

Note: Guidelines were changed from 5000 characters to 2-pages

Introduction: Neuroscience, psychology and biophysics have a converging problem: the mystery of the underlying mechanisms surrounding the brain's ability to rapidly recall information about faces and objects. Humans excel at effortlessly recognizing objects and faces, surpassing the capabilities of artificial intelligence. This ability helps with recognizing familiar faces amidst a crowded environment at rapid speeds.

Processing of object quality and identity¹ occurs via the ventral stream pathway², allowing the top-down signal to connect with the bottom-up signal for a match to be made with both signals to aid in recognizing visual information. It is unclear how this match or exchange of information is made. Researchers at UCLA's Arisaka Lab have proposed the MePMoS (Memory-Prediction-Motion-Sensing) Model³ to decode mechanisms underlying this process. This model proposes that the brain employs timing delays to synchronously match incoming visual information with pre-existing memory. This process is twofold: (1) sensory neurons first receive stimuli, initiating a bottom-up signal that undergoes coordinate transformation; (2) top-down information is initiated to facilitate the matching process. Timing delays are theorized to align incoming visual stimuli with stored memory, facilitating perception and recognition through scaling and rotation. Timing delay have previously been correlated⁴ with brain oscillations, with event-related synchronizations potentially suppressing irrelevant information and event-related desynchronization aiding in the retrieval of semantic information.

Collaborative efforts with the Arisaka Lab have yielded consistent results with the collection of Behavior and Reaction Time data related to facial recognition: increases and decreases in angle from the initial position of 0° correlates with increases in participant reaction time after initial stimulus onset for each trial. We will finalize our analysis of our Behavior and Reaction Time data for a joint publication with the Arisaka Lab. We will advance our research by incorporating novel EEG recordings with Behavior-Reaction Time experiments. Insights gained from studying brain processing delays may shed light on neurological disorders such as Alzheimer's Disease or

¹DiCarlo, J, et al. "How does the Brain Solve Visual Object Recognition?" *Neuron*, 73(3), 415-434, 2012. Accessed 8 February 2024.

² Kravitz, D, et al. "The ventral visual pathway: an expanded neural framework for the processing of object quality." *Trends in Cognitive Sciences*, 17(1), 26-35. Accessed 8 February 2024.

³ Le, Caominh, et al. "Visual Perception of 3D Space and Shape in Time: 3D Recognition by Rotation." *BioRxiv*, 2022. Accessed 8 February 2024. Preprint.

⁴ Klimesh, W., Fellinger, R., and Freunberger, R. "Alpha Oscillations and Early Stages of Visual Encoding." *Frontiers in Psychology*, 2, 2011. Accessed 8 February 2023.

Traumatic Brain Injuries⁵, presenting avenues for early screening and intervention. By deciphering the intricacies of how the brain encodes and retrieves spatial information, this research paves the way for advancements in both neuroscience and artificial intelligence.

Aims

1. Completing Final Analysis of Behavior and Reaction Time Participant Data
2. Integrating EEG into Pre-Existing Behavioral and Reaction Time Experimental Set-Up
3. Conducting a Pilot Study for Behavior and Reaction Time + EEG Experiment

Approach:

Behavior-Reaction Time experiments, approved by the IRB, involved participants trained on three faces matched to keyboard keys. A chinrest/headrest maintained a gaze at the center of the monitor. Participants pressed keys matching displayed stimuli. Faces were shown at Roll, Pitch, and Yaw angles ($0^\circ, \pm 30^\circ \pm 90^\circ$). We will be compiling our data and finalizing our analysis, comparing the IRB approved experimental data to pre-existing data from our collaborations for publication. Upon completing our analysis, we will integrate our newly acquired EEG into our Behavior-Reaction Time set-up to eliminate timing, electronic and environmental interferences. This integration facilitates data collection on changes in brain signal processing correlated with stimuli onset, benefiting from faster acquisition provided by the new EEG. Ensuring synchronized electronics for millisecond precision in real-time neural activity, we'll adjust timing parameters to avoid overlap with EEG data processing. Following the integration of the experimental set-up with EEG, we will conduct a pilot study to establish a reliable protocol for participant trials. This study will help outline our experimental procedure, refine methodologies, ensure equipment compatibility with human participants, and minimize data interference, resolving logistical and technical issues before testing our Brain and Behavior experiments on external participants.

⁵ Morris, N, et al. "Visual Dysfunction after Repetitive Mild Traumatic Brain Injury in a Mouse Model and Ramifications on Behavioral Metrics." *Journal of Neurotrauma*, 38:20, 2881-2895, 2021. Accessed 20 February 2024.