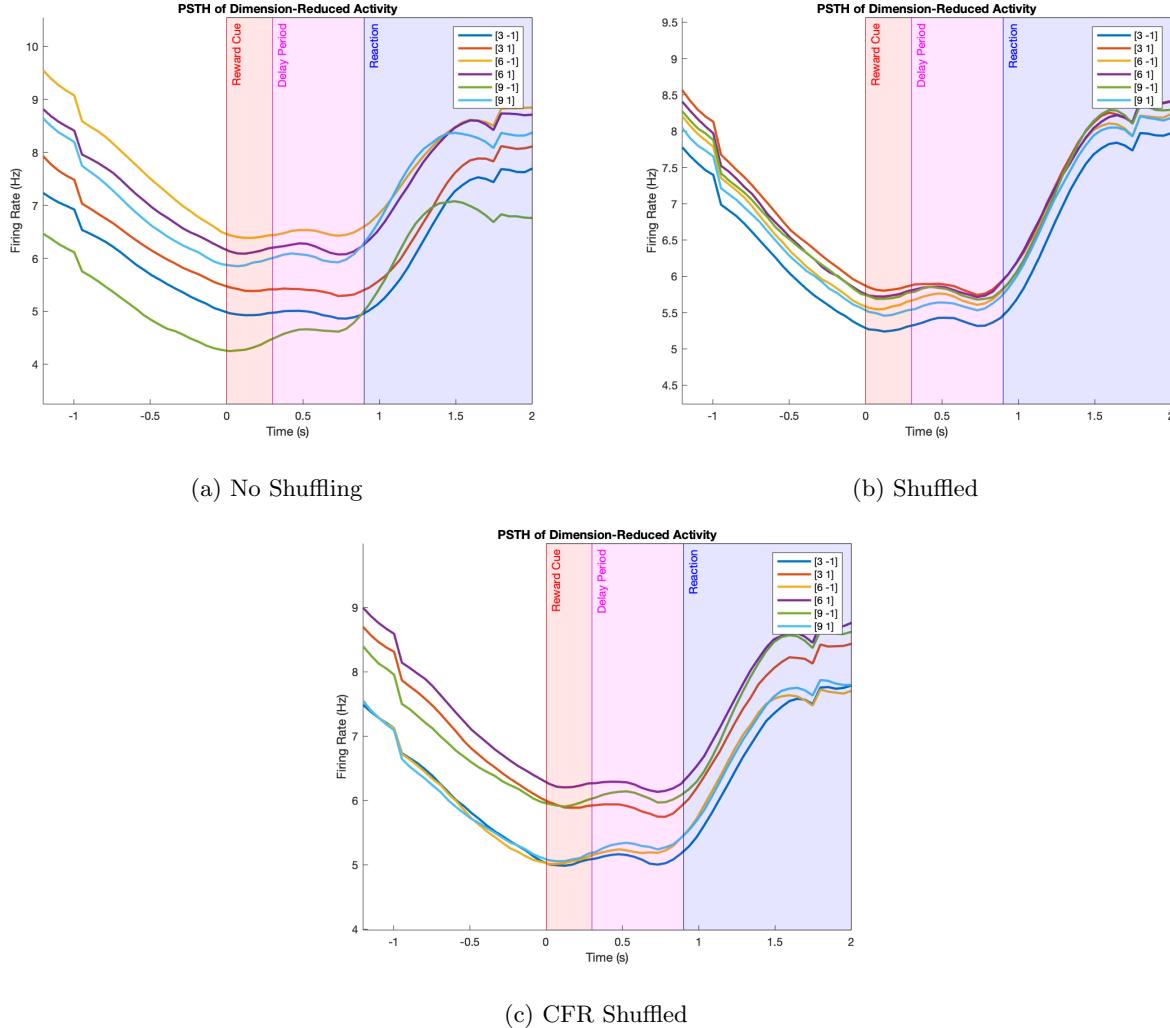


Figure 12: PSTH Plot

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 bee seen in the Figures above.



