Advanced neuroscience

Assignment 2

Sajad Ahmadi Nabi

Sajjadahmadi7627@gmail.com

ID: 400206584

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?

Answers:

Q1:

No, they act differently, because each unit encodes information of different condition and situation and actually encodes different information.

So, each unit under different circumstances has different frequency responses in different time.

Q2:

almost Yes, each unit has different response to the stimulation, as condition of the test changes, neuron frequency response change relative to the condition. Obviously, some units don't have any meaningful response to the stimulation and doesn't encode any information about this test.

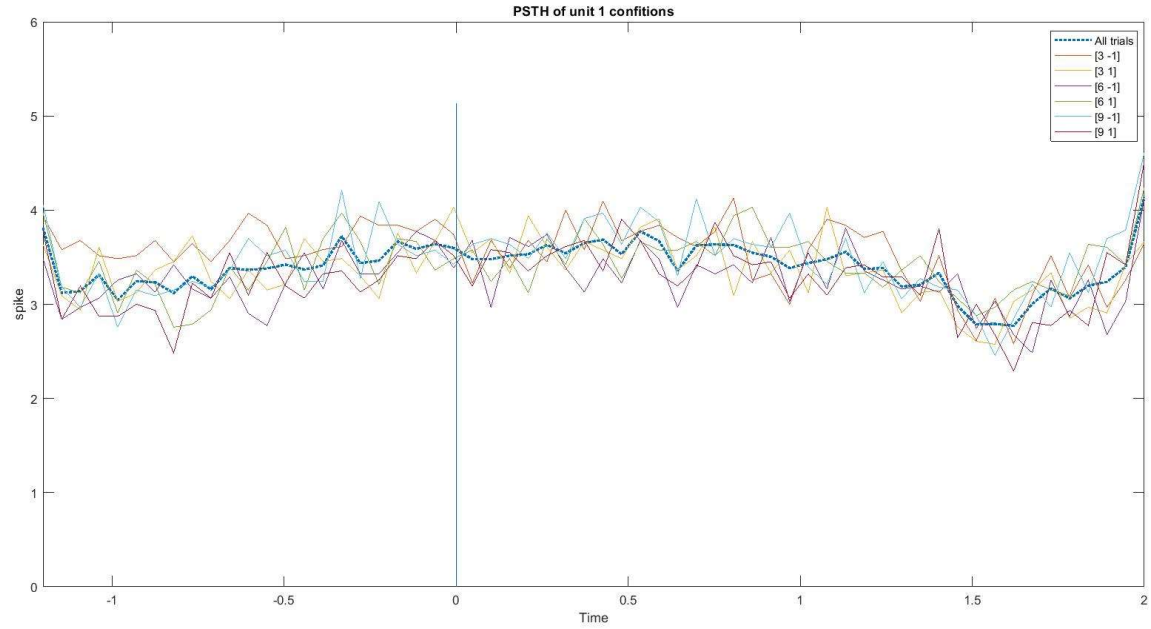
I used hist to draw PSTHs. The total time is 3200 milliseconds, which divided by 60 will eventually be 53, which is the number of spikes per millisecond.

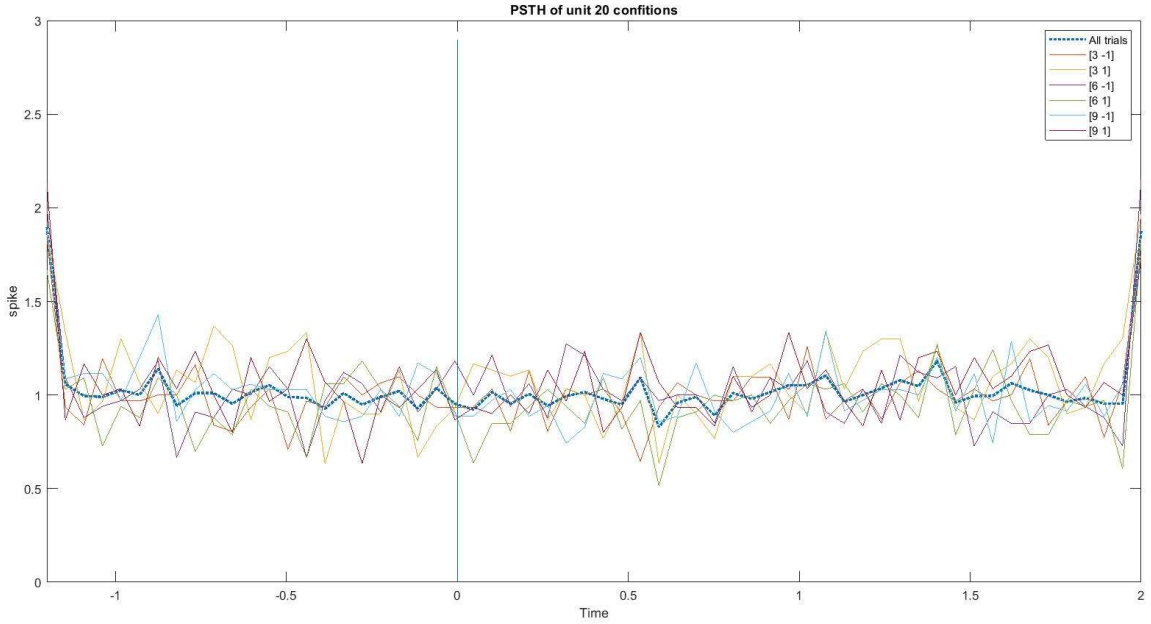
For each condition, I separated the indices of each condition from each trail and hist the corresponding trails, and finally plotted the average of each frame which was the PSTH of each condition.

