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]

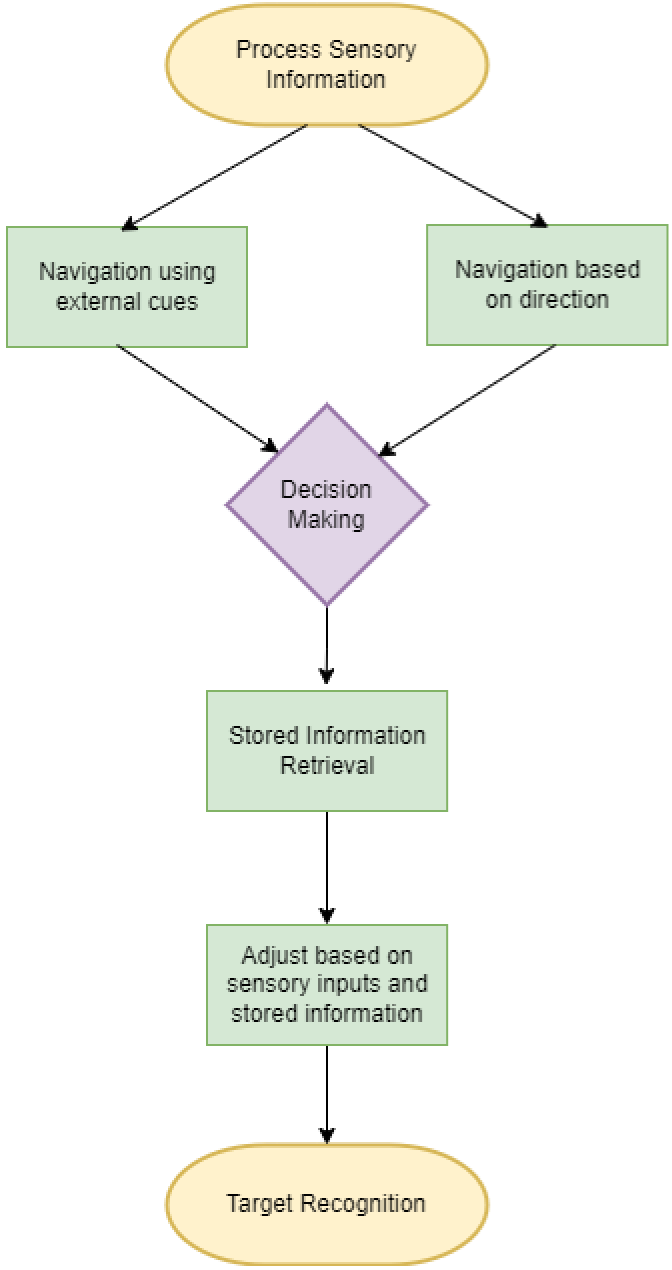
[Answer]

Note: The below flowchart only contains steps from "position outside the library after the call to our original reading space inside the library", as mentioned in the GC post. A brief explanation is, however, provided of how the previous steps affect the steps in the flowchart.

<u>**Description of initial steps NOT present in the flowchart**</u>

When we first enter the library and, subsequently, the reading room, our mind creates a mental map of the surrounding environment. This includes information like the location of the table and chair where we choose to sit down. As we stand and explore the reading room to take our call outside, our brain automatically updates the cognitive map of our environment, adding new information and updating the representation of our environment. Also, any movement that we make from the moment we stood up to take the call, our brain tracks this motion by a process called Path Integration. It helps us keep track of our movements relative to the starting point.

Below is the flowchart for the neural mechanism:



Brief Description of each step:

- Process Sensory Information: Our brain processes sensory information like visual and auditory information, which would help us in remembering any unique landmarks and find our way back to the reading room.
- Navigation using external cues: Two navigation systems will be utilized by our brains to find our way back. One will be navigation based on our external environment and is independent of self. This is called Allocentric navigation. Place cells in our brain would fire electrical impulses thereby marking the important landmarks.
- Navigation based on direction: The second navigation system is based on our own movements and is independent of our surrounding environment. This is called Egocentric navigation.
- Decision Making: As we head back to the reading room, our brains would process information from both the navigation systems described above and make decisions accordingly for way back.

