Assignment 3: Learning and Memory PSY 306 (Winter 2023)

Name:

Roll Number:

Instructions: Please write your own responses and do not copy or lift text/code from any source. If you are referring to credible external sources other than the attached paper for your answers, please cite those sources (within the body of text and the provide a reference list at the end) in the APA citation format (https://www.mendeley.com/guides/apa-citation-guide). Word limits given are indicative and less than the indicated numbers may also be used.
Please download this MS word question-cum-response template to TYPE your answers and feel free to add sheets as required. Convert this document to a PDF and rename the file:. before submitting. Please note that answers in this template only will be evaluated and hand-written or scanned answer sheets will not be evaluated. Please submit ONLY ONE PDF and no extra files as it increases the time to evaluate them. DO NOT change the basic structure of the template. DO NOT remove the marks assigned for each question.

[Strict deadline for submission: 23rd April, 11:00 PM]

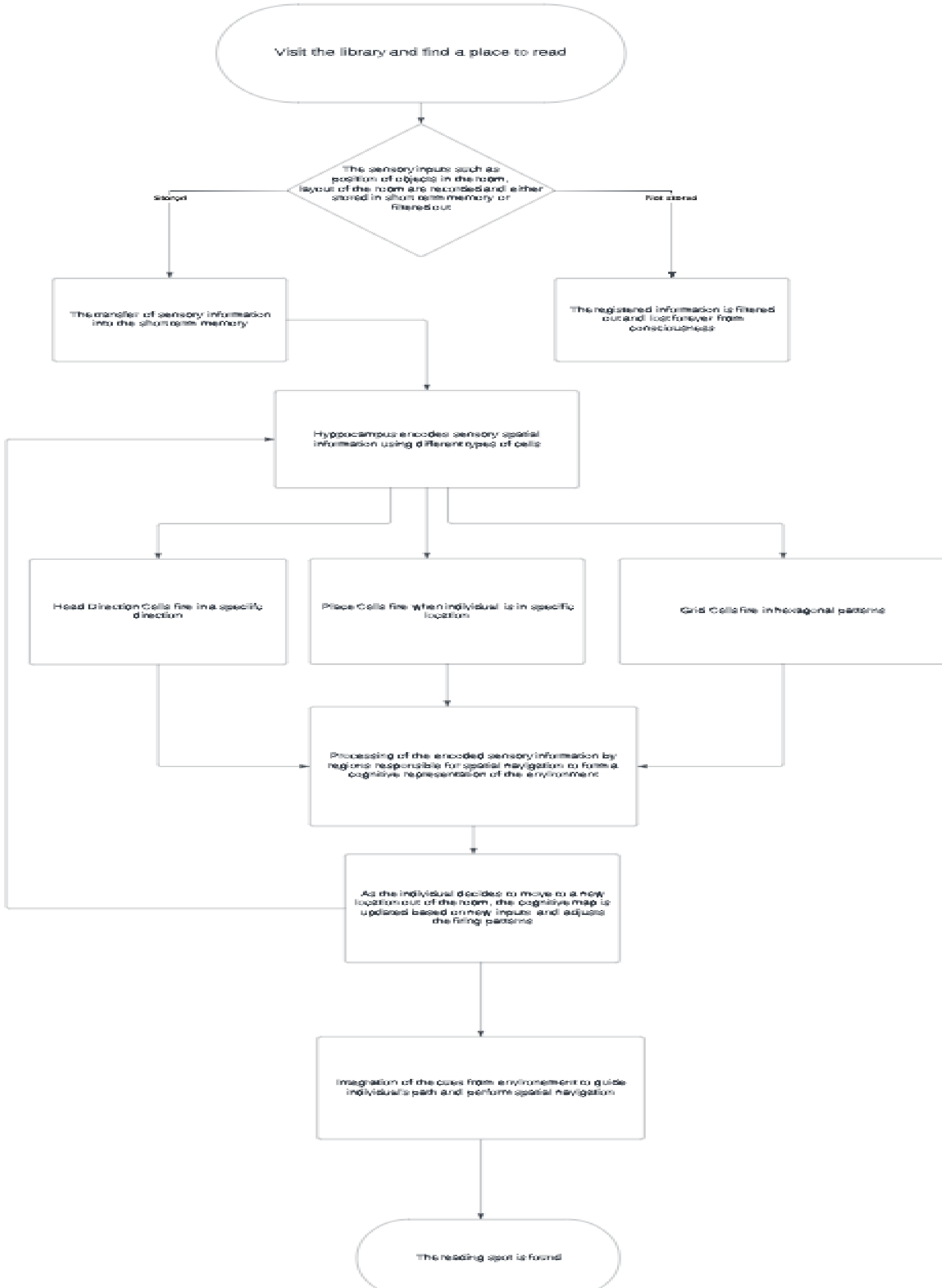
Q2) Please watch the attached video by Prof. Neil Burgess (Institute of Cognitive Neuroscience, University College London) and answer the following questions based on your understanding of the video.