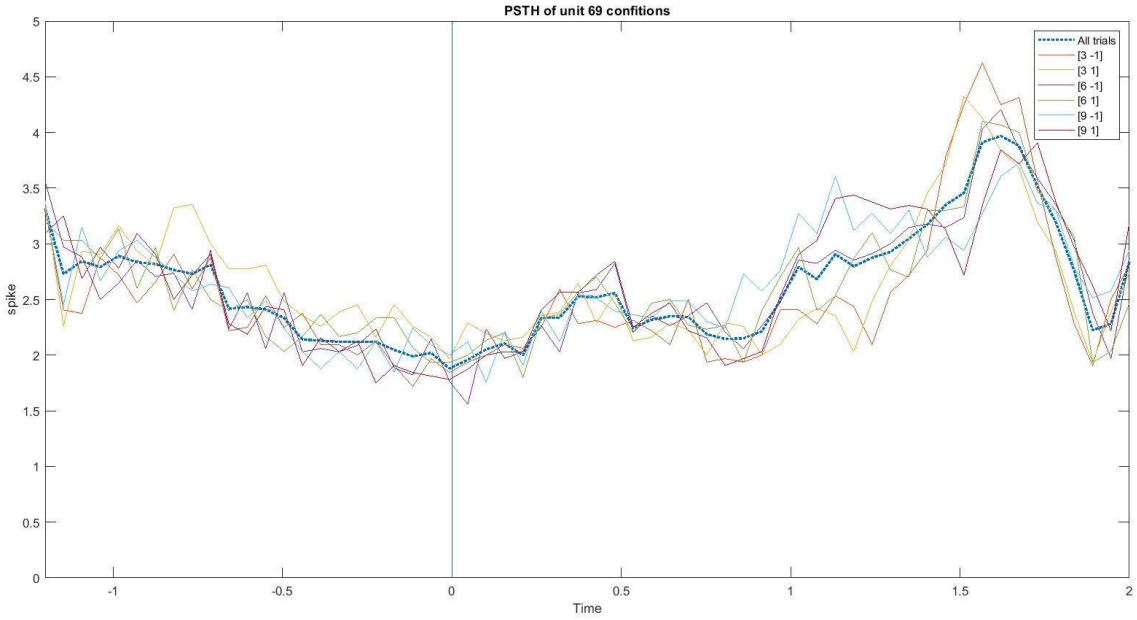
I also drew the whole unit of PSTH and displayed it all in one plot.

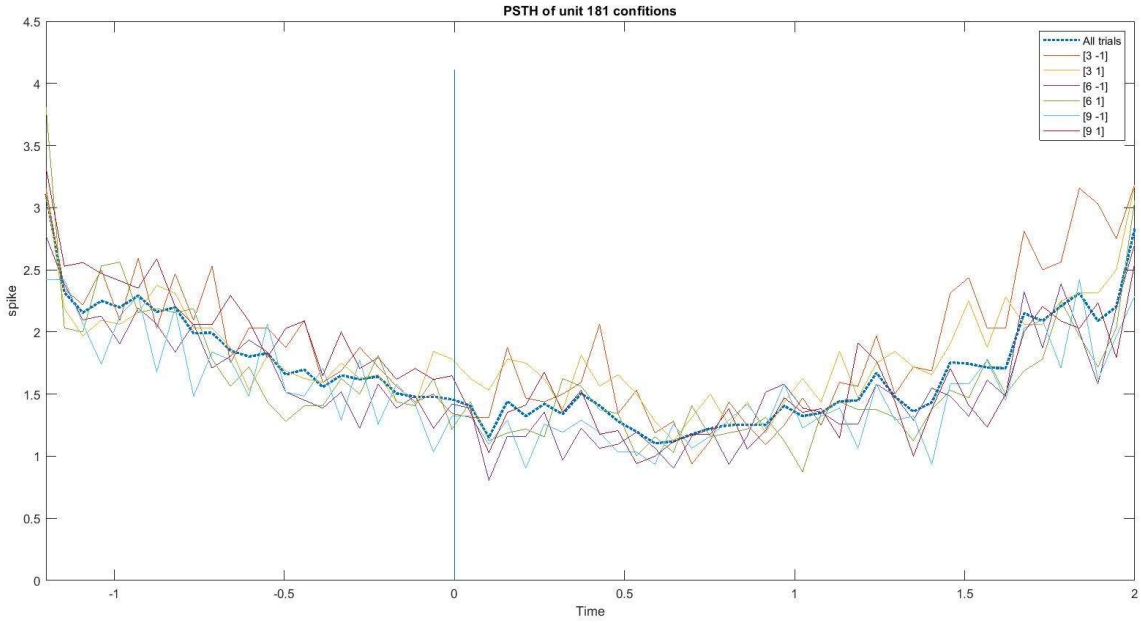
It is observed that some units respond to stimulation and decode information by increasing the frequency, but some do not have a significant effect after stimulation and do not decode any information from this stimulation. Also, the response of each unit to different types of conditions is different, and some of them have more spikes with different 'Expected reward' and some of them respond to 'Cue location'.