- <u>Stored Information Retrieval:</u> As we finish our call and head back to the reading room, our brain would retrieve stored information about where we were sitting.
- <u>Adjust based on sensory inputs and stored information:</u> As we approach the reading room, our brain would compare the stored information in our mind with the sensory information it is getting from the surrounding environment.
- <u>Target Recognition:</u> As we reach the reading room, our brain would recognize the familiar visual and spatial cues and accordingly identify where we were sitting.

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]

[Answer]

<u>Code and Explanation</u>

- Importing Libraries

Importing Libraries

```
[1] import pandas as pd
    import matplotlib.pyplot as plt
    import numpy as np
```

- Loading Dataset

Loading Dataset

```
[2]  xls = pd.ExcelFile('/content/drive/MyDrive/Assignment3-Q2Bdata.xls')

     df_t1_standard = pd.read_excel(xls, "0.75s").iloc[1:21,1:]
     df_t1_deviant = pd.read_excel(xls, "0.75s").iloc[23:,1:]

     df_t2_standard = pd.read_excel(xls, "1.5s").iloc[1:21,1:]
     df_t2_deviant = pd.read_excel(xls, "1.5s").iloc[23:,1:]

     df_t3_standard = pd.read_excel(xls, "3s").iloc[1:21,1:]
     df_t3_deviant = pd.read_excel(xls, "3s").iloc[23:,1:]

     df_t4_standard = pd.read_excel(xls, "8s").iloc[1:21,1:]
     df_t4_deviant = pd.read_excel(xls, "8s").iloc[23:,1:]

     df_t5_standard = pd.read_excel(xls, "9s").iloc[1:21,1:]
     df_t5_deviant = pd.read_excel(xls, "9s").iloc[23:,1:]
```

- Creating subplots with appropriate legends and caption

```python
fig, ((plot1, plot2), (plot3, plot4), (plot5,plot6)) = plt.subplots(3, 2, figsize = (16,16))
fig.delaxes(plot6)
fig.suptitle('Average EEG response for all participants across each interstimulus interval', y = 0.92, fontweight = 'bold')

mean1_s = df_t1_standard.mean(axis = 0)
mean1_d = df_t1_deviant.mean(axis = 0)
plot1.plot(np.arange(1,101), mean1_s, color = 'blue', label = 'Standard tone')
plot1.plot(np.arange(1,101), mean1_d, color = 'red', label = 'Deviant tone')
plot1.set_xlabel('Time Point')
plot1.set_ylabel('Amplitude')
plot1.set_title('Average EEG response with interval = 0.75s')
plot1.legend()

mean2_s = df_t2_standard.mean(axis = 0)
mean2_d = df_t2_deviant.mean(axis = 0)
plot2.plot(np.arange(1,101), mean2_s, color = 'blue', label = 'Standard tone')
plot2.plot(np.arange(1,101), mean2_d, color = 'red', label = 'Deviant tone')
plot2.set_xlabel('Time Point')
plot2.set_ylabel('Amplitude')
plot2.set_title('Average EEG response with interval = 1.5s')
plot2.legend()

mean3_s = df_t3_standard.mean(axis = 0)
mean3_d = df_t3_deviant.mean(axis = 0)
plot3.plot(np.arange(1,101), mean3_s, color = 'blue', label = 'Standard tone')
plot3.plot(np.arange(1,101), mean3_d, color = 'red', label = 'Deviant tone')
plot3.set_xlabel('Time Point')
plot3.set_ylabel('Amplitude')
plot3.set_title('Average EEG response with interval = 3s')
plot3.legend()

mean4_s = df_t4_standard.mean(axis = 0)
mean4_d = df_t4_deviant.mean(axis = 0)
plot4.plot(np.arange(1,101), mean4_s, color = 'blue', label = 'Standard tone')
plot4.plot(np.arange(1,101), mean4_d, color = 'red', label = 'Deviant tone')
plot4.set_xlabel('Time Point')
plot4.set_ylabel('Amplitude')
plot4.set_title('Average EEG response with interval = 8s')
plot4.legend()

mean5_s = df_t5_standard.mean(axis = 0)
mean5_d = df_t5_deviant.mean(axis = 0)
plot5.plot(np.arange(1,101), mean5_s, color = 'blue', label = 'Standard tone')
plot5.plot(np.arange(1,101), mean5_d, color = 'red', label = 'Deviant tone')
plot5.set_xlabel('Time Point')
plot5.set_ylabel('Amplitude')
plot5.set_title('Average EEG response with interval = 9s')
plot5.legend()

caption = """Figure above shows Average EEG response of standard (blue) and deviant (red)
        tones for 20 participants across 5 interstimulus intervals."""

fig.text(0.5, 0.06, caption, ha = 'center')
```

