An Introduction to Cognitive Computational Neuroscience

I will present an introductory lesson on several iterations of cognitive computational neuroscience - namely, neuronal ensemble modeling, functional brain connectivity, graph theoretical network analysis, and neural decoding. This beginner-friendly seminar will delve into the theory behind said techniques and the types of scientific questions which are appropriate for each technique. Furthermore, I will provide examples on how I have used the methods in my own research. To begin, I will introduce the Neural Resource Model developed by Bays Lab (2014; https://www.paulbays.com/toolbox/index.php), which is designed to estimate population encoding parameters. As an example, I will demonstrate how the model can be used to study spatial working memory. Next, we will move into phase-based measures of functional connectivity, which models the exchange of information between brain regions. Using classic graph theory techniques, I will describe how to quantify various parameters of the resulting neural network (e.g. information integration versus segregation). Finally, we will explore the basics of neural decoding via multivariate pattern analysis. This technique can be used to estimate the perception of a stimulus given neural data (e.g. EEG) from a participant, and I will demonstrate how I have applied this to a working memory paradigm. The primary objectives of this seminar are threefold: (1) to spark further interest in cognitive computational neuroscience at UVic, (2) to make these techniques accessible, especially for those who feel like computational neuroscience is beyond their comfort zone, and (3) to clearly outline the strengths and limitations of a given technique.