Python Workshop
Final Project
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Introduction:

The study, "Neural pattern similarity predicts long-term fear memory" by Renée M. Visser et al., investigates the relationship between neural patterns during fear learning and the long-term expression of fear memory using fMRI. The researchers found that trial-by-trial neural similarity could effectively predict the retention of learned fear across various stimuli. This study highlights the significance of specific brain regions in understanding fear memory formation and retention.

In our project, in order to replicate the original research conducted by Visser et al. (2013), we performed various statistical analyses following the preprocessing of fMRI data.
This approach allows us to validate the key findings of the original study regarding the involvement of specific brain regions in fear memory processing.

Methods:

preprocess:

Preprocessing of fMRI data is essential to remove artifacts and noise that can obscure the true neural signals, ensuring that the data accurately reflects brain activity related to cognitive tasks.

Therefore we performed:

- Slice time correction
- Motion correction
- Spatial smoothing
- Alignment of anatomical scan to MNI

It is worth noting that since we don't have FSL software or other fMRI data preprocessing tools, along with the aim of this project that is to improve our python skills, some of the corrections that have been implemented are not 100% correct. This may affect our statistical analysis results.

Mask & Data:

After preprocessing the data, we extracted Bold values from each ROI to a dataframe.

We used Harvard-Oxford Cortical Atlas and Harvard-Oxford Sub-Cortical Atlas for masking.

Statistical analysis:

We performed 2 main analyses, Pearson correlation and ANOVA.

The correlation we did was in 2 ways:

1. Correlate the mean bold of different regions for each stimulus.
2. Trial by trial correlation

For the Longitudinal Assessment of Memory we performed ANOVA test between the learning phase and the memory phase.

Results & Discussion:

Figure 1A-C present correlation matrices of BOLD values between different ROIs for:

A) CSminFt

B) CSnegHt

C) CSneutHt

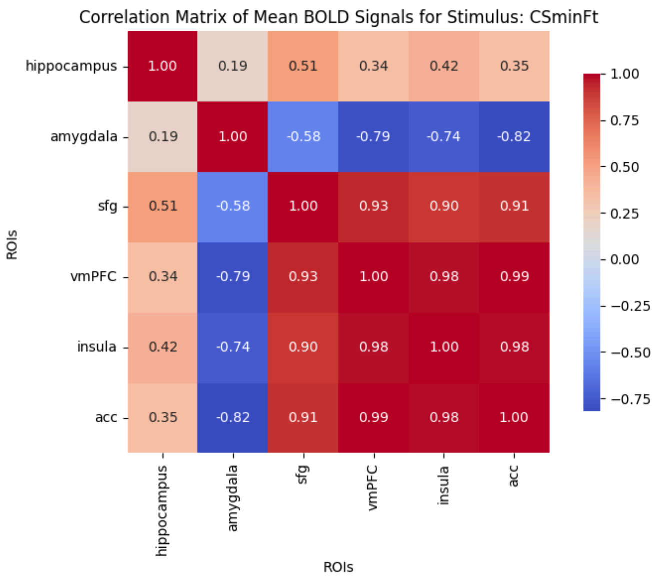
(minimal (min)a n image without conditioning, neutral (neut) an image with a tone conditioning, negative (neg) an image with shock conditioning, Ht - image of a house, Ft image of a face)

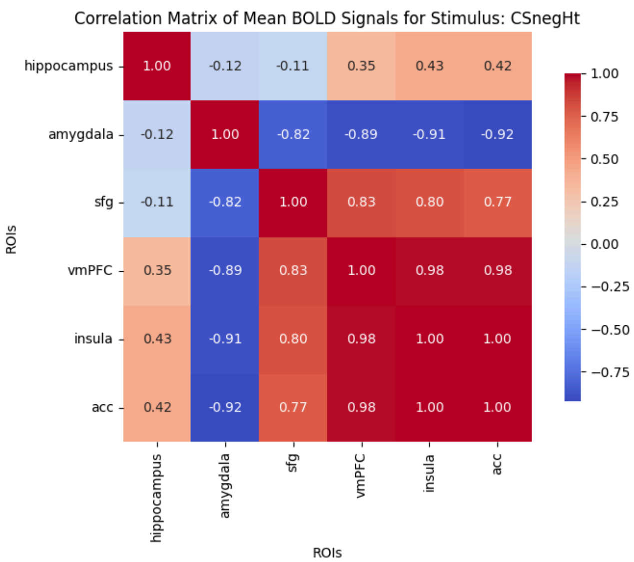
Across all stimuli, there is a strong positive correlation among cortical ROIs, indicating a high degree of functional connectivity within these regions.

