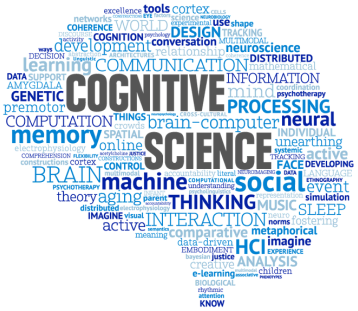

UC San Diego
Cognitive Science

Quirine van Engen's dissertation defense

The Significance of Aperiodic Activity in Relation to Brain States and Working Memory

Thursday November 13th, 2025
9:30 - 11:30 am (PDT), PEB 721
or
https://ucsd.zoom.us/j/92396206163

Abstract:
Electroencephalography (EEG) has been a fruitful tool to investigate brain mechanisms involved in cognition and disease. EEG analysis is dominated by the event-related potential (ERP) technique and the study of rhythmic oscillations. However, novel analysis techniques made it possible to also investigate aperiodic activity, characterized by its seemingly unstructured fluctuations in time. However, in the frequency domain it manifests as a clear, inverse relationship between frequency and power, measured from its spectral decay. Physiologically, aperiodic activity is hypothesized to reflect the aggregate excitatory and inhibitory drive in local brain regions. Historically, aperiodic activity was considered noise, masking its potential as a signal of interest. The aim of this thesis is to examine the functional relevance of aperiodic activity in relation to cognition, using causal neurostimulation methods. To do this, I first investigated how seizure-based treatments for patients with Major Depressive Disorder (MDD), electroconvulsive therapy (ECT), alter aperiodic activity. Here, I showed that ECT for MDD steepens aperiodic activity in relation to treatment efficacy. Next, I sought to examine the causal role for aperiodic activity in the context of visual working memory. First, I used traditional, non-causal approaches, and found that aperiodic activity systematically flattens during working memory maintenance, with greater flattening with increasing working memory load. To causally assess the nature of this relationship, I developed a novel non-invasive electrical stimulation protocol that I call transcranial random aperiodic stimulation (tRAS). Designed to causally manipulate aperiodic activity, I show that tRAS toward steeper aperiodic activity increases working memory performance across individuals compared to sham protocols. Taken together, I show that aperiodic activity should be considered a signal of interest, rather than noise. Aperiodic activity is not only reshaped due to seizure-based treatments when measured at rest, but also dynamically changes due to cognitive demands, as shown in the case of visual working memory, in a manner that causally influences working memory precision.

Committee members:

Dr. Bradley Voytek (Chair) - Cognitive Science
Dr. Greg Appelbaum - Psychiatry
Dr. Anastasia Kiyonaga - Cognitive Science
Dr. John Serences - Psychology