Reducing num of Units to 2 using PCA

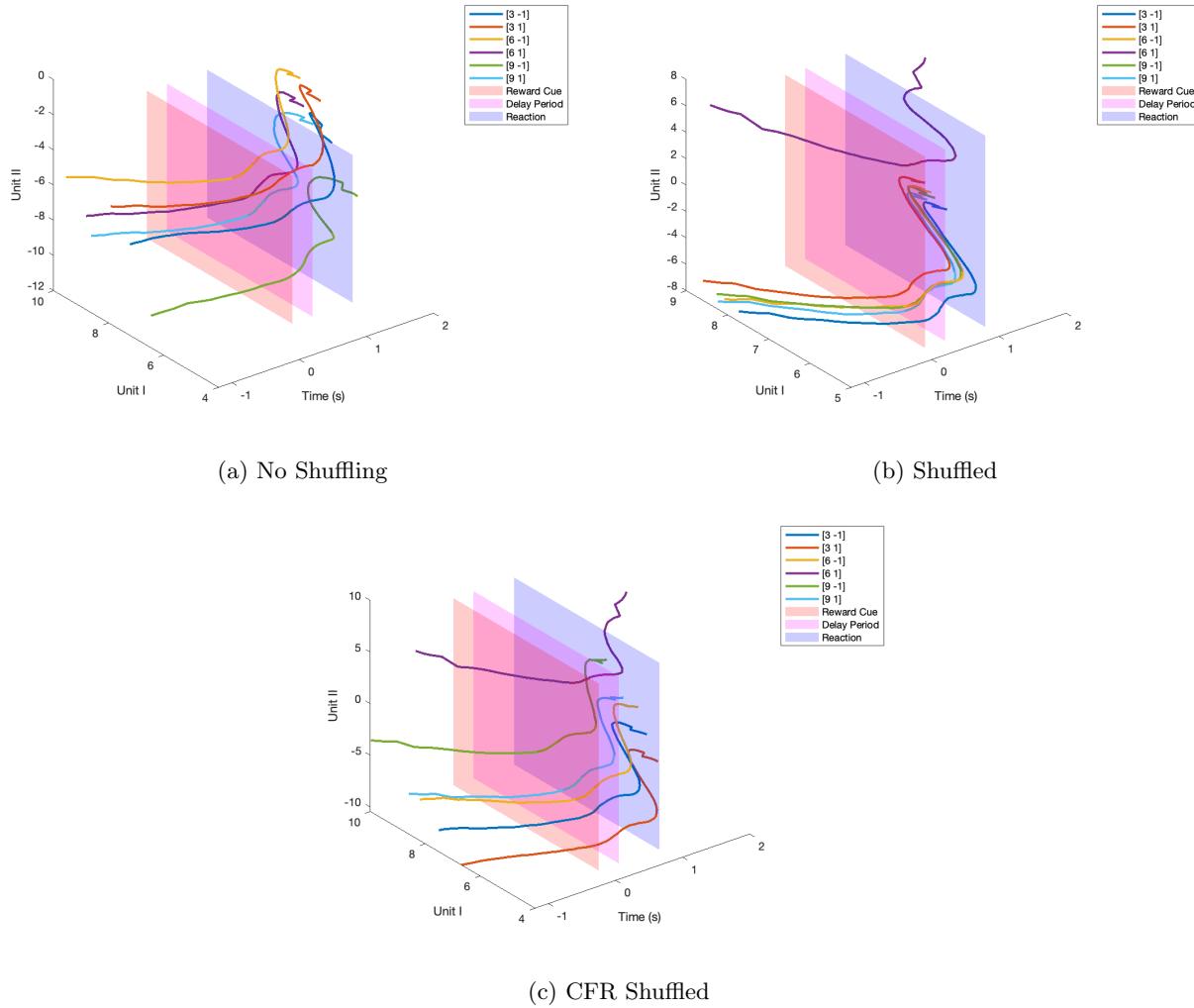


Figure 13: Unit I vs Unit II vs Time

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