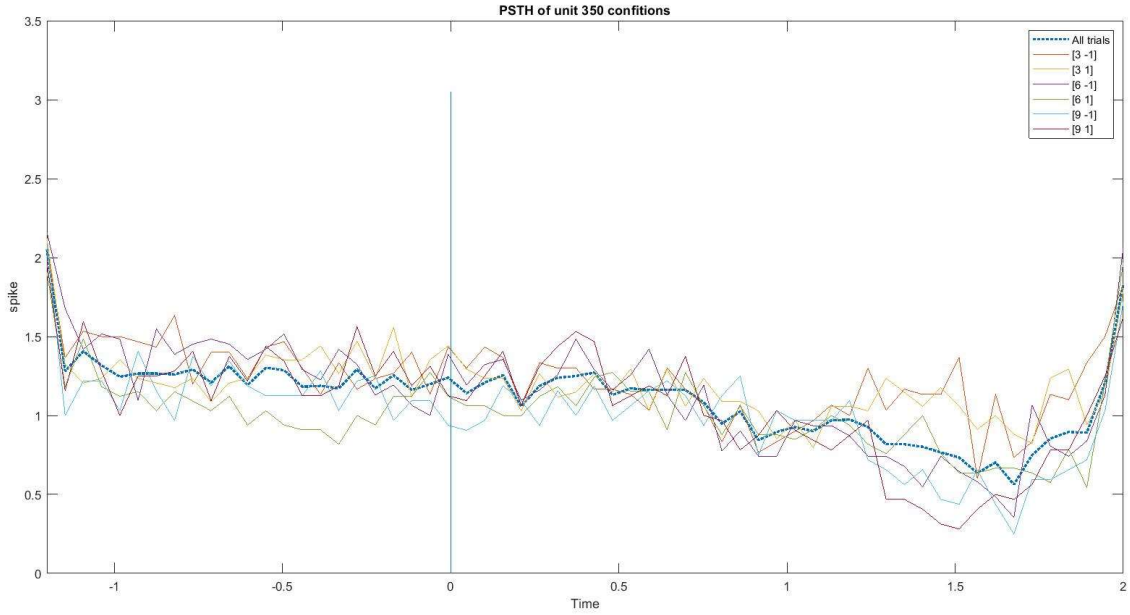
PSTH for some units:

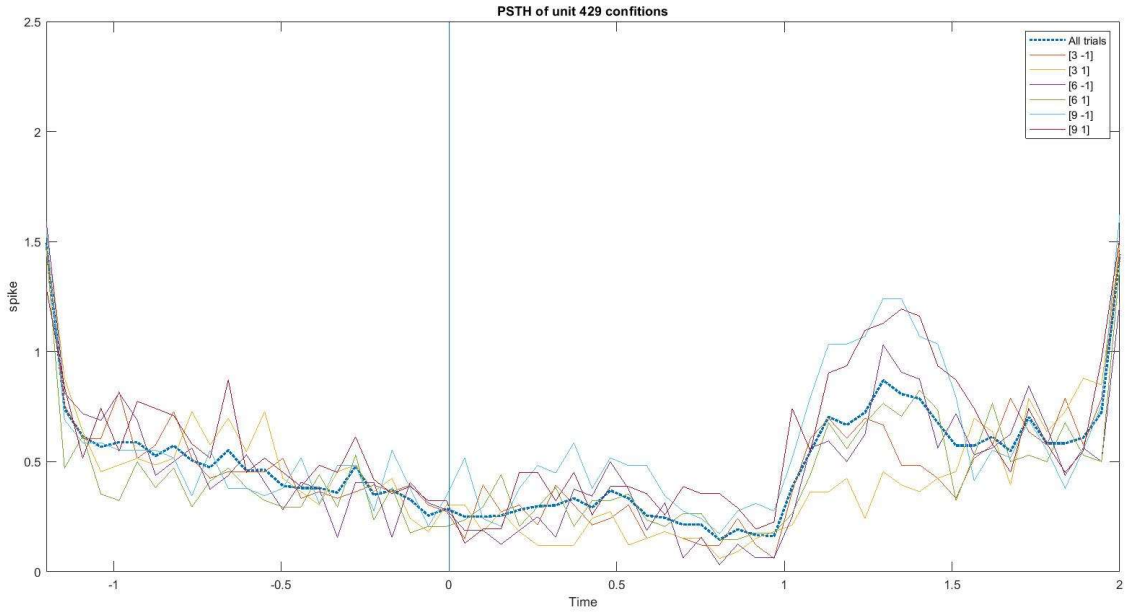

PSTH of unit 1 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
1
2
3
4
5
6
-1
-0.5
0
0.5
1
1.5
2


PSTH of unit 20 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
0.5
1
1.5
2
2.5
3
-1
-0.5
0
0.5
1
1.5
2


PSTH of unit 69 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
-1
-0.5
0
0.5
1
1.5
2


PSTH of unit 181 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
-1
-0.5
0
0.5
1
1.5
2


PSTH of unit 350 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
0.5
1
1.5
2
2.5
3
3.5
-1
-0.5
0
0.5
1
1.5
2


PSTH of unit 429 confitions
All trials
[3 -1]
[3 1]
[6 -1]
[6 1]
[9 -1]
[9 1]
spike
Time
0
0.5
1
1.5
2
2.5
-1
-0.5
0
0.5
1
1.5
2

STEP2: 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)

In this section we want to know which neurons change more when the condition changes. In fact, we linearly fit the condition changes for each trail and the PSTH response of each unit to these changes. Finally, we find out which neurons are sensitive to which condition change.

