Hippocampus & Striatum's Roles in Interval Timing

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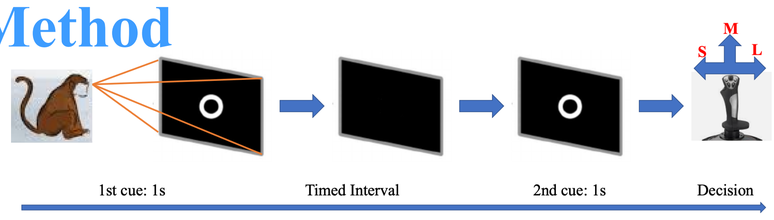
Introduction

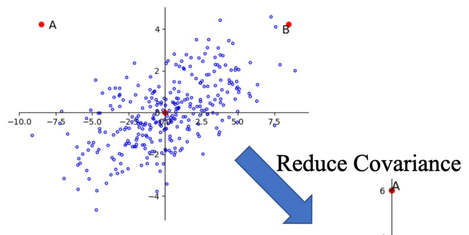
This research focus on monkey's hippocampus and striatum's roles in interval timing and working memory. It's an analysis of pre-recorded monkey brain local field potential data acquired using interval timing experiment. The experiment trained monkey to distinguish different time intervals (short, median, and long) in four sets and recorded monkey's deep brain local field potential while it was performing experimental trials.

Method



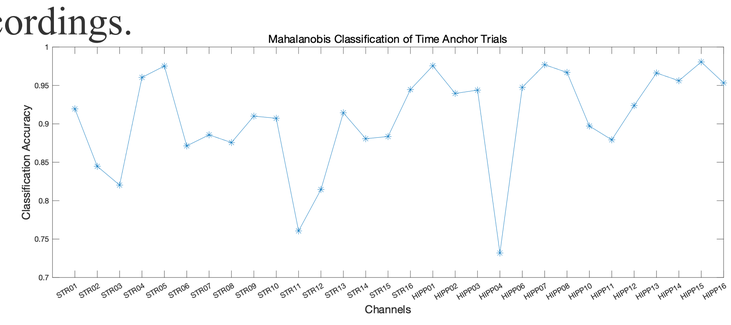
Time Anchor (0.5s, 1s, 2s)
Retiming Short (0.25s, 0.5s, 1s)
Retiming Long1(1s, 2s, 4s)
Retiming Long2(2s, 4s, 8s)
Recorded Window: 2s + interval + 1.8s

Results



1. *Classifiers*

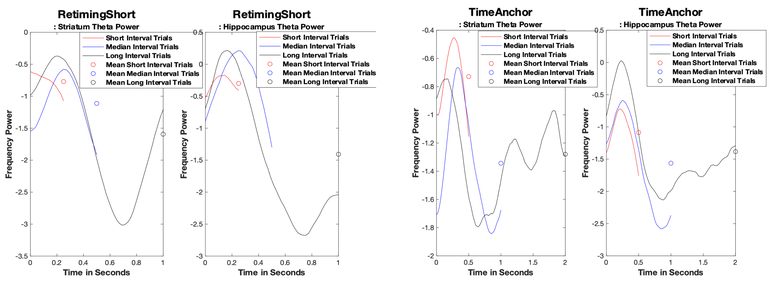
Calculate individual data's *mahalanobis distance*[1] $D_M(x) = \sqrt{(x-\mu)^T\Sigma^{-1}(x-\mu)}$ to short, median, and long data matrix groups. Group it to its closest group to build classifiers. Below are 32 classifiers' accuracy on time-anchor set channel recordings.