Plotting PCs instead of Dimension Reduced Data

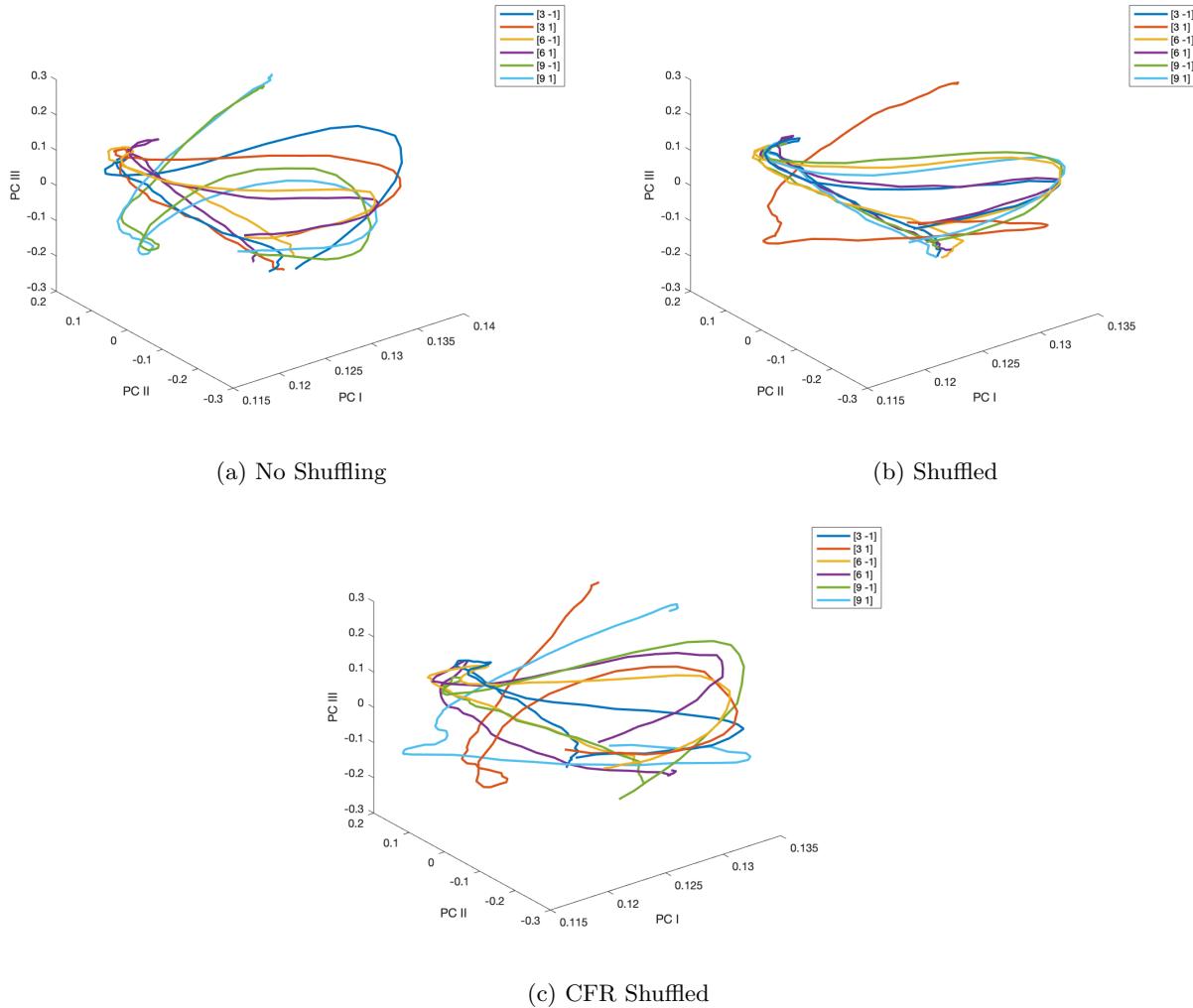


Figure 14: PC I vs PC II vs PC III