For this process, we create a matrix of the same size as the trailers and put the number of each condition in the trail index. We fit these two matrixes with GLM and select the units with P_value less than 0.05. In fact, neurons with P_value of less than 0.05 have responded significantly to changes of that condition.

Then, we repeat this operation once for the changes in the 'Expected reward' and once for the changes in 'Cue location'.

First, units which encode 'Expected reward'

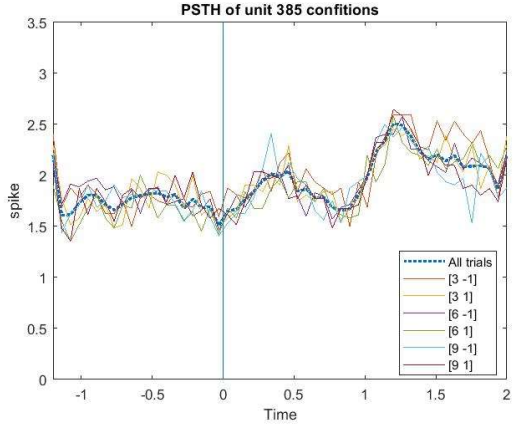
This units have P_value less than 0.05 and encode Expected reward condition.

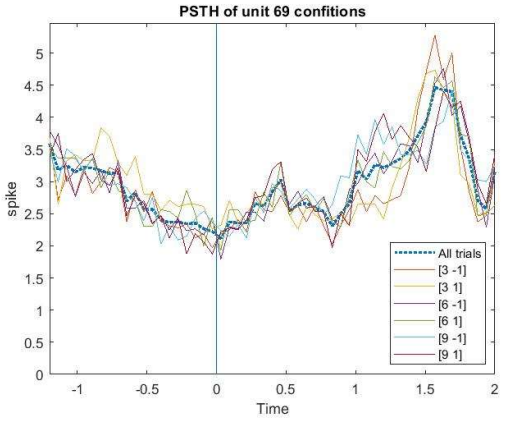
5	12	13	15	17	18	21	28	33	34	35	36	42
	46	48	53	55	56	58	59	60	61	62	64	66
	67	69	71	72	73	74	77	89	90	93	96	97
	103	104	108	110	111	115	117	118	119	120	129	134
	136	140	142	146	148	154	157	174	181	183	185	188
	190	194	196	197	227	231	233	235	237	238	247	248
	256	260	280	284	294	299	300	310	313	315	316	329
	332	334	335	336	342	343	344	345	347	348	349	350
	352	353	359	361	362	363	364	365	368	369	375	379
	385	392	398	399	400	407	409	410	411	412	413	414
	415	416	417	418	419	420	429	431	433	437	441	446
	449	453	463	466	467	468	469	470	471	474	475	481

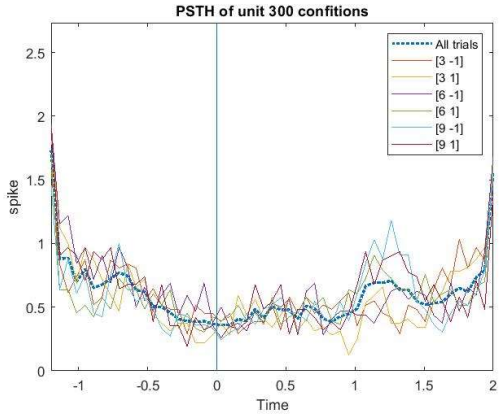
In this units, firing of the neuron increases meaningful, as we see, a little bit after stimulation, frequency of spikes increases.

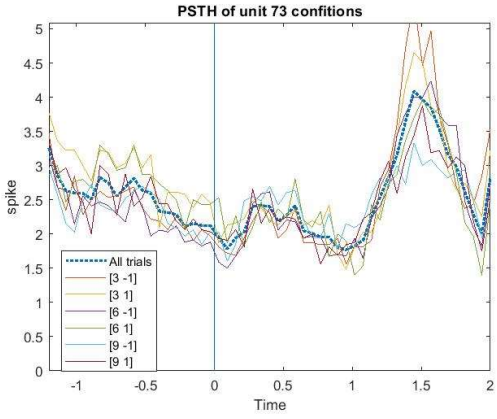
Plot 6 of them randomly:

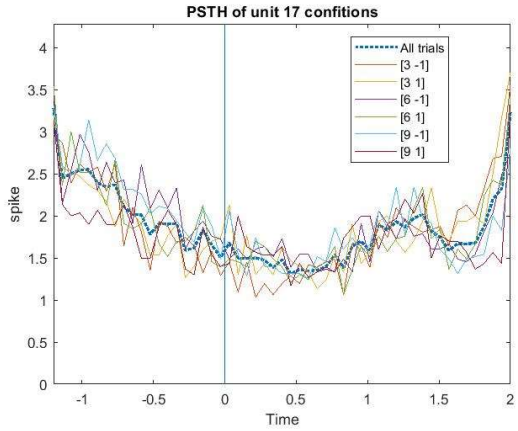
Some Units which encode Expected Value

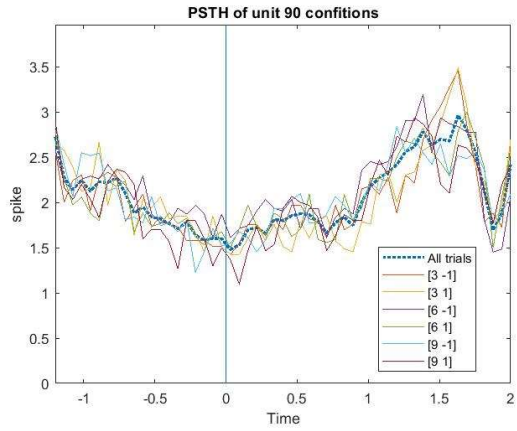












Now, units which encode ‘Cue location’

This units have P_value less than 0.05 and encode Cue location condition.