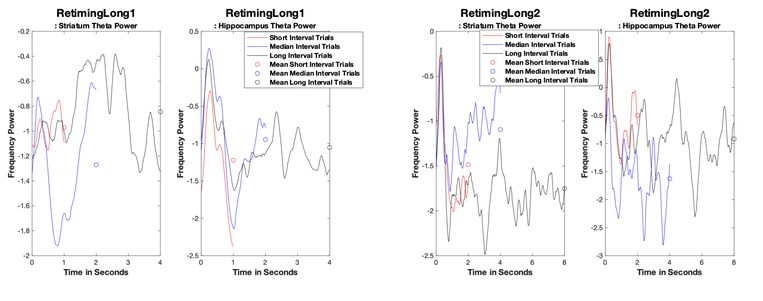


2. *Wavelet Decomposition & Analysis*

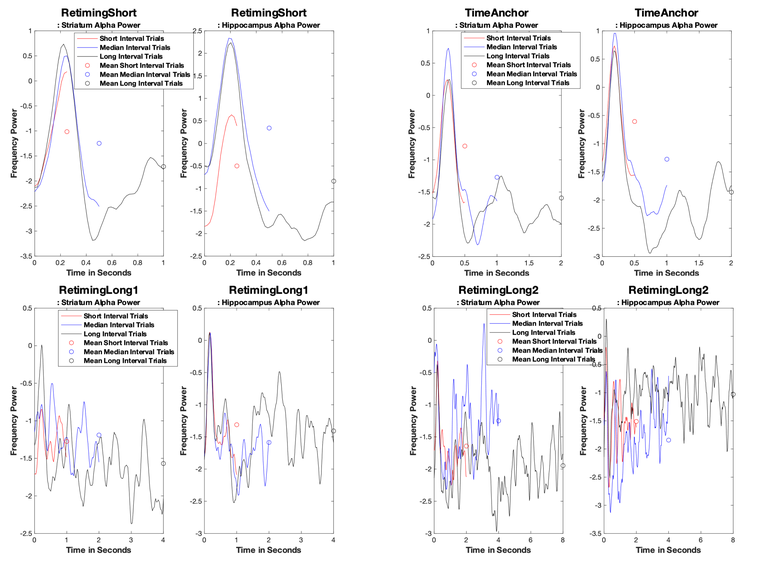
Decompose raw data into the summation of waves with frequency equaling 4 to 40 Hz with step of o.5 Hz. This paper uses MATLAB *fieldtrip*[2] to conduct this decomposition. Among the decomposed signal, some unimodal peak forms exist in theta wave and alpha wave oscillations, that are followed by ramping behaviors[3]. However, these distinctive events only exist in some relatively shorter time intervals. And these unimodal peaks have increasing wave lengths as time interval length increases.

(Theta Wave: 4 – 7 Hz)



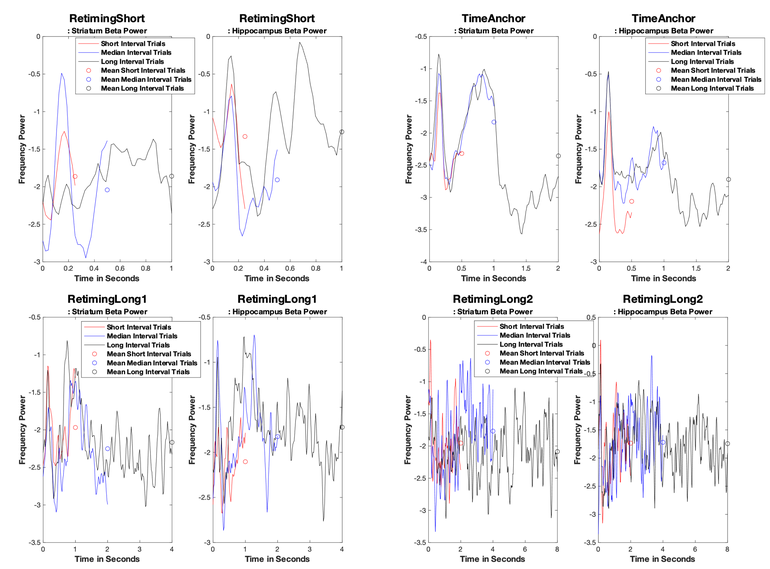


(Alpha Wave: 9 – 11 Hz)