In CSnegHt and CSminFt, the amygdala exhibits a strong negative correlation with cortical ROIs, while the hippocampus shows a positive correlation.

In CSneutHt, both the amygdala and hippocampus exhibit strong negative correlations with the cortex, with the amygdala showing stronger negative connections.

Additionally, the amygdala and hippocampus consistently show a strong positive correlation, suggesting close functional coupling between emotional processing and memory-related regions.





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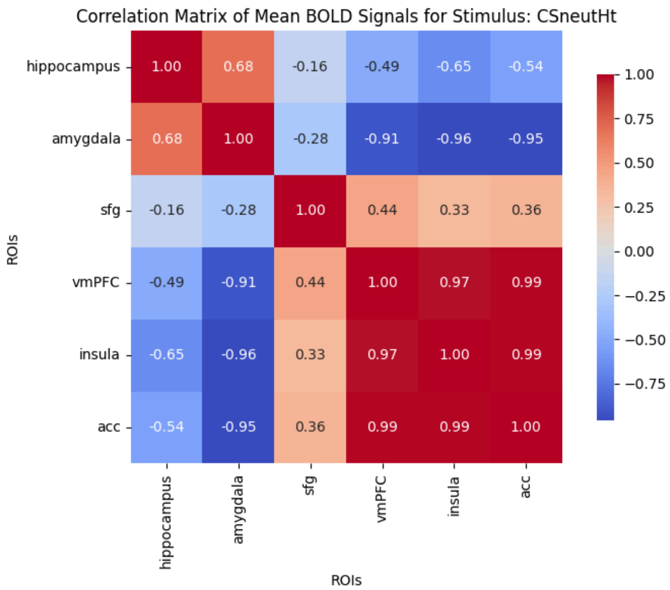
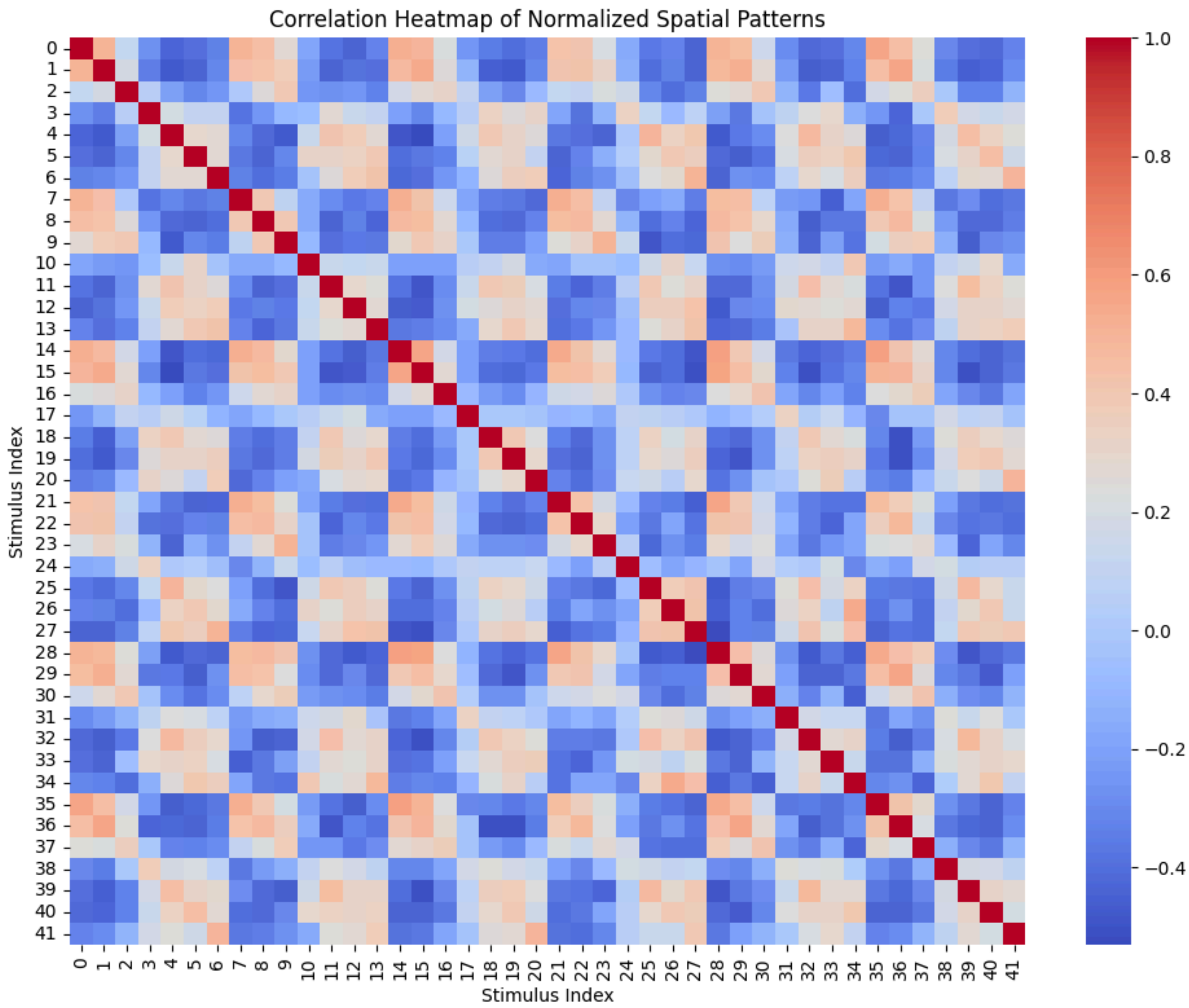