[All figures/schematics should be properly labelled and should have accompanying captions/legends to provide all information necessary to interpret the same…]

A) You are in the library and just found a place in the reading room. You settle down to study when
you get a call and must step outside the library to take the call. After finishing the call as you are going back to the reading room your brain helps you navigate to the location in the library that you chose for yourself. Draw a flowchart of the neural algorithm/mechanism that will enable your brain to guide your path in moving to the spatial location that you had found inside the library reading room.
Hint: Use proper flowchart shapes and conventions
[https://support.microsoft.com/en-us/office/create-a-basic-flowchart-in-visio-e207d975-4a51-4bfa-a356-eeec314bd276]

Briefly explain the key steps of the above neural mechanism.

[8 + 2 points]


Visit the library and find a place to read
The sensory inputs such as position of objects in the room, layout of the room are recorded and either stored in short term memory or filtered out
Stored
Not stored
The transfer of sensory information into the short term memory
The registered information is filtered out and lost forever from consciousness
Hyppocampus encodes sensory spatial information using different types of cells
Head Direction Cells fire in a specific direction
Place Cells fire when individual is in specific location
Grid Cells fire in hexagonal patterns
Processing of the encoded sensory information by regions responsible for spatial navigation to form a cognitive representation of the environment
As the individual decides to move to a new location out of the room, the cognitive map is updated based on new inputs and adjusts the firing patterns
Integration of the cues from environement to guide individual's path and perform spatial navigation
The reading spot is found

Lucidchart
Link:https://lucid.app/lucidchart/dd832bf7-f6ff-4c37-8fa0-3591f169f704/edit?viewport_loc=-380%2C1713%2C2663%2C1187%2C0_0&invitationId=inv_c74472c2-d291-4eb4-9871-8dcb92f022ea

The process involves multiple sensory neurons and regions of the brain participating in the task of visual spatial navigation. The first step in spatial navigation involves the brain receiving sensory inputs from the environment where position of objects, layout of the room is stored. Next, the sensory information is filtered and sent to the short term memory of the brain where further processing happens. The encoding of the spatial information is done into a cognitive map and stored after firing patterns by several parts of the Hippocampus. The cognitive map is a mental representation of the environment, which includes landmarks, and other relevant information. The firing pattern guides a person to a specific path after following a process called path integration. The different cells work in conjunction to find the path and help the person navigate back to the desired reading location.

B) Use the data given in Assignment3-Q2Bdata.xlsx | An experimenter recorded and pre-processed EEG data from 20 participants on an auditory oddball task playing them standard and deviant tones. The interstimulus intervals between the two tones were manipulated at four levels – 0.75 s, 1.5s, 3s, 8s, 9s as the EEG traces evoked by both standard and deviant tones were measured (1000 Hz sampling rate) from the participants' brains. Each sheet of the Excel file has data for both standard tone (beginning from cell 'B3') and deviant tone (beginning from cell 'B25'). For each of the above tone there is a 20 (participants) x 100 (time point) matrix in each sheet. Do the following…

[All figures/schematics should be properly labelled and should have accompanying captions/legends to provide all information necessary to interpret the same…]

B-i) Make a figure with five subplots – one for each interstimulus interval. In each subplot, graph the average EEG response (across 20 participants) from both standard and deviant tones in blue and red colours respectively. [4 points]

Step1: The excel file is read using the pandas library

```
from google.colab import drive

drive.mount('/content/gdrive')

import pandas as pd
filep='/content/gdrive/My Drive/LM_datasets_Assignment/Assignment3-Q2Bdata.xls'
file = pd.ExcelFile(filep)
```