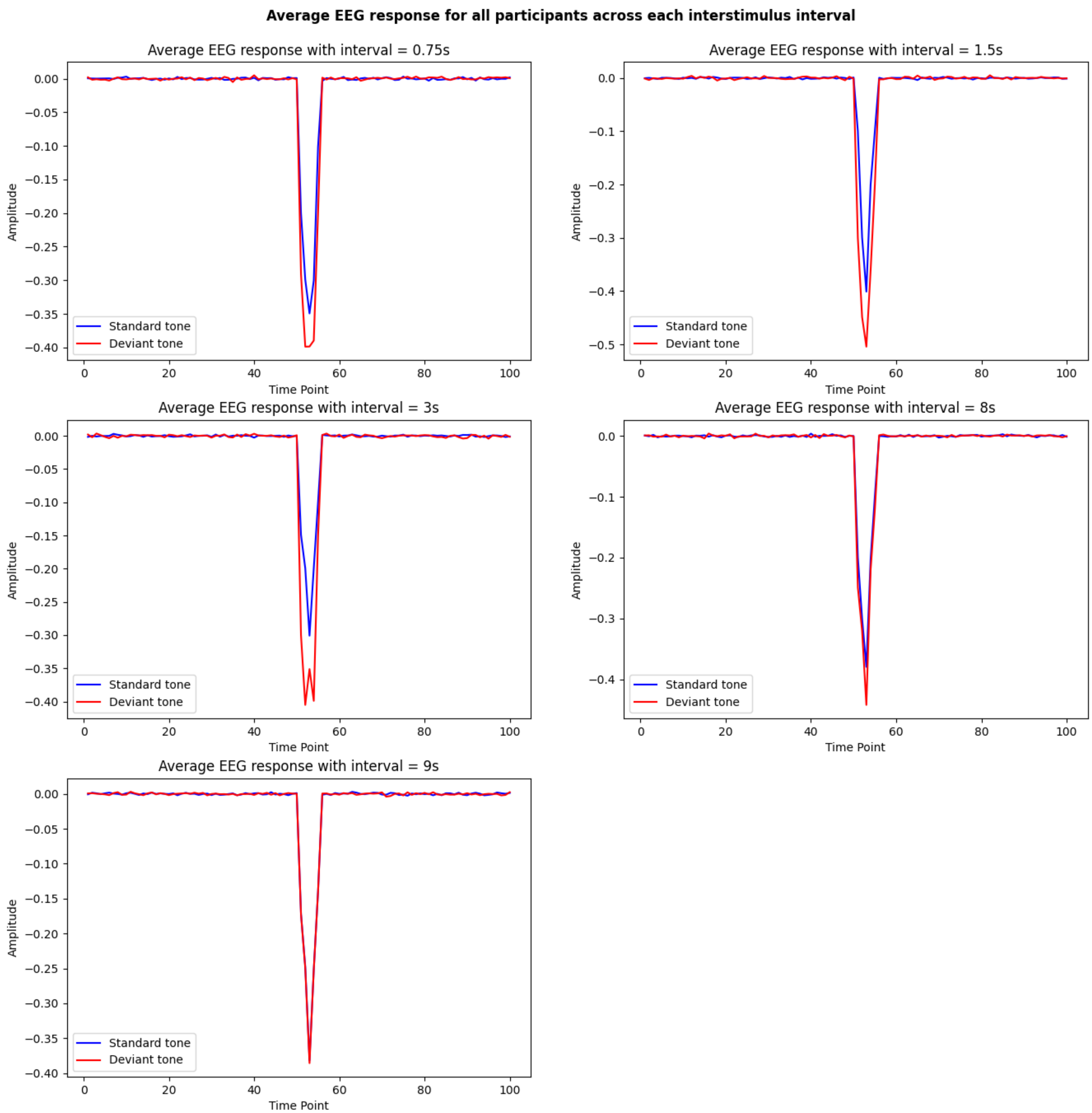


Figure above shows Average EEG response of standard (blue) and deviant (red) tones for 20 participants across 5 interstimulus intervals.

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.

[Answer]

To analyze the above data, we'll use a statistical t-test between the standard and deviant tones of each interstimulus interval. If the resultant p-value is less than 0.05, this means that there is a significant difference between the standard and deviant tones for the particular interval.
Below is the code snippet for the t-test

B (ii)

```
[12] p_values = {}
     p_values['0.75s'] = stats.ttest_rel(mean1_s, mean1_d)[1]
     p_values['1.5s'] = stats.ttest_rel(mean2_s, mean2_d)[1]
     p_values['3s'] = stats.ttest_rel(mean3_s, mean3_d)[1]
     p_values['8s'] = stats.ttest_rel(mean4_s, mean4_d)[1]
     p_values['9s'] = stats.ttest_rel(mean5_s, mean5_d)[1]

     for interval, p in p_values.items():
         if p > 0.05:
             print('The time scale of our echoic memory is: ',interval)
             break
```

```
The time scale of our echoic memory is:  8s
```

Echoic memory refers to a type of sensory memory that registers and temporarily stores auditory information until it is processed. To estimate the time scale of our echoic memory, we need to find the interstimulus interval at which our brain is no longer able to detect the difference between standard and deviant tones. This happens when p_value > 0.05, or more precisely, at 8 seconds.

The cognitive science consistent rationale behind the calculation and reported time scale is to determine how our brain processes and differentiates between the standard and deviant tones. Echoic memory holds this information. It has a limited capacity and duration. By identifying the interval at which the brain can no longer tell the difference between the two tones, we can estimate the time scale of our echoic memory.