22	45	65	104	117	130	141	193	199	206	210	221	223
	240	242	260	265	267	293	372	375	385	389	403	424
				435	436	440	454	458	477			

Plot 6 of them randomly in next page.

Finally let’s find neurons which are most significant ones!

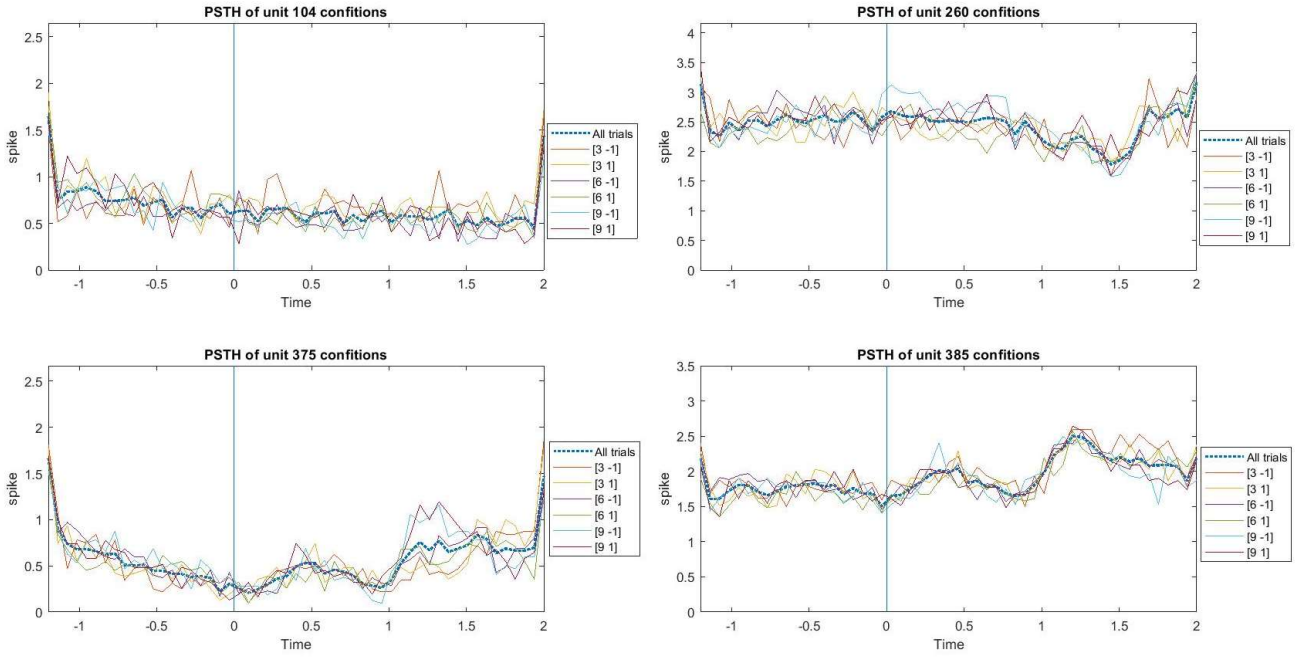
I found units which have P_value less than 0.05 for both ‘Expected reward’ and ‘Cue location’ conditions.

These units are common to the both conditions stated:

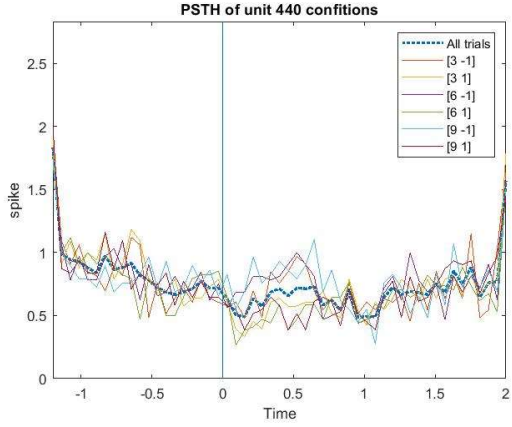
104 260 375 385

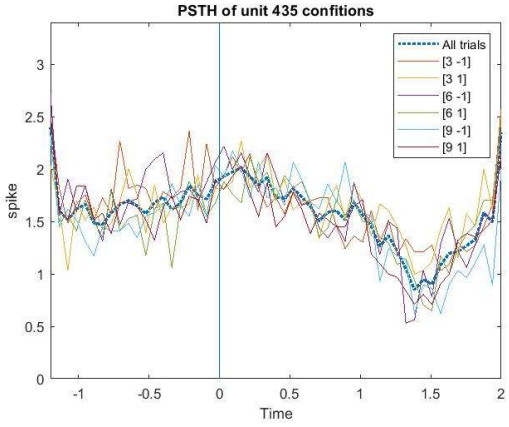
In fact, these neurons encode both conditions ‘Expected Reward’ and ‘Cue location’ and have a significant effect on the crypt

