CNeuro2024 Lecture Abstracts

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Abstract 1 – Basic Lecture (Educational Talk):

Linking Human EEG and MEG Data to Deep Neural Networks

In recent years, there has been a growing interest in using multivariate approaches to analyze human EEG and MEG data. These approaches help in identifying the representational specific brain activity patterns related to human perception in various tasks. In parallel, convolutional neural networks (CNNs) have shown great potential in categorizing natural images in the field of machine learning. It has been suggested that the representations learned by these deep neural networks correspond to the hierarchical representations of visual stimuli in the human brain.
This session will focus on how representational similarity analysis (RSA) can be used to establish links between human brain activity and representations in CNNs. Specifically, we will explore how CNNs can be designed to incorporate temporal aspects of human vision, with a focus on repetition priming. In human vision, repeated exposure to a visual stimulus leads to the accumulation of evidence, resulting in a more reliable representation that is coded by fewer neurons (known as 'sharpening'). We will discuss this phenomenon based on a human MEG study investigating repetition priming and suppression and its relevance to CNNs.
The study found that repetition suppression is reflected in the early layers of the CNN, while sharpening is related to the deeper layers. However, the CNNs cannot fully explain the accumulation of evidence observed in the human brain, indicating the need for future research to incorporate temporal dynamics with memory properties into CNNs.

Abstract 2 – Advanced Lecture (Research Talk):

Pipelining in the Brain by Coupled Oscillations

Deep neural networks (DNNs) resemble the hierarchically organised neural representations in the primate visual ventral stream. However, these models often overlook the temporal dynamics observed in the visual system of the brain. For example, alpha oscillations are dominant in the human visual cortex, but their

computational relevance is rarely taken into account in artificial neural networks (ANNs). We propose an ANN that incorporates oscillatory dynamics to convert simultaneous inputs from two different locations into a temporal code. The network was trained to classify three individually presented letters. After training, we introduced semi-realistic temporal dynamics to the hidden layers, including relaxation dynamics in the hidden units and pulsed inhibition resembling neuronal alpha oscillations. Without these dynamics, the trained network correctly classified visual stimuli individually, but produced mixed outputs when presented with two stimuli simultaneously, revealing a bottleneck problem. When we introduced refraction and oscillatory inhibition, the output nodes corresponding to the two stimuli activated sequentially, ordered along the phase of the inhibitory oscillations. Our model offers a new approach for implementing multiplexing in ANNs and generates experimentally testable predictions about how the primate visual system handles competing stimuli.