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

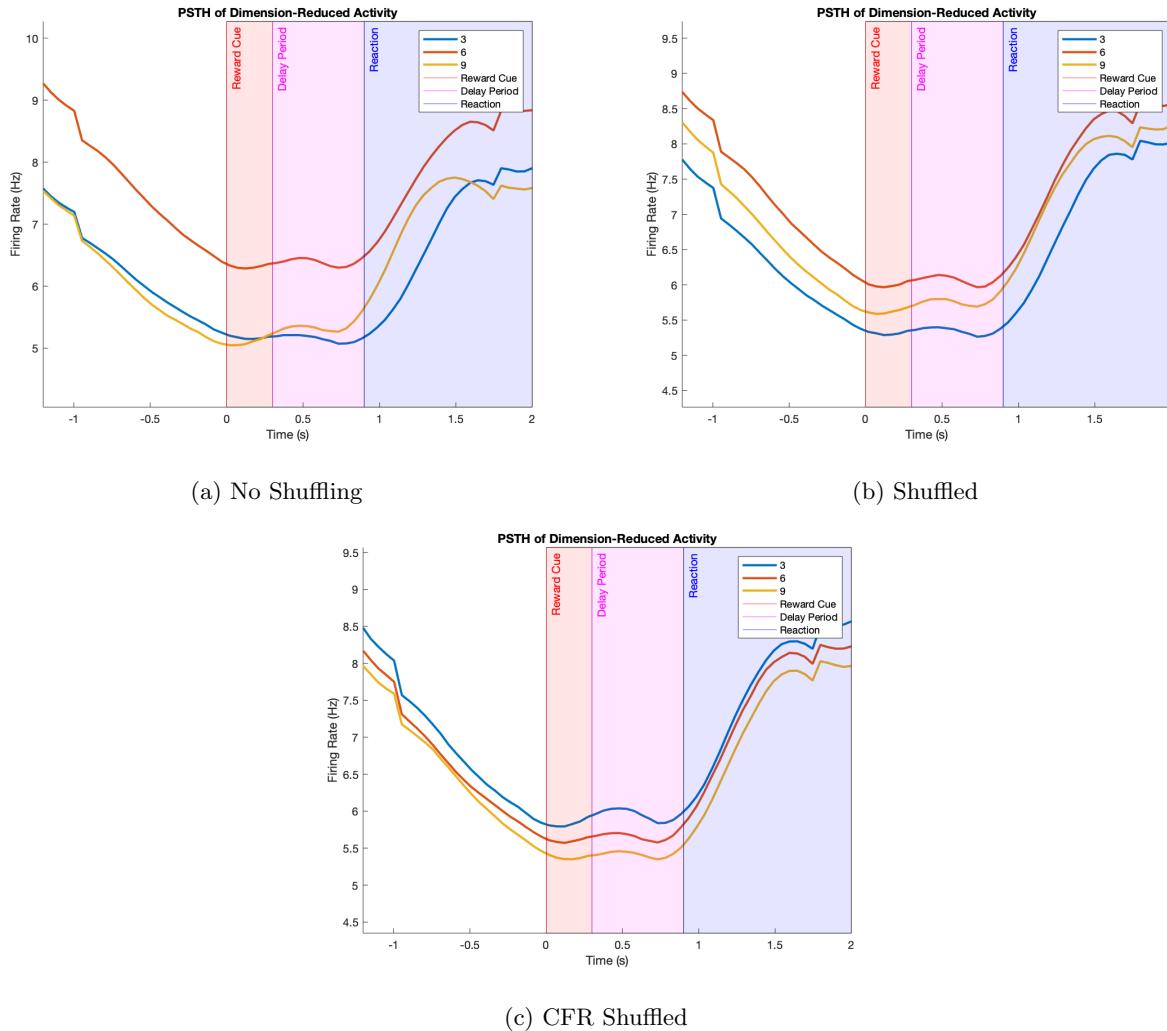


Figure 15: PSTH Plot

