

Background

Neuroscience tools help answer the fundamental question of how neurological behavior in the brain is related to actions initiated by the mind. One aspect of this question is how changes in context impact behavior, and the hippocampus has been shown to be crucial in switching between these contexts. Place cells in the hippocampus fire when a rat is in a specific location in the room, and these place cells change firing location in different physical environments. Place cells also change firing locations, called remapping, when rats change cognitive contexts: remapping occurs when a rat must deal with different frames of reference despite being in the same physical space. How remapping occurs with respect to specific behaviors, as well as what activity occurs in the hippocampus during a context switch, are poorly understood. This project seeks to provide answers to these questions using data that are already collected. Recordings from the CA1 region of rats using a virtual reality apparatus (Aronov & Tank, unpublished data) were taken after experimenters trained rats to perform two distinct behaviors (different trajectories) in a single virtual environment. First, I will build on previous work to develop a classifier that will take CA1 spiking data from a rat to predict which task the rat is performing (Aim 1). Next, I will extend the previous classifier and build on existing work to implement a new classifier that predicts rat activity in real time, taking electrode recordings as they are generated (Aim 2). Lastly, I will use the two classifiers to investigate the periods of time during which remapping is actually occurring, and correlate the classifier's results with rat behavior (Aim 3).

Data

Data collected from eight CA1 tetrodes will be recorded from a rat performing two distinct behaviors in virtual reality. Electrodes from a single tetrode are spaced far enough apart so that typical electric waves register different amplitudes, but close enough together so that all electrodes measure a wave if one does. This assumption allows spike data to be sorted according to which neuron generated the spike. Training data for supervised learning can be obtained from neural recordings taken when a rat is unambiguously attending to one task or the other.

Aim 1. Develop a Spike Data Classifier

This step will extend previous work (Jezek, 2011) by processing waveform into spike rate data and sort the results according to which neuron cause the spike. The waveform will be segmented into bins, and waveforms that rise above a threshold will be considered a spike. Data suggests that context switches occur during the troughs of the theta rhythm, so bin sizes will be a simple fraction of theta period. A baseline algorithm will be provided by a dot product metric: the physical space will be chunked into regions, and population averages will be calculated. By segmenting space into regions and calculating population averages for each region and each task, computing the dot product of a feature vector with a population average can provide a simple method for classification. The baseline classifier will be extended to include a confidence rating for the classification, as well as a greater robustness to poorly formed spike data. All classification done in this step will assume that instantaneous feature vectors are sampled independently (the classifier will ignore previous data and only look at the current vector).

Aim 2. Develop a Real-time Classifier

This step will extend previous work by Kloosterman (2013) and extend the classifier from Aim 1 to take electrode data as it is recorded from a rat. The temporal structure of the data will be investigated, along with the snapshot of the current state. Bayesian statistics and a feature space extended to include time-based features will allow for a classification to occur as data is generated.

Aim 3. Investigate Remapping

Finally, the classifiers constructed in Aims 1 and 2 will be used to investigate periods when neural data becomes more ambiguous, as well as periods when rats are performing the wrong task. Unlike previous studies, virtual reality allows me to compare my classifiers' predictions with the actual behavior of the rat. By sharpening the classifier's temporal accuracy, I will be able to predict the exact moment when contextual switching occurs in the rat's hippocampus.