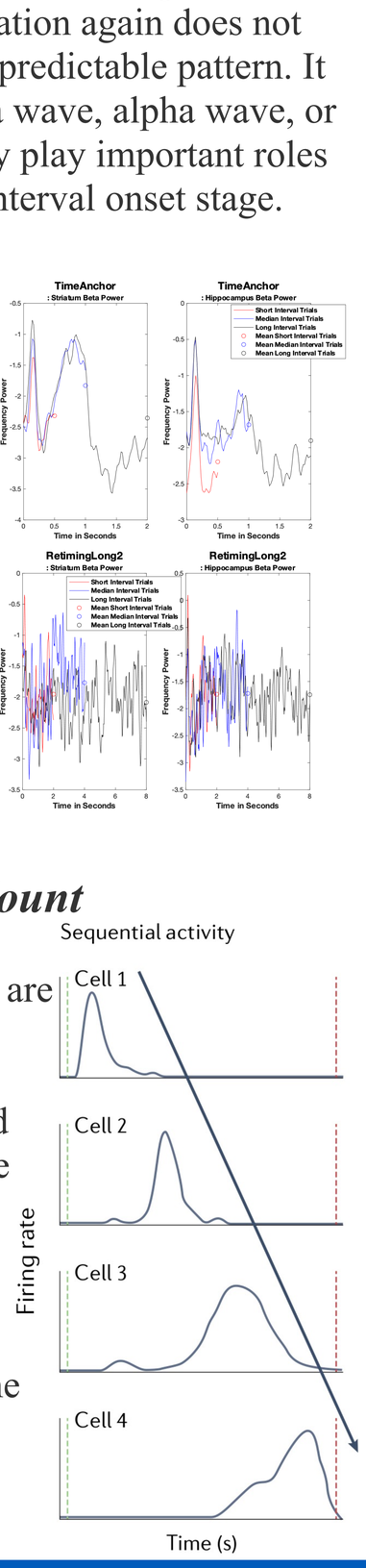
In beta wave oscillation, specifically in both retiming short set and time anchor set, there are bimodal peak forms at the beginning of different timed interval. However, in relatively longer timed interval, for instance those longer than 2 seconds, the above observation again does not hold and is replaced by unpredictable pattern. It is possible that either theta wave, alpha wave, or beta wave oscillations only play important roles for interval timing at the interval onset stage.

(Beta Wave: 18 – 21 Hz)

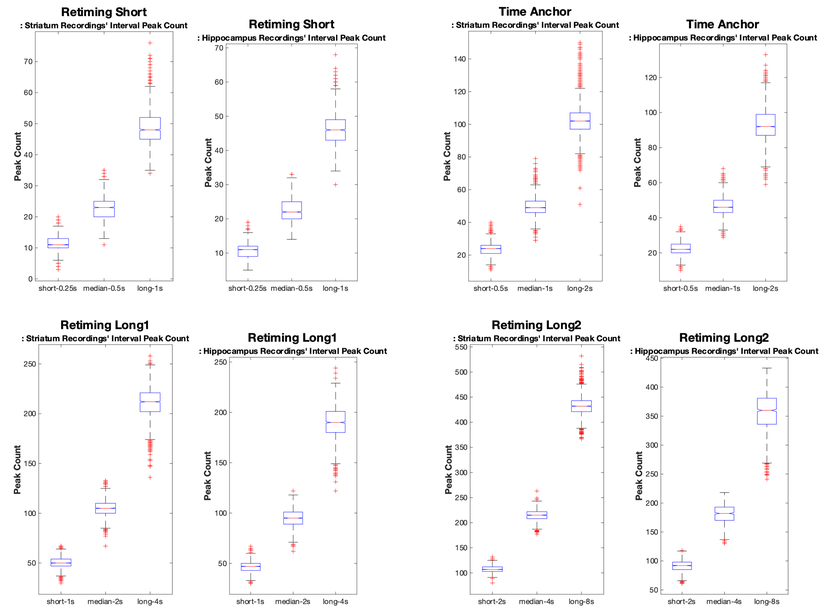


3. *Oscillation Peak Count*

Hippocampus time cells[4,5] are known for their sequential activation to generate an internal clock as illustrated on the right[6]. It is therefore hypothesized that the number of peak within each trial's timed interval should follow a specific pattern and increase as time interval length doubles.

