CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S1309

Project Title

Hippocampal Theta Phase Precession Adapts to Changing Place Fields: Implications for Episodic Memory

Abstract

Objectives/Goals

The Hippocampus is critical for the formation of new episodic memories in rats and humans. O Keefe's Nobel Prize winning work demonstrated that "place cells" in the CA1 region of the Hippocampus exhibit a theta rhythm with a frequency range of 4-12 Hz. As an animal traverses a cell's firing field, action potentials shift to earlier phases of the theta oscillation, exhibiting phase precession. This study is the first of its kind to assess whether the spiking activity of Hippocampal neurons is consistent with the irregularities in time that exist in human episodic memory. Using a data-set with single neurons with multiple fields and fields of different lengths, I used the phase precession phenomenon to test this hypothesis.

Methods/Materials

I obtained files of data set of animal firing pattern recordings which included the position, and LFP's (local field potential). I filtered the LFP file using MATLAB to isolate the frequency range of 5-10 Hz and wrote a script to calculate the theta phase. I assigned "phases" to each LFP data point, using the fraction of the wavelength at that point. I then created spiral maze with a sample rat's repeated firing fields from a single recorded neuron. Then, I created a script in MATLAB to define each loop and provide an image of the rat's neuronal firing. Subsequently, I calculated the Pearson correlation between theta phase in polar coordinates and the fraction of the field length in linear coordinates. Finally, I ran Kruskal-Wallis statistical test on loop length versus loop number and phase precession versus loop number.

Results

There is strong correlation between loop length and loop number across all the neurons. The Phase precession versus fraction of field length (Loop 4, Loop 3, Loop 2, Loop 1) shows significant correlation between phase precession and loop length and similar correlation across loops.

Conclusions/Discussion

The strength of phase precession is the same despite the field length which leads to the conclusion that the rate of phase precession adapts to the field lengths. This means that the Hippocampus is capable of compressing memories as they are being laid down. This is a novel finding that sheds light on the fundamental process of memory formation. This work has significant clinical implications, as this form of memory is most susceptible to injury and is the first symptom of dementia such as in Alzheimer's disease.

Summary Statement

Similar experiences of different durations are laid down in memory as if they were the same.

Help Received

I received the data set of the recordings of firing neurons from Douglas Nitz, PhD,Professor ,Cognitive Neuroscience at University of California at San Diego. He also provided guidance on implications and reviewed my work which was done at home and my school.