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

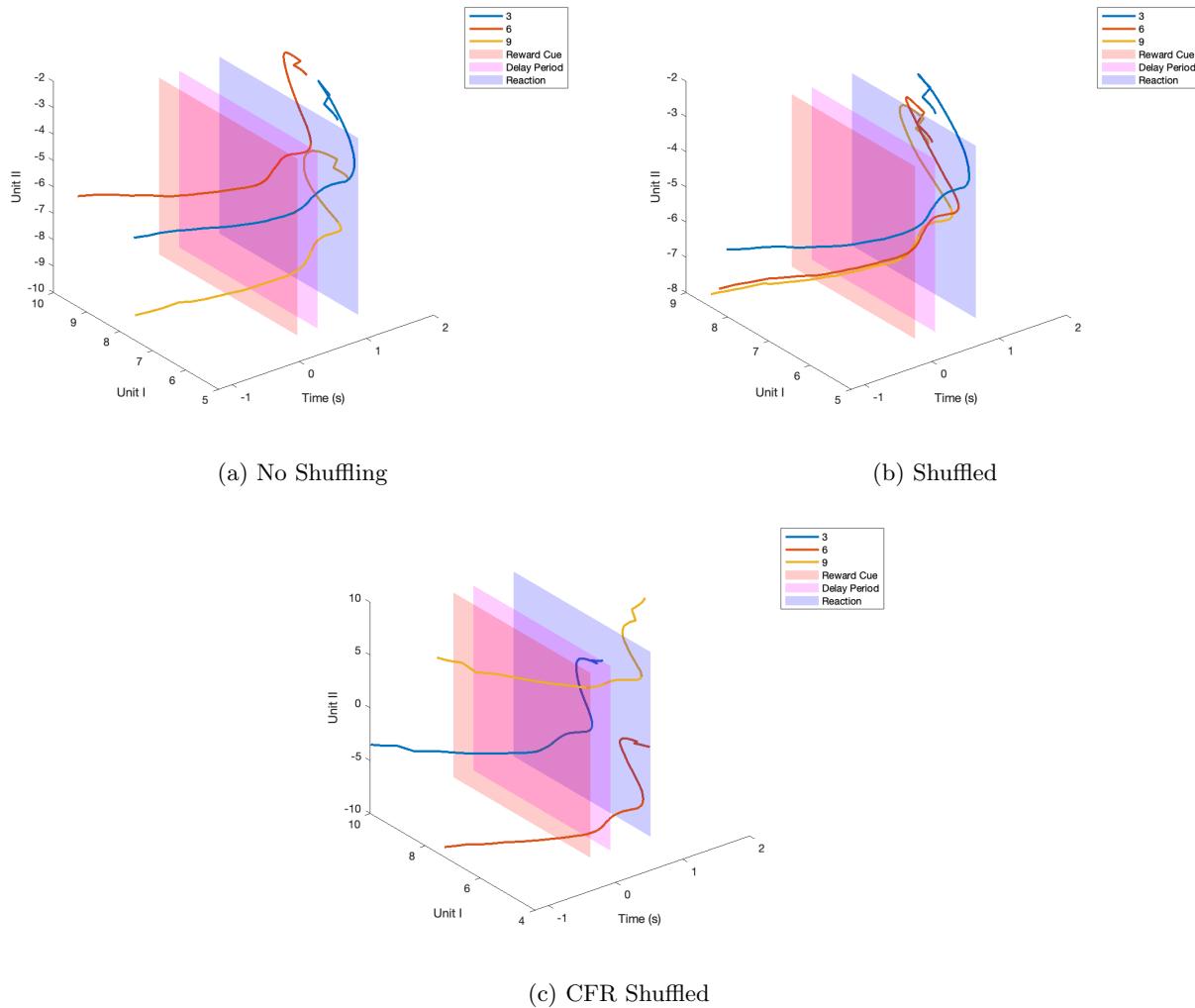


Figure 16: Unit I vs Unit II vs Time

Same as the last part.



