Advanced neuroscience

Assignment 7

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Q1:

In this part I implemented simple drift diffusion model based on x(t) equation. To find the distribution of choices, first distribution of x must be found. If X(t) is positive at the final, the choice is 1 and if negative, choice is -1.

Since the dW() is from a gaussian pdf and x(t) is the summation of many gaussian variables, it is also a gaussian variable. Then mean value and variance of of x(t) are:

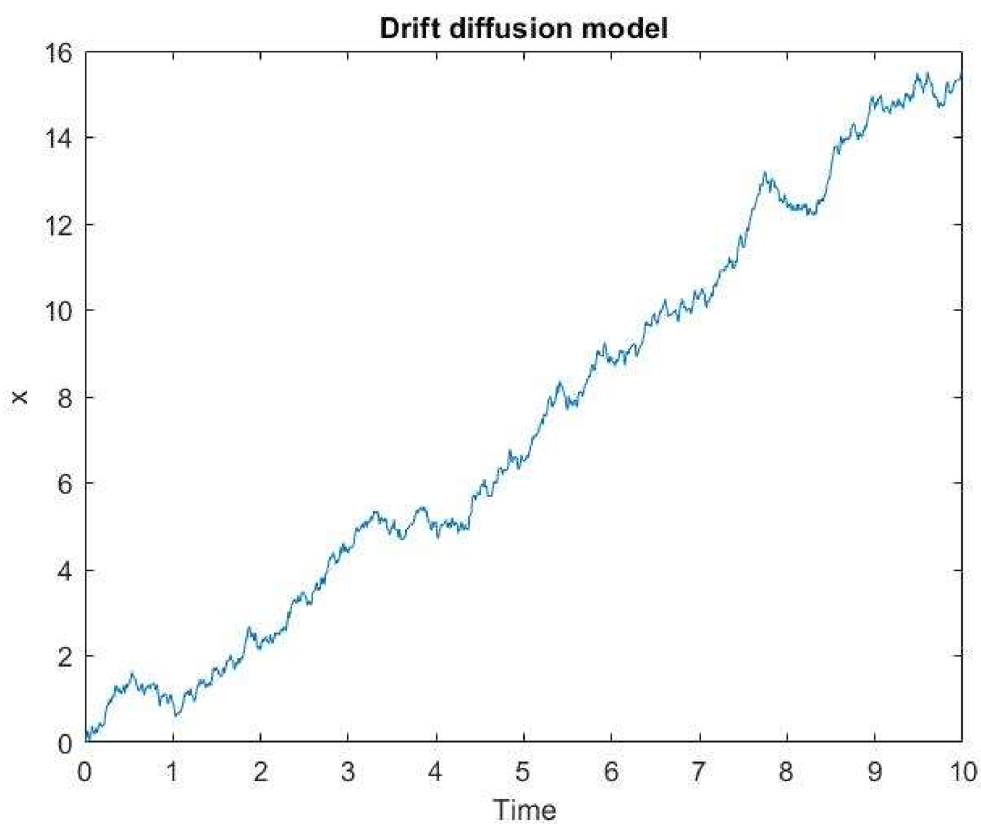
$$x(t+dt) = B \times dt + \sigma \times dW + x(t)$$