Complete Code

```
# -*- coding: utf-8 -*-
"""Untitled8.ipynb

Automatically generated by Colaboratory.

Original file is located at
    https://colab.research.google.com/drive/1UM-An7EvDB4vLzEoeyFNXTEcFn6mG8qf

Importing Libraries
"""
```

```python
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import scipy.stats as stats

"""Loading Dataset"""

xls = pd.ExcelFile('/content/drive/MyDrive/Assignment3-Q2Bdata.xls')

df_t1_standard = pd.read_excel(xls, "0.75s").iloc[1:21,1:]
df_t1_deviant = pd.read_excel(xls, "0.75s").iloc[23:,1:]

df_t2_standard = pd.read_excel(xls, "1.5s").iloc[1:21,1:]
df_t2_deviant = pd.read_excel(xls, "1.5s").iloc[23:,1:]

df_t3_standard = pd.read_excel(xls, "3s").iloc[1:21,1:]
df_t3_deviant = pd.read_excel(xls, "3s").iloc[23:,1:]

df_t4_standard = pd.read_excel(xls, "8s").iloc[1:21,1:]
df_t4_deviant = pd.read_excel(xls, "8s").iloc[23:,1:]

df_t5_standard = pd.read_excel(xls, "9s").iloc[1:21,1:]
df_t5_deviant = pd.read_excel(xls, "9s").iloc[23:,1:]

"""B (i)"""

fig, ((plot1, plot2), (plot3, plot4), (plot5,plot6)) = plt.subplots(3, 2, figsize =
(16,16))
fig.delaxes(plot6)
fig.suptitle('Average EEG response for all participants across each interstimulus
interval', y = 0.92, fontweight = 'bold')

mean1_s = df_t1_standard.mean(axis = 0)
mean1_d = df_t1_deviant.mean(axis = 0)
plot1.plot(np.arange(1,101), mean1_s, color = 'blue', label = 'Standard tone')
plot1.plot(np.arange(1,101), mean1_d, color = 'red', label = 'Deviant tone')
plot1.set_xlabel('Time Point')
plot1.set_ylabel('Amplitude')
plot1.set_title('Average EEG response with interval = 0.75s')
plot1.legend()

mean2_s = df_t2_standard.mean(axis = 0)
mean2_d = df_t2_deviant.mean(axis = 0)
```

```
plot2.plot(np.arange(1,101), mean2_s, color = 'blue', label = 'Standard tone')
plot2.plot(np.arange(1,101), mean2_d, color = 'red', label = 'Deviant tone')
plot2.set_xlabel('Time Point')
plot2.set_ylabel('Amplitude')
plot2.set_title('Average EEG response with interval = 1.5s')
plot2.legend()

mean3_s = df_t3_standard.mean(axis = 0)
mean3_d = df_t3_deviant.mean(axis = 0)
plot3.plot(np.arange(1,101), mean3_s, color = 'blue', label = 'Standard tone')
plot3.plot(np.arange(1,101), mean3_d, color = 'red', label = 'Deviant tone')
plot3.set_xlabel('Time Point')
plot3.set_ylabel('Amplitude')
plot3.set_title('Average EEG response with interval = 3s')
plot3.legend()

mean4_s = df_t4_standard.mean(axis = 0)
mean4_d = df_t4_deviant.mean(axis = 0)
plot4.plot(np.arange(1,101), mean4_s, color = 'blue', label = 'Standard tone')
plot4.plot(np.arange(1,101), mean4_d, color = 'red', label = 'Deviant tone')
plot4.set_xlabel('Time Point')
plot4.set_ylabel('Amplitude')
plot4.set_title('Average EEG response with interval = 8s')
plot4.legend()

mean5_s = df_t5_standard.mean(axis = 0)
mean5_d = df_t5_deviant.mean(axis = 0)
plot5.plot(np.arange(1,101), mean5_s, color = 'blue', label = 'Standard tone')
plot5.plot(np.arange(1,101), mean5_d, color = 'red', label = 'Deviant tone')
plot5.set_xlabel('Time Point')
plot5.set_ylabel('Amplitude')
plot5.set_title('Average EEG response with interval = 9s')
plot5.legend()

caption = """Figure above shows Average EEG response of standard (blue) and deviant
(red)
        tones for 20 participants across 5 interstimulus intervals."""

fig.text(0.5, 0.06, caption, ha = 'center')

"""B (ii)"""

p_values = {}
```

```
p_values['0.75s'] = stats.ttest_rel(mean1_s, mean1_d)[1]
p_values['1.5s'] = stats.ttest_rel(mean2_s, mean2_d)[1]
p_values['3s'] = stats.ttest_rel(mean3_s, mean3_d)[1]
p_values['8s'] = stats.ttest_rel(mean4_s, mean4_d)[1]
p_values['9s'] = stats.ttest_rel(mean5_s, mean5_d)[1]

for interval, p in p_values.items():
    if p > 0.05:
        print('The time scale of our echoic memory is: ',interval)
        break
```