Step2: The sheets corresponding to each ISI is split into different data frames

```
isi_1=  pd.read_excel(file, '0.75s')
isi_2=  pd.read_excel(file, '1.5s')
isi_3=  pd.read_excel(file, '3s')
```

```
isi_4=  pd.read_excel(file, '8s')
isi_5=  pd.read_excel(file, '9s')
```

Step1: Each data frame is further subdivided into 2 types based on them being either standard or deviant tones.

```
isi_1_std=isi_1.iloc[1:21,1:]
isi_1_dev=isi_1.iloc[23:,1:]

isi_2_std=isi_2.iloc[1:21,1:]
isi_2_dev=isi_2.iloc[23:,1:]

isi_3_std=isi_3.iloc[1:21,1:]
isi_3_dev=isi_3.iloc[23:,1:]

isi_4_std=isi_4.iloc[1:21,1:]
isi_4_dev=isi_4.iloc[23:,1:]

isi_5_std=isi_5.iloc[1:21,1:]
isi_5_dev=isi_5.iloc[23:,1:]
```

```
isi1_std_avg=[]
isi1_dev_avg=[]

isi2_std_avg=[]
isi2_dev_avg=[]

isi3_std_avg=[]
isi3_dev_avg=[]

isi4_std_avg=[]
isi4_dev_avg=[]

isi5_std_avg=[]
isi5_dev_avg=[]
```

Step4:: The means of each column in a dataframe corresponding to each time frame is calculated and appended in respective lists.

```
#first isi
for column in isi_1_std:
  isi1_std_avg.append(isi_1_std[column].mean())
```

```python
for column in isi_1_dev:
  isi1_dev_avg.append(isi_1_dev[column].mean())

#second isi

for column in isi_2_std:
  isi2_std_avg.append(isi_2_std[column].mean())

for column in isi_2_dev:
  isi2_dev_avg.append(isi_2_dev[column].mean())

#third isi

for column in isi_3_std:
  isi3_std_avg.append(isi_3_std[column].mean())

for column in isi_3_dev:
  isi3_dev_avg.append(isi_3_dev[column].mean())

#fourth isi
for column in isi_4_std:
  isi4_std_avg.append(isi_4_std[column].mean())

for column in isi_4_dev:
  isi4_dev_avg.append(isi_4_dev[column].mean())


#fifth isi
for column in isi_5_std:
  isi5_std_avg.append(isi_5_std[column].mean())

for column in isi_5_dev:
  isi5_dev_avg.append(isi_5_dev[column].mean())
```

Step6: Using matplotlib library, the plot is divided into multiple subplots for each interstimulus interval. The blue line in each subplot represents the average EEG response (across 20 participants) to the standard tone, while the red line represents the deviant tone. The x-axis represents time in ms, and the y-axis represents the amplitude of the EEG response in the unit of the measurement used.

```python
import matplotlib.pyplot as plt
```

```
time=[]
for i in range(100):
  time.append(i)

fig, axs = plt.subplots(2,3, figsize=(20,10))

axs[0][0].plot(time,isi1_std_avg,color="blue", label='Standard Tone')
axs[0][0].plot(time,isi1_dev_avg,color="red", label='Deviant Tone')
axs[0][0].set_title("Inter Stimulus Interval: 0.75s")
axs[0][0].set_xlabel('Time(ms)')
axs[0][0].set_ylabel('Average EEG amplitude(µV)')
axs[0][0].legend()


axs[0][1].plot(time,isi2_std_avg,color="blue", label='Standard Tone')
axs[0][1].plot(time,isi2_dev_avg,color="red", label='Deviant Tone')
axs[0][1].set_title("Inter Stimulus Interval: 1.5s")
axs[0][1].set_xlabel('Time(ms)')
axs[0][1].set_ylabel('Average EEG amplitude(µV)')
axs[0][1].legend()


axs[0][2].plot(time,isi3_std_avg,color="blue", label='Standard Tone')
axs[0][2].plot(time,isi3_dev_avg,color="red", label='Deviant Tone')
axs[0][2].set_title("Inter Stimulus Interval: 3s")
axs[0][2].set_xlabel('Time(ms)')
axs[0][2].set_ylabel('Average EEG amplitude(µV)')
axs[0][2].legend()

axs[1][0].plot(time,isi4_std_avg,color="blue", label='Standard Tone')
axs[1][0].plot(time,isi4_dev_avg,color="red", label='Deviant Tone')
axs[1][0].set_title("Inter Stimulus Interval: 8s")
axs[1][0].set_xlabel('Time(ms)')
axs[1][0].set_ylabel('Average EEG amplitude(µV)')
axs[1][0].legend()

axs[1][1].plot(time,isi5_std_avg,color="blue", label='Standard Tone')
axs[1][1].plot(time,isi5_dev_avg,color="red", label='Deviant Tone')
axs[1][1].set_title("Inter Stimulus Interval: 9s")
axs[1][1].set_xlabel('Time(ms)')
axs[1][1].set_ylabel('Average EEG amplitude(µV)')
axs[1][1].legend()
plt.suptitle('Figure 1')
```

```
plt.legend()
plt.show()
```