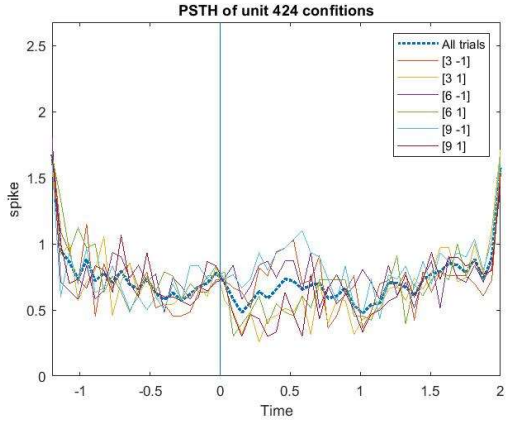
ography of both conditions.

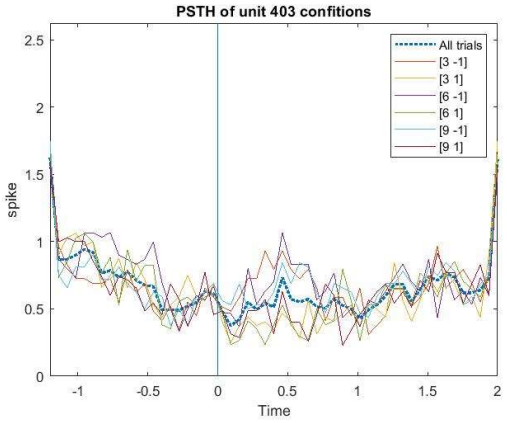


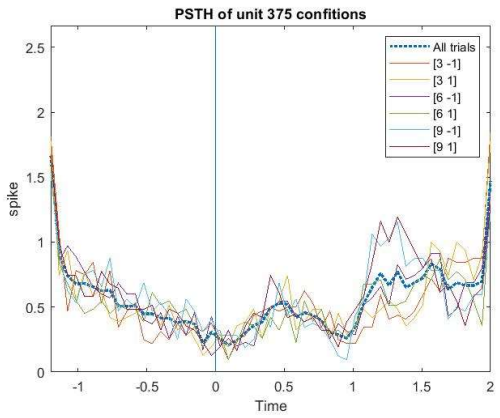
Some Units which encode Cue location

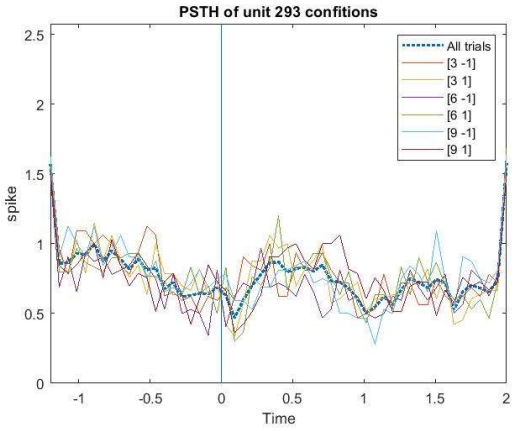












Step3: plot the population activity in lower dimension (2 or 3) by using suitable dimension reduction algorithm.

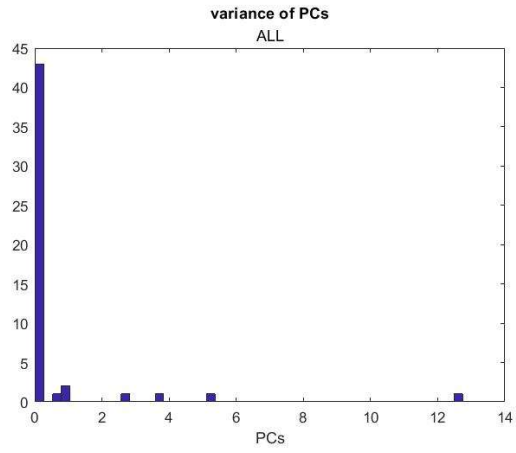
For this part, I had 53 bins as well as 481 units and 192 trailers for each, averaging the number of trailers per unit, made a matrix of 481 x 53 for 431 unit and 53 bins for all units without condition.

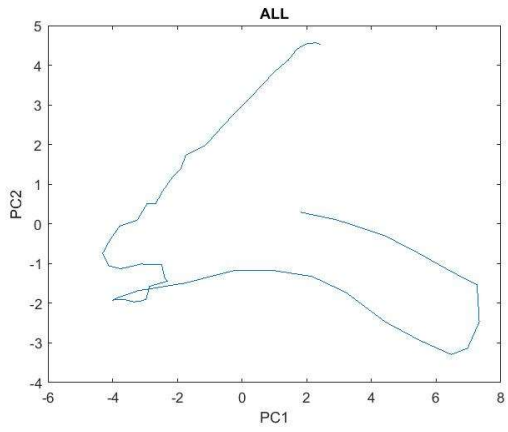
In fact, with PCA, we examine the impact of each condition separately. The average was taken after the trailers of each episode.