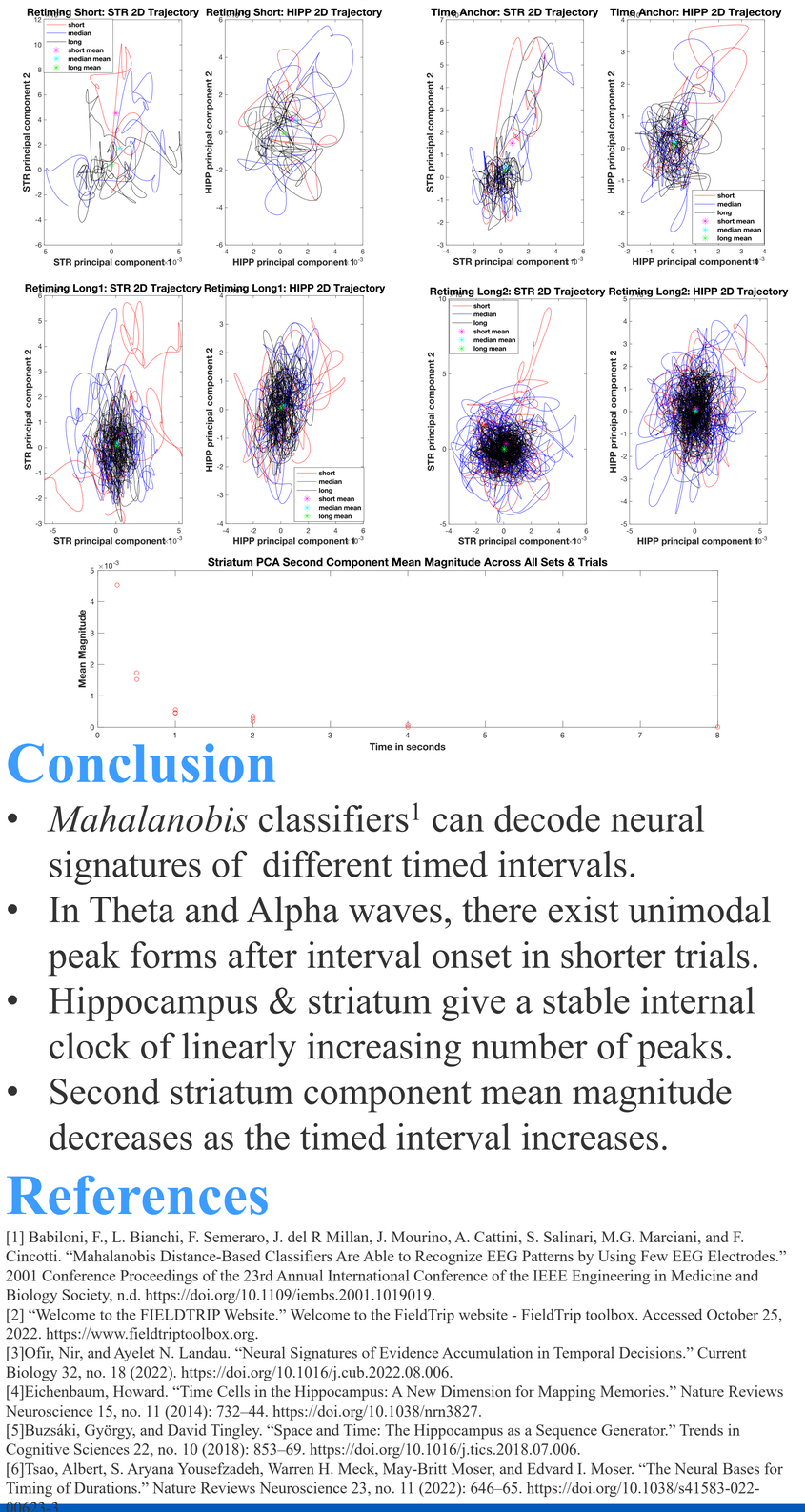


These results below demonstrate a stable linear total peak number increase as the timed interval length doubles, suggesting both hippocampus and striatum as the sites where neural sequential activity take place.



4. *PCA and Neural Trajectories*

Since our recordings consist of 16 channels in both hippocampus and striatum, principal component analysis is applied to reduce dimension. First two components of recorded signals at both sites as well as second striatum component are plotted below:



Conclusion

- *Mahalanobis* classifiers[1] can decode neural signatures of different timed intervals.
- In Theta and Alpha waves, there exist unimodal peak forms after interval onset in shorter trials.
- Hippocampus & striatum give a stable internal clock of linearly increasing number of peaks.
- Second striatum component mean magnitude decreases as the timed interval increases.

References

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