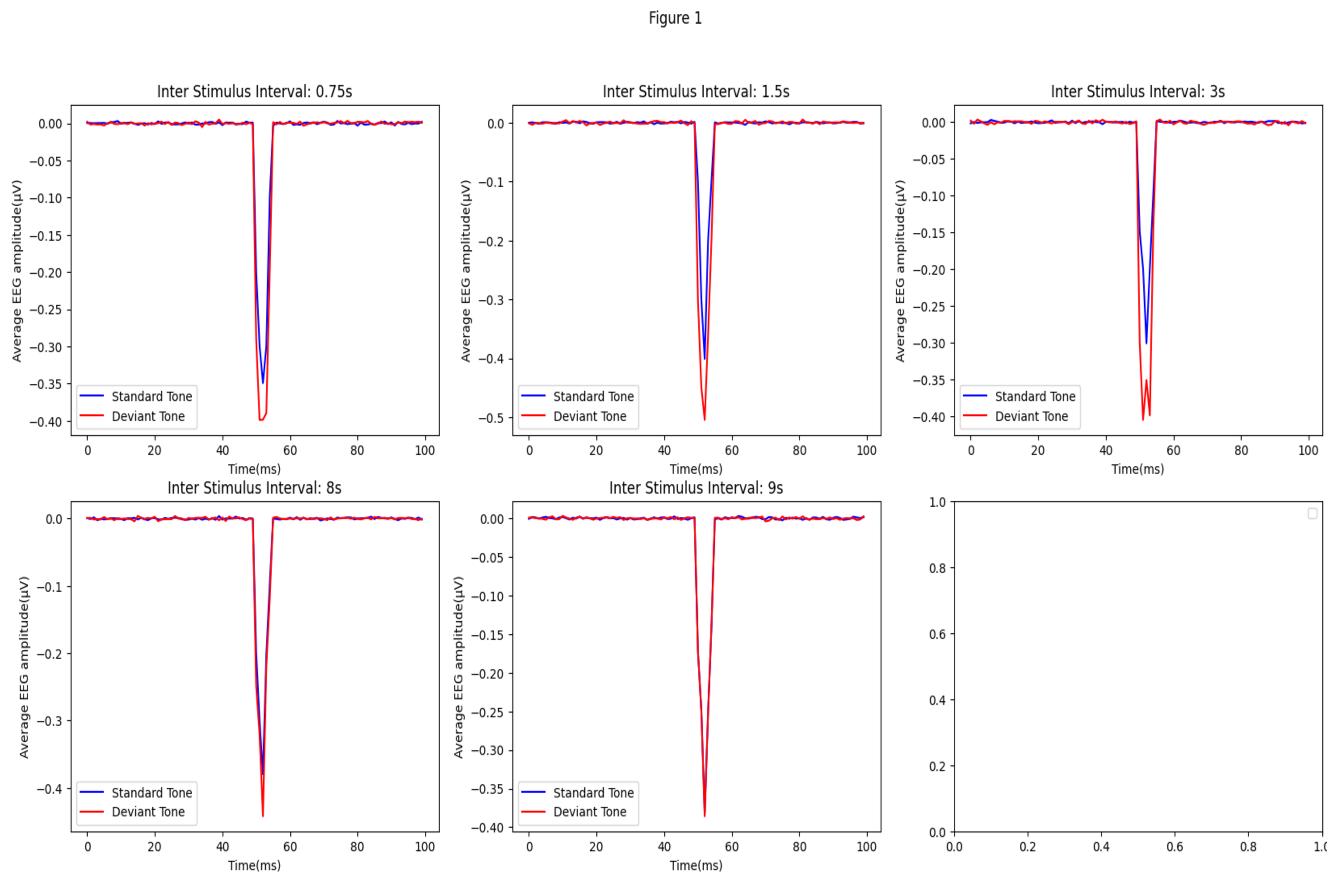


Figure: This figure consists of five subplots for each interstimulus interval. The blue line in each subplot represents the average EEG response (across 20 participants) to the standard tone, while the red line represents the deviant tone. The x-axis represents time in ms, and the y-axis represents the amplitude of the EEG response in the unit of the measurement used.

B-ii) Analyze the data from each interstimulus interval statistically and report the time scale of echoic memory. Explain the cognitive science consistent rationale behind the calculation and reported time scale. [4 + 2 points]
Hint: Carefully inspect the correctly created figure above for clues.

```
import pandas as pd
import numpy as np
import scipy.stats as stats

#Compute the difference between the average responses to the standard and
deviant tones for each segment.
isi1_diff=[]
isi2_diff=[]
isi3_diff=[]
isi4_diff=[]
isi5_diff=[]

for i in range(100):
  isi1_diff.append(np.abs(isi1_std_avg[i]-isi1_dev_avg[i]))
  isi2_diff.append(np.abs(isi2_std_avg[i]-isi2_dev_avg[i]))
  isi3_diff.append(np.abs(isi3_std_avg[i]-isi3_dev_avg[i]))
  isi4_diff.append(np.abs(isi4_std_avg[i]-isi4_dev_avg[i]))
  isi5_diff.append(np.abs(isi5_std_avg[i]-isi5_dev_avg[i]))


sd=[]
sd.append(np.std(isi1_diff , ddof=1))
sd.append(np.std(isi2_diff , ddof=1))
sd.append(np.std(isi3_diff , ddof=1))
sd.append(np.std(isi4_diff , ddof=1))
sd.append(np.std(isi5_diff , ddof=1))
```

```
] sd

[0.018859644699247162,
 0.0320958107446442,
 0.03241472645694488,
 0.008389140857458144,
 0.0010647352249408383]
```

```python