$$x(t) = B \times \sum dt + \sigma \times \sum dW + x(0)$$

$$E[x(t)] = B \times \sum E[dt] + \sigma \times \sum E[dW] = BT$$

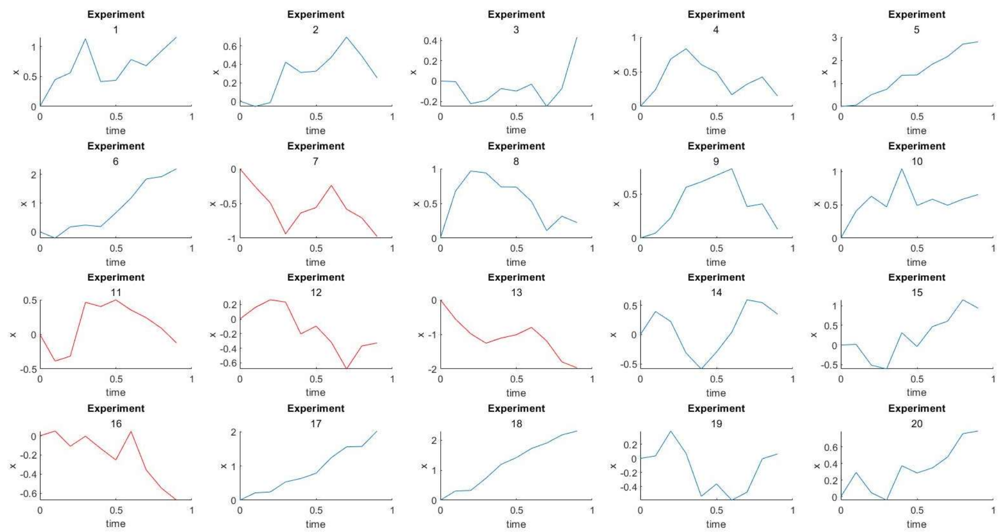
$$\sigma_x^2 = var[BT] + \sigma \times \sum var[dW] = \sigma T$$

$$P(choice = 1) = P(x(t) > 0) = \frac{1}{\sqrt{2\sigma\pi T}} \exp \int \left(-\frac{(t - BT)^2}{2\sigma^2 T^2}\right) dt$$

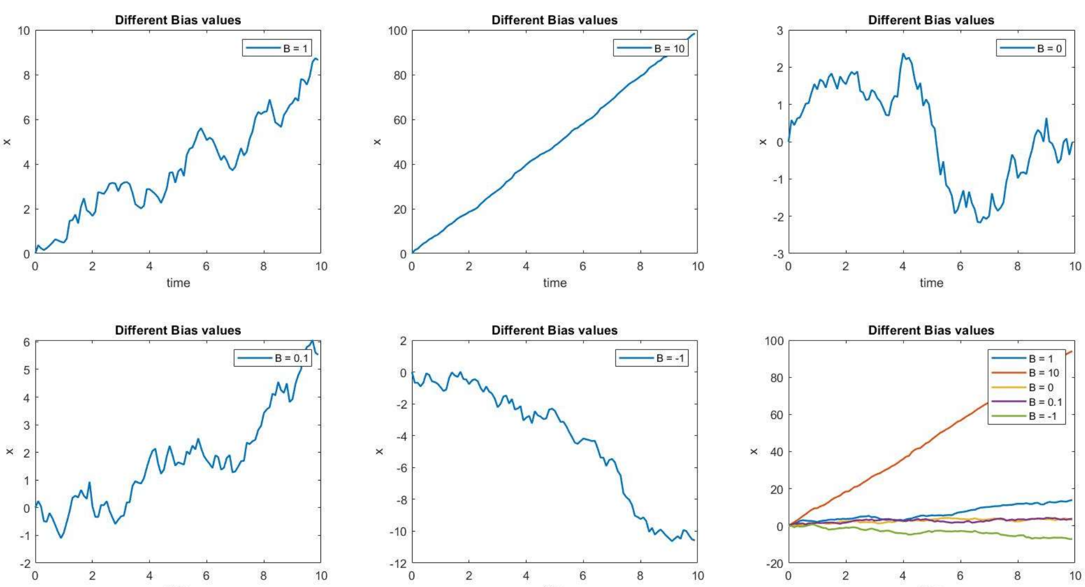


Q2:

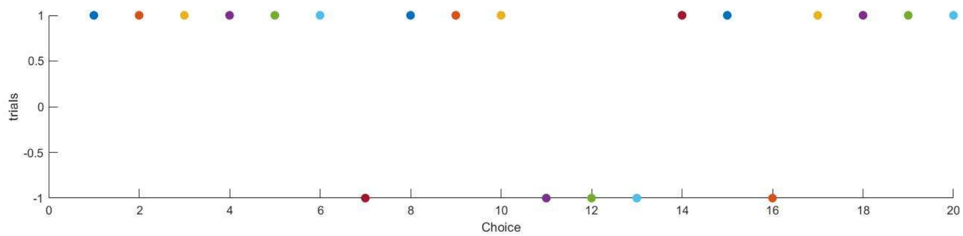
In this part we have 20 trials which all start from 0. Bias is equal to 1 and in first figure we see the result for 20 trials. Blue ones are trials which chose 1 and red ones are -1 ones.



