MSc in Computational Cognitive Neuroscience

Goldsmiths
UNIVERSITY OF LONDON

Decoding the Neural Bases of Sequential Action Planning With a Classifier

Author: Rooyum Ibrar
Supervisor: Dr. Peter Holland

Introduction

- Certain motor tasks require multiple movements to be executed sequentially with specific temporal and/or spatial configurations. Performance in such tasks is reliant on the effectiveness of goal selection, action selection, and action execution (Krakauer et al., 2019).
- Competitive queuing (CQ) is a theory that assumes multiple plan representations can be simultaneously active in a parallel planning layer, and through competition the most active representation is selected in a competitive choice layer (Bullock & Rhodes, 2002).
- Patterns of activity in the pre-frontal cortex have been found to be simultaneously active in non-human primates during planning of action execution, whereby the strength of activity corresponded to the ordinal structure of a sequential task (Averbeck et al., 2002). In humans, MEG has revealed patterns of activity in parahippocampal and cerebellar regions to be associated with CQ (Kornysheva et al., 2019).
- Explicit reward and performance feedback have been found to lead to the emergence of behaviors that increase the efficiency of action execution in sequential motor tasks (Sporn et al., 2022).
- Not many studies have looked at decoding EEG data with a classifier to obtain evidence of CQ as well as its neural bases during a continuous sequential motor task. If evidence for CQ is found, the neural bases of emerging sequential motor behaviors can also be investigated.

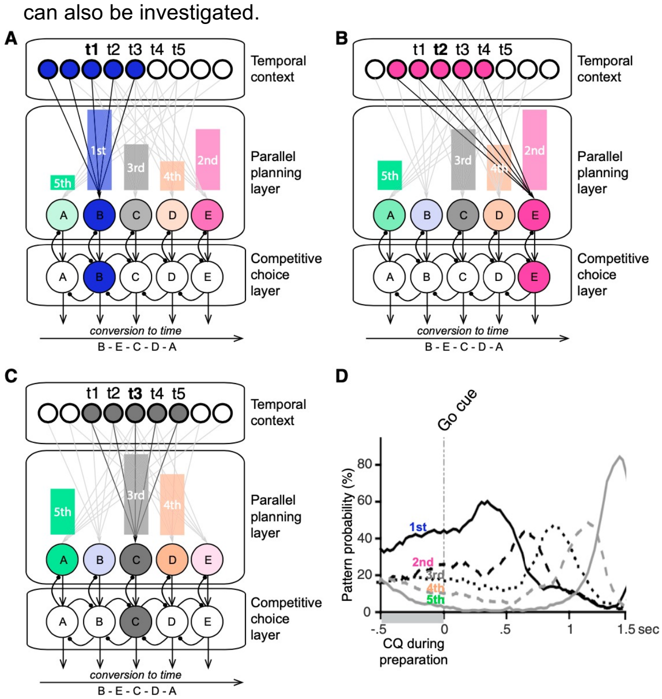

Fig. 1: CQ model taken from Kornysheva et al. (2019)

Hypotheses

- An existing EEG dataset of recordings from a sequential reaching task adapted from Sporn et al. (2022) can be decoded for neural representations of CQ.
- Frequency content of the EEG dataset can be decoded to improve classification of neural representations of CQ.
- Amplitudes of neural representations during planning of action execution in CQ correspond to the ordinal structure of movements to be executed in the sequential reaching task.
- The emergence of sequential motor behaviors can be identified through changes in amplitudes of neural representations for movements that increase efficiency of action execution.

Method

- EEG was recorded from 12 participants who completed 200 trials of a sequential reaching task adapted from Sporn et al. (2022).
- Participants were randomly allocated equally to two conditions in this between-groups design. One condition drew a “k” letter like shape starting from the top point, whilst the other drew it starting from the bottom point. Six movements were to be done in correct order for a trial to be successfully complete, failure meant redoing the trial.
- The independent variable is the starting position of the sequential reaching task, and the dependent variable is the amplitude of neural representations for CQ decoded from the EEG dataset.

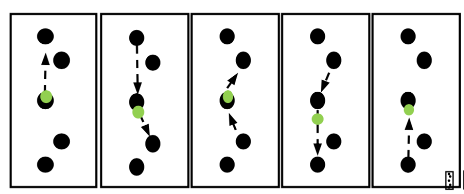

Fig. 2: Sequential reaching task taken from Sporn et al. (2022)

Timeline/Expected Results

- The EEG dataset will be cleaned through coding in MATLAB to remove any artifacts and hinderances – June 2024.
- Different classifiers, starting with linear discriminant analysis, will be tested to see if neural representations for CQ can be decoded from the EEG dataset – July 2024.
- Final write up – August 2024.
- Considering the findings of Kornysheva et al. (2019), activity in parahippocampal and cerebellar regions can be expected prior to action execution.
- Cortical and subcortical structures such as motor areas and basal ganglia have been found to be involved in sequential motor control by Tanji (2001), amplitudes of these regions can be expected to change as sequential motor behaviors emerge.

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