Figure 2 presents a correlation heatmap of normalized spatial patterns, illustrating the relationships between different stimuli. The color scale ranges from blue (indicating negative correlations) to red (indicating positive correlations), with the diagonal representing a perfect correlation (1.0) between identical stimuli.

The strong red diagonal suggests that each stimulus has a high self-correlation, which is expected. The surrounding patterns of blue and red indicate varying degrees of similarity and dissimilarity between different stimuli. Regions with strong positive correlations (warmer colors) suggest similar spatial patterns, whereas regions with negative correlations (cooler colors) indicate opposing spatial trends.


Correlation Heatmap of Normalized Spatial Patterns
Stimulus Index
Stimulus Index
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
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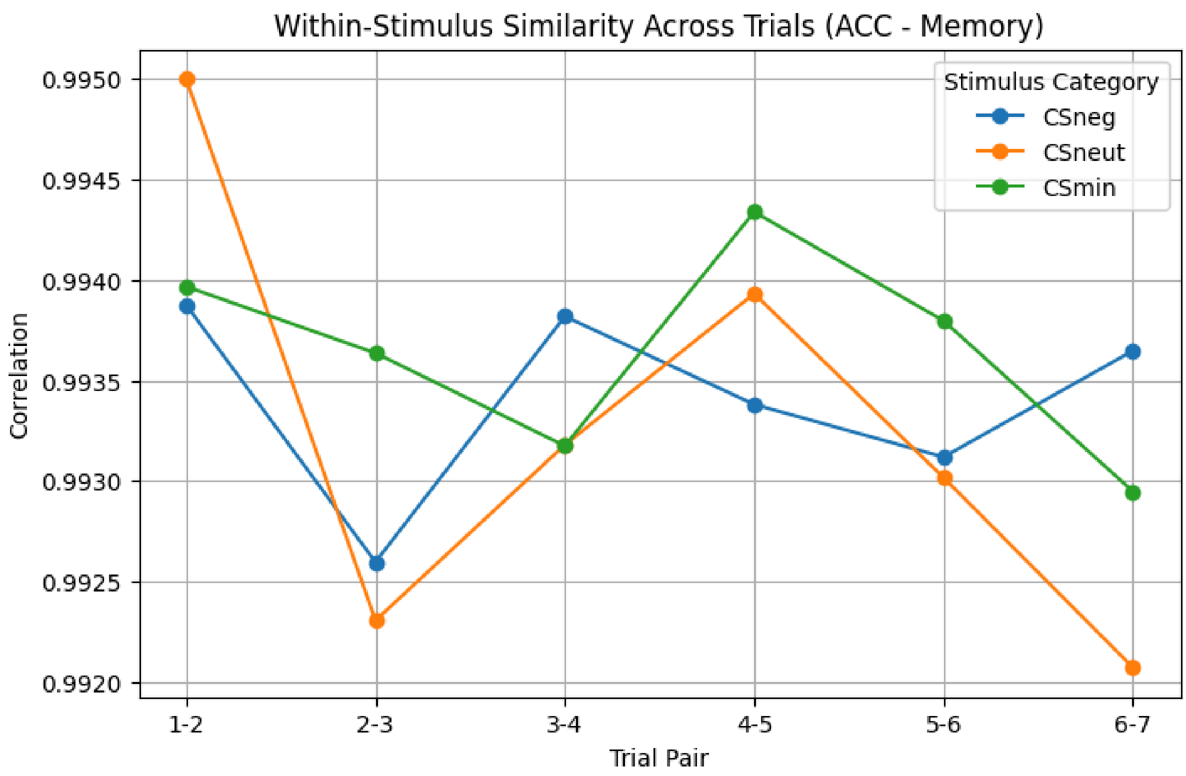
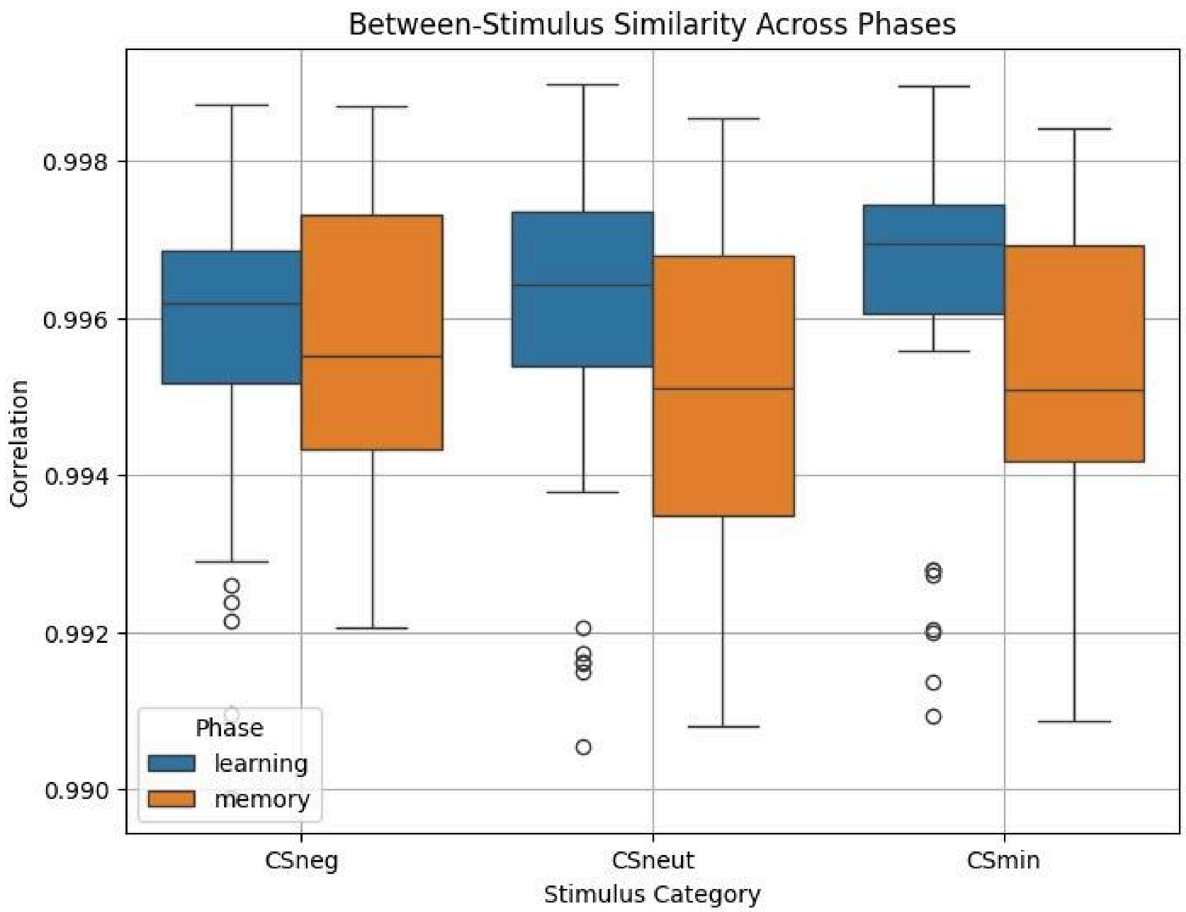
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4


Within-Stimulus Similarity Across Trials (ACC - Memory)
Stimulus Category
CSneg
CSneut
CSmin
0.9950
0.9945
0.9940
0.9935
0.9930
0.9925
0.9920
Correlation
1-2
2-3
3-4
4-5
5-6
6-7
Trial Pair


Between-Stimulus Similarity Across Phases
0.998
0.996
0.994
0.992
0.990
Correlation
Phase
learning
memory
CSneg
CSneut
CSmin
Stimulus Category