Plotting PCs instead of Dimension Reduced Data

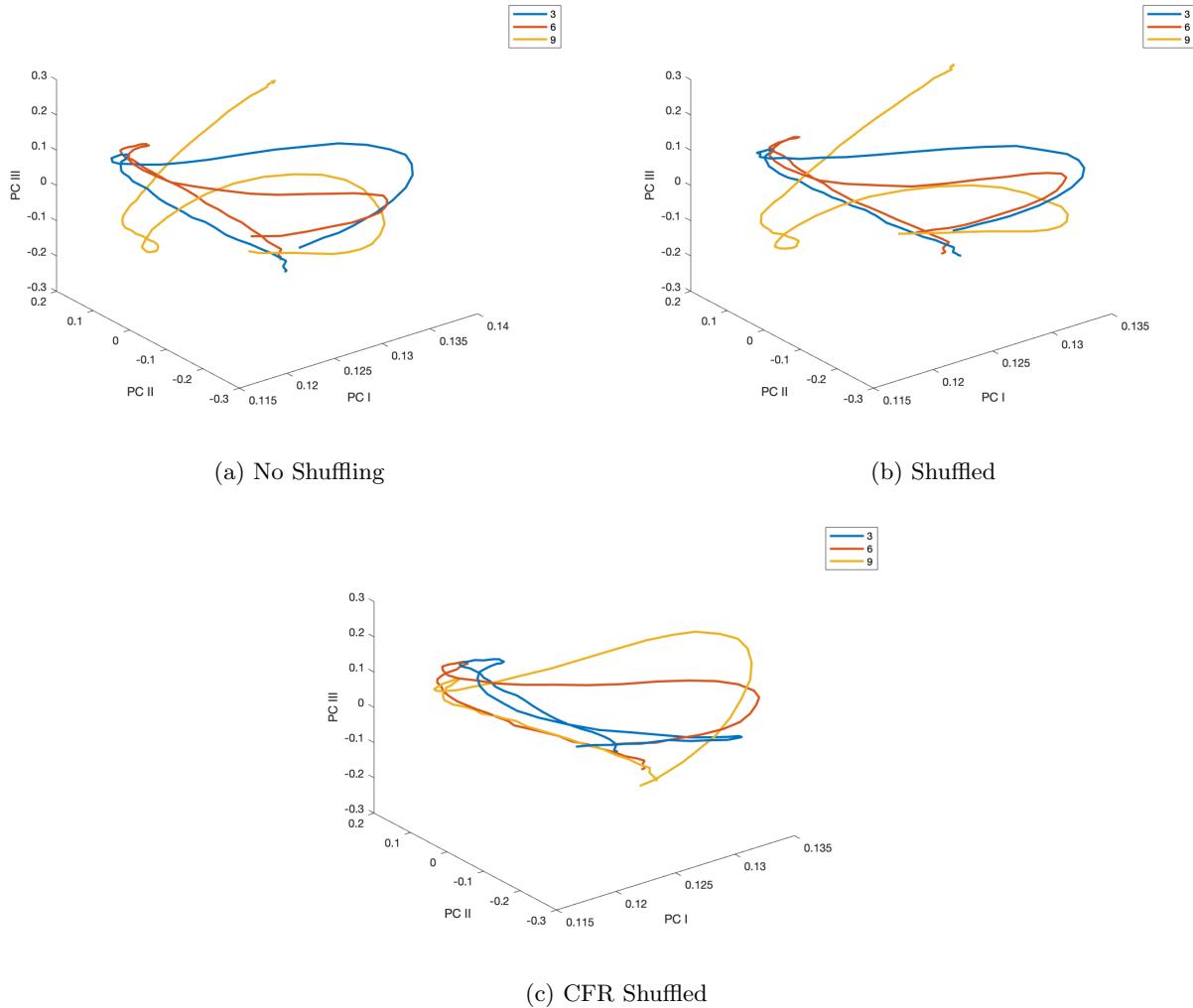


Figure 17: PC I vs PC II vs PC III

As mentioned for Figure 14, 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 a same pattern in their trajectories.