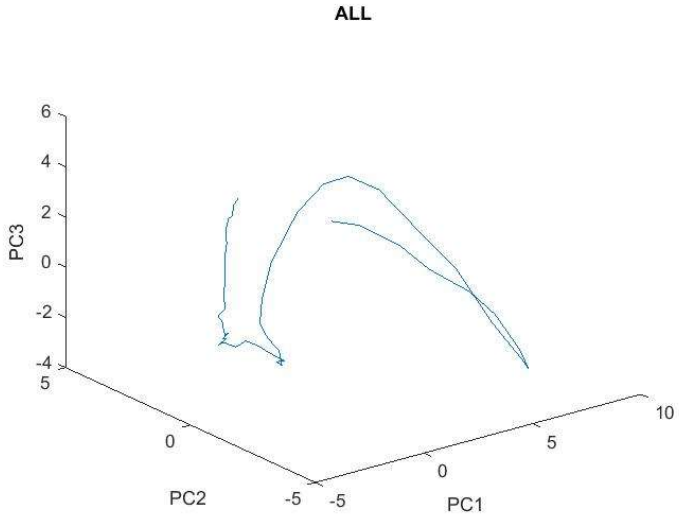
Finally for the correct format of the input matrix to PCA, I reshaped each entry and deleted the first and last bins to get the correct shape.

Finally, it was checked out which PCs were more effective and actually encoded more information. I used the variance output of the PCA function and plotted the variance histogram for each condition. It is observed that the maximum amount of variance for the first PC and the variance of PC2 and PC3 are meaningfully less than PC1. Therefore, finally, the 3D variance diagram of PC1, PC2 and PC3 was drawn.

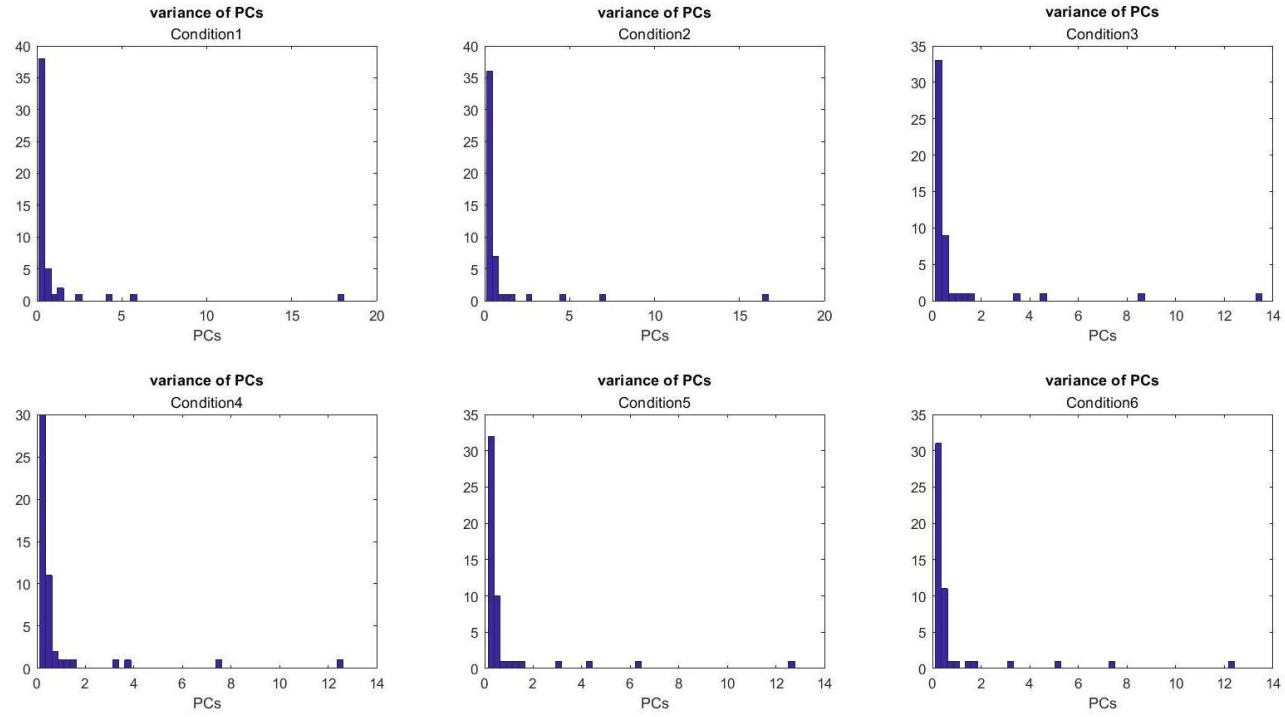
Finally, 2D and 3D PCs was plotted for each condition and for all units separately. Here we go!