In this figure I changed B values and plotted all. The value of bias not only affects the magnitude of evidence accumulation but also it may affect the final decision. In fact, it speeds up the selection and increases the slope of evidence collection and is selected with more certainty.

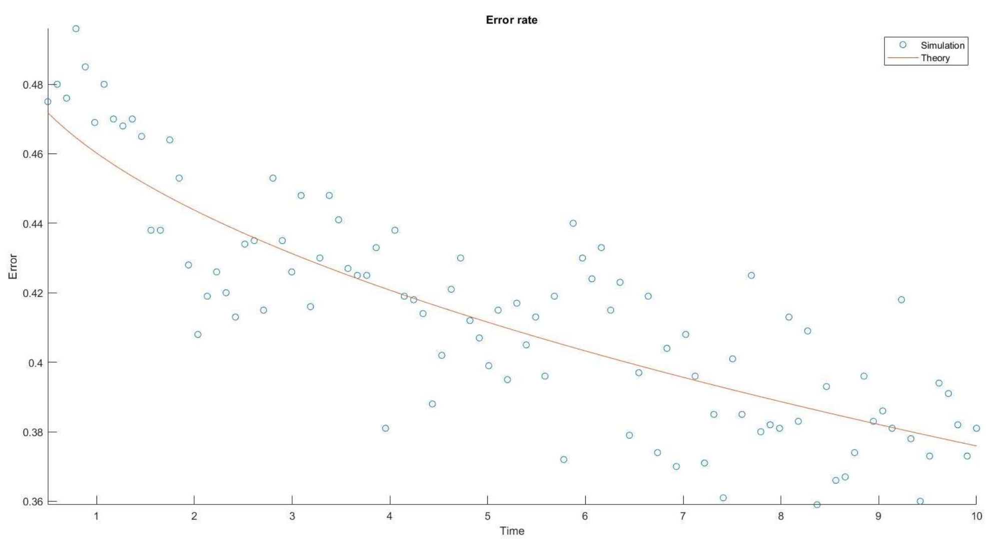


In this figure final choice of each trial is shown.



Q3:

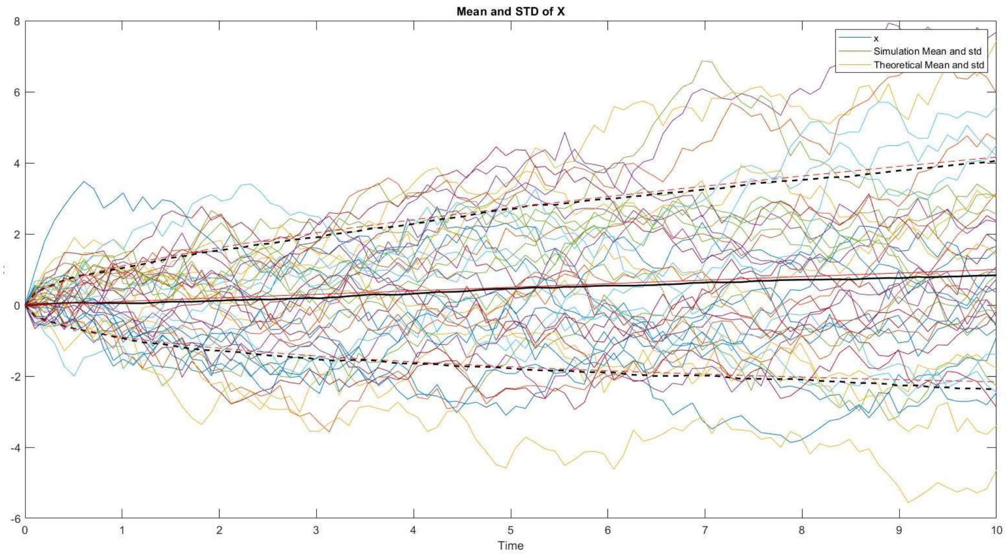
Error rate is the probability of choice -1. As it accumulates evidences by the time, chance of choosing incorrect answer decreases and it would be more confident.



$$P_{Error} = 1 - P_{chois} \ = 1 - P(X(t) > 0) = P(X(t) < 0) = \int \frac{1}{\sqrt{2\pi(\sigma t)}} e^{\frac{-1}{2(\sigma t)}(\tau - Bt)^2} d\tau$$

Q4:

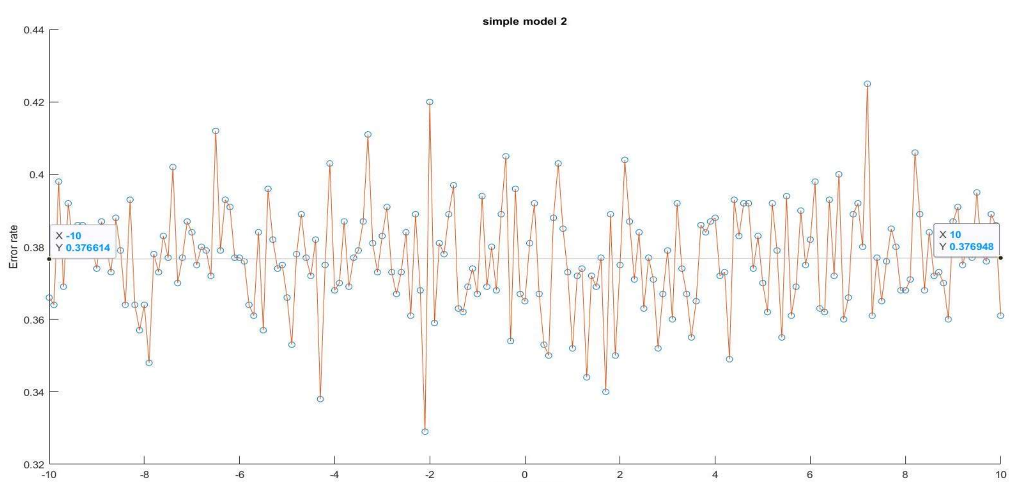
in this part we have X(t) for some trials. also mean and std are plotted. According to question 1's calculation the mean and variance values, theoretically calculated and plotted std and mean.



Q5:

The probability of being above or below the start point p, in MATLAB is calculated using: $p = cdf\ ('Normal', BT + start\ point, \sigma T)$. Error rate for different points is plotted and a line is fitted to find the effect.

$$X(T) \sim N(BT + StartP, \sigma T)\frac{1}{\sqrt{2\pi(\sigma t)}}e^{\frac{-1}{2(\sigma t)}((\tau - Bt) - StartP)^2}$$

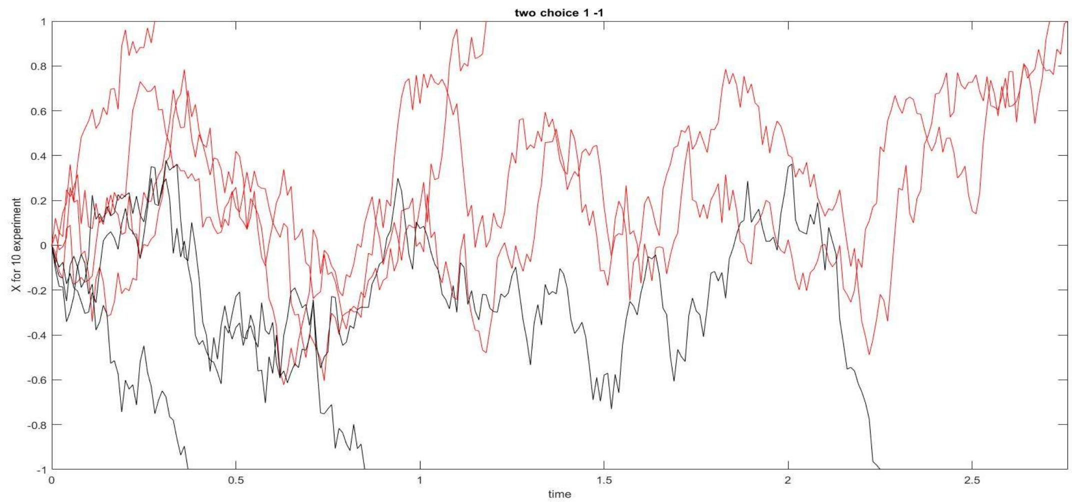


Error rate of simple model 2 for six different initial points. Data are averaged over 5000 trials.

Q6:

The drift diffusion model is implemented but with the consideration of positive and negative thresholds. The start point is set to 0 and the positive and negative thresholds are equal to 1 and -1.

Red ones are Trials which chose 1 and black ones are Trials which chose -1 as the answer.

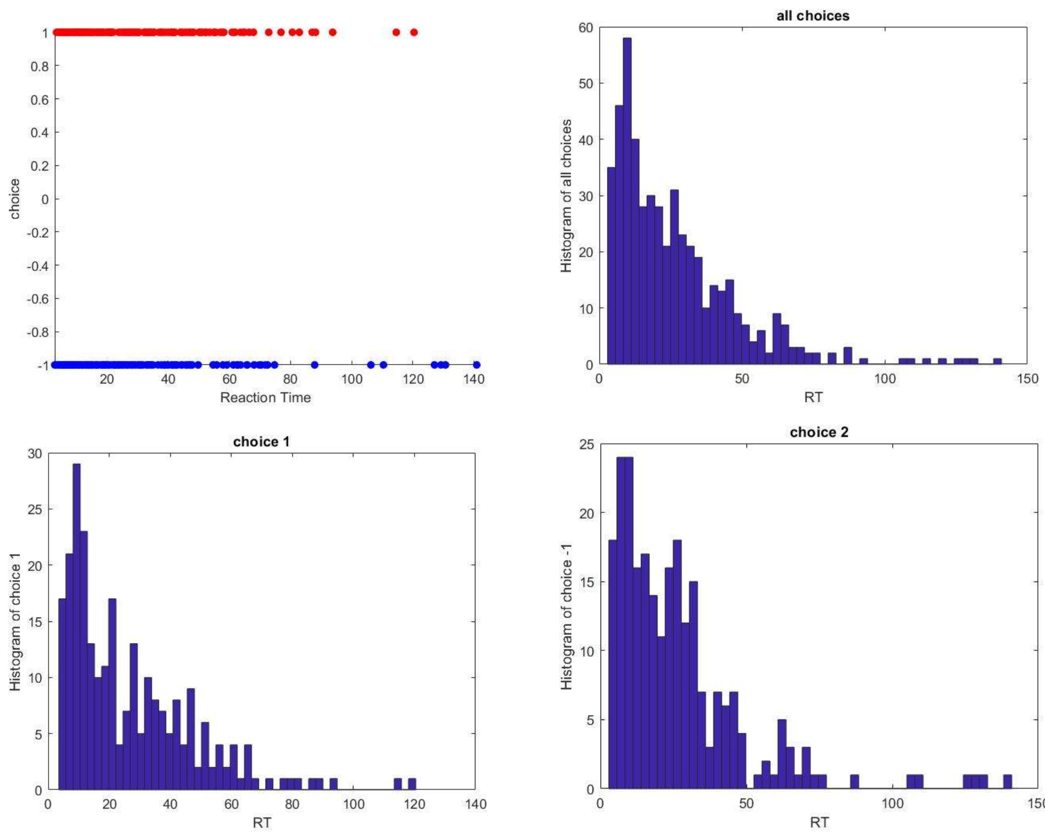


Q7:

For 5000 trials the result is shown in her. the longer it takes for it to decide between the choices, the less it has confidence in its choice. For example, if it decides between the choices in 1 seconds and in 50 seconds, it is probably more confident in 1 seconds. Also, when you are more far from 0, the probability that you choose the right answer is more.

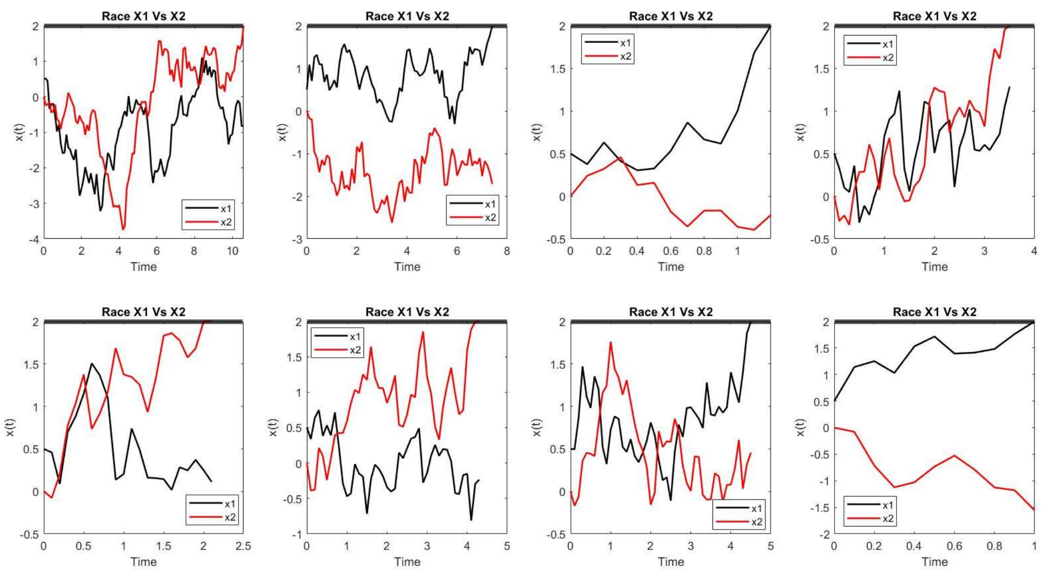
Histogram of choosing right answer (choice = 1), it shows the relationship between reaction time and choosing right answer.

Also figure of histogram for all choices and incorrect choice is plotted.



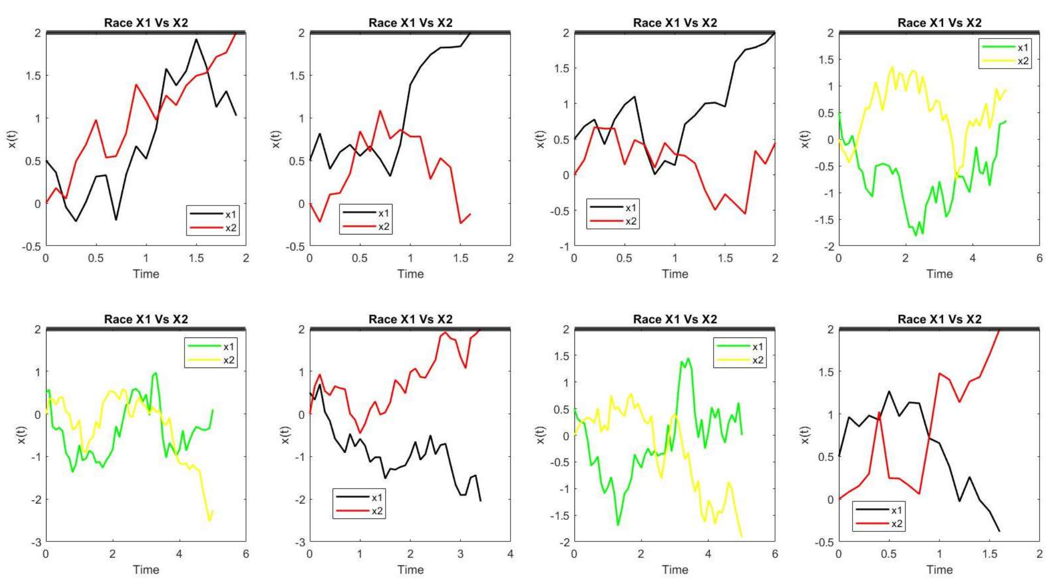
Q8:

In this section we have a Race for x1 and x2. We want to see which subject reaches answer (Choice =1) faster. I plotted 8 trials below.



Q9:

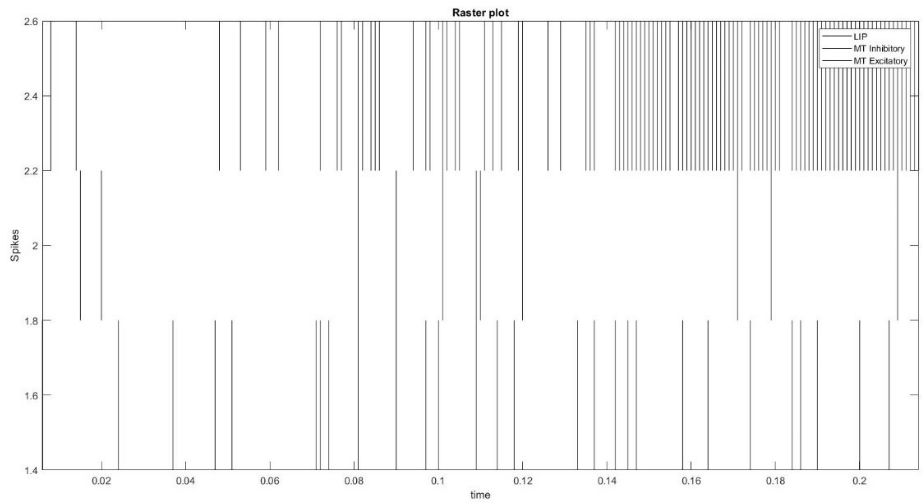
in this section I chose Time limit=5 seconds. some trials which are red-black could achieve the final choice but trials which are green-yellow couldn't get the result and doesn't have any specific answer.



Step2:

Q1:

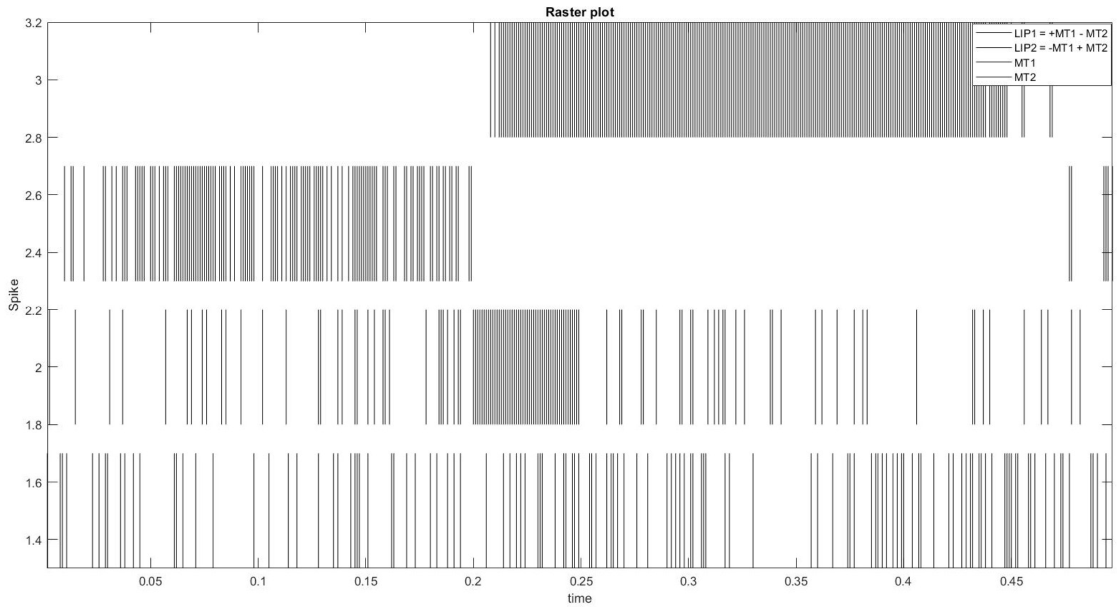
In this part I changed the Lip.m function. I assumed probability of MT1 and MT2 are 0.07 and 0.04. MT1 excites LIP neuron and MT2 inhibits LIP neuron with weights 0.1 and -0.15. LIP threshold is set to 30. The raster plot of result is shown below. Whenever the firing rate of MT1 neuron is high and firing rate of MT2 neuron is low, the LIP neuron starts firing.



Q2:

Four variant stimuli in four periods of 250_msec are provided. The MT neurons' probabilities are different for each stimulus and then for each 250 msec of time interval. The weights from MT neurons to LIP neurons are as below: $LIP1\ neuron\ weights = [0.1\ -0.1]$ $LIP2\ neuron\ weights = [-0.1\ 0.1]$ MT1 excites LIP1 and inhibits LIP2. MT2 inhibits LIP1 and excites LIP2. For the first 250 msecs the MT probability values are 0.05 and 0.08. For the second period are 0.05 and 0.02. For the third period 0.05 and 0.06, and for the last period are 0.05 and 0.03.

Whenever the MT1 firing rate increases, LIP1's firing rate increases as well. However, the increment in MT1's firing rate results in a decrement of LIP2's firing rate and vice versa.



Raster plot
LIP1 = +MT1 - MT2
LIP2 = -MT1 + MT2
MT1
MT2
Spike
time
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45