# Perform a t-test between the responses to the standard and deviant tones for each time segment. If the p values computed are less than the threshold, means there is significant difference recall performance between the two at that time frame. Thus based on this we can identify the time scale of echoic memory by determining the time interval at which the significant drop occurs.

ans=[]

t, p = stats.ttest_ind(isi_1_std, isi_1_dev)
ans.append(np.sum(p<0.05)/1000)

t, p = stats.ttest_ind(isi_2_std, isi_2_dev)
ans.append(np.sum(p<0.05)/1000)

t, p = stats.ttest_ind(isi_3_std, isi_3_dev)
ans.append(np.sum(p<0.05)/1000)

t, p = stats.ttest_ind(isi_4_std, isi_4_dev)
ans.append(np.sum(p<0.05)/1000)

t, p = stats.ttest_ind(isi_5_std, isi_5_dev)
ans.append(np.sum(p<0.05)/1000)


isi=[0.75, 1.5, 3, 8, 9]
count=0
for i in isi:
  print("The Time Scale for Echoic Memory with InterStimulus Interval :", i,
"seconds is", ans[count],"seconds")
  count=count+1
```

```
The Time Scale for Echoic Memory with InterStimulus Interval : 0.75 seconds is 0.013 seconds
The Time Scale for Echoic Memory with InterStimulus Interval : 1.5 seconds is 0.011 seconds
The Time Scale for Echoic Memory with InterStimulus Interval : 3 seconds is 0.013 seconds
The Time Scale for Echoic Memory with InterStimulus Interval : 8 seconds is 0.008 seconds
The Time Scale for Echoic Memory with InterStimulus Interval : 9 seconds is 0.004 seconds
```

The t test could be performed because both the samples are independent and have minimum variance.

The figure formed in the previous section also suggests that the latency and duration of the eeg signals can help in determining the time duration of processing in case of echoic memory. The differences between the two waveforms are more prominent in the initial intervals, with lesser isi values which further suggests that the time scale of echoic memory may be very short. Thus in general echoic memory has a very short duration and capacity.