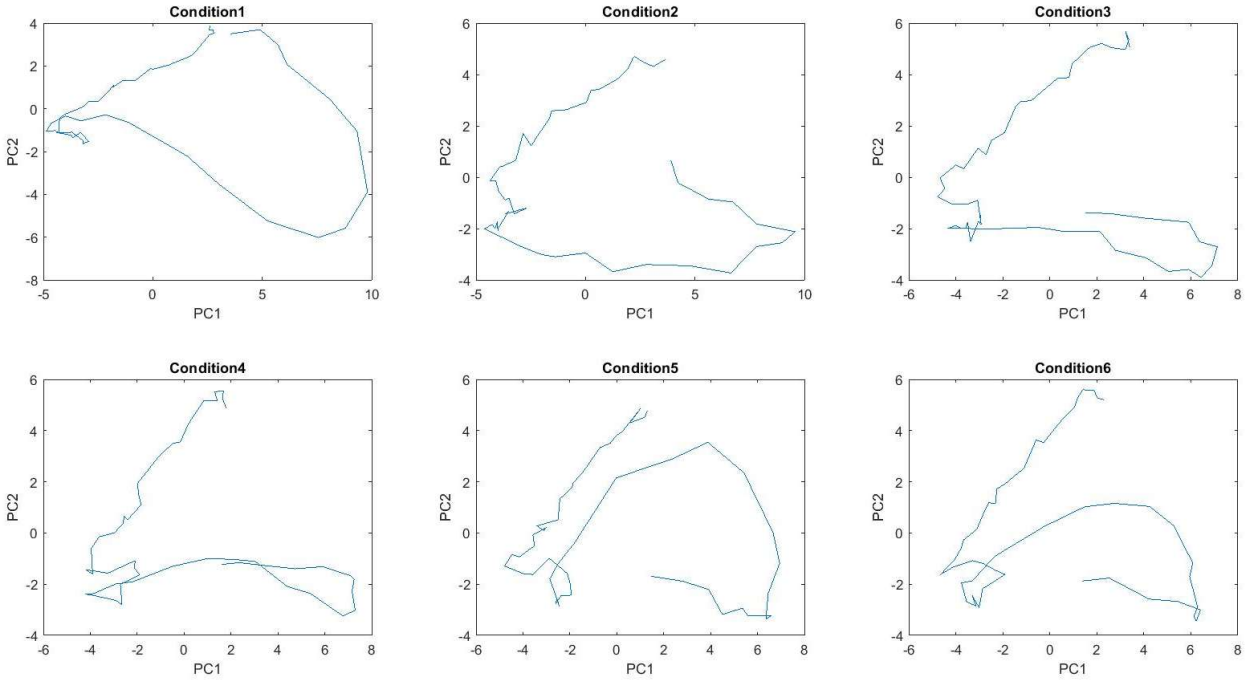




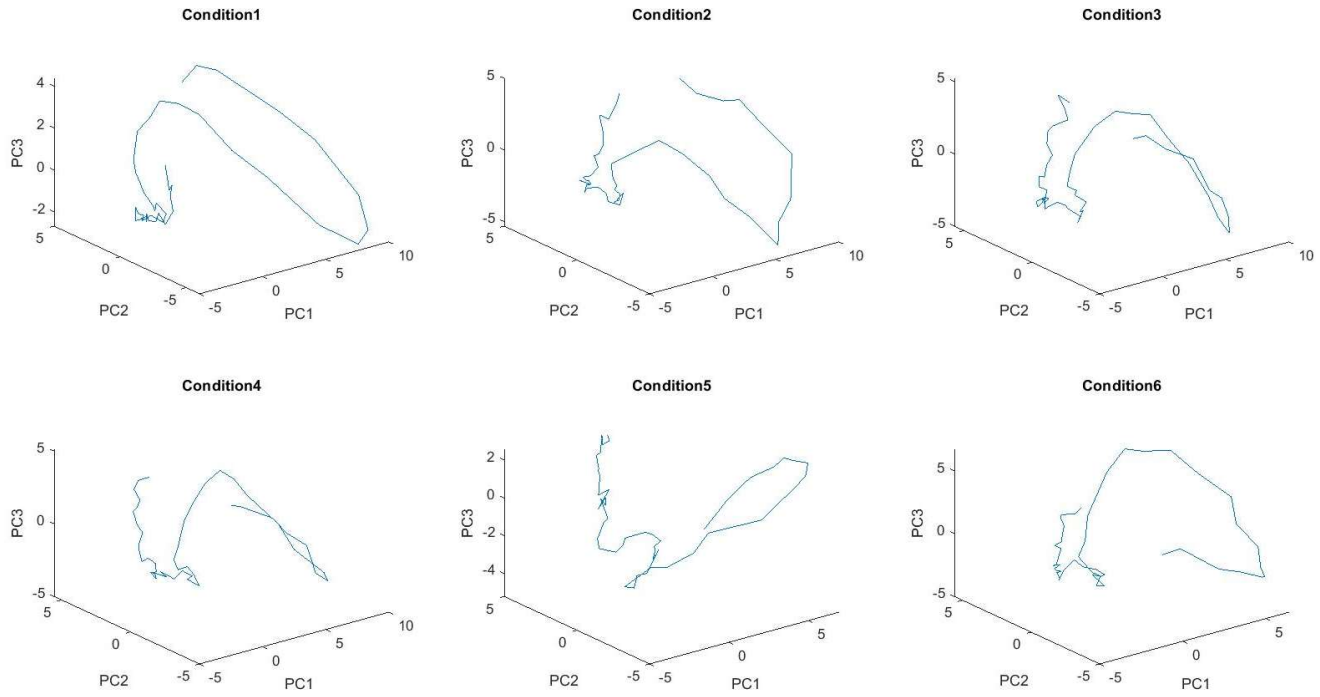
Variance of PCs for each condtion



2D plot of PC1 and PC2 for each condition



3D plot of PC1, PC2 and PC3 for each condition



It’s good to say, conditions for trials, as we said before, were as table below,

Condition 1	Condition 2	Condition 3	Condition 4	Condition 5	Condition 6	
3	3	6	6	9	9	Expected Reward
-1	1	-1	1	-1	1	Cue Location