DISTRACTOR-SPECIFIC SINGLE NEURON ACTIVITY PREDICTS VISUAL WORKING MEMORY TASK OUTCOMES

INTRODUCTION

- **Visual working memory (VWM)**: allows us to process and temporarily maintain visual information in our working memory in order to focus on and complete tasks (Olivers et al., 2020)
- Prefrontal cortex (PFC) has been identified as the primary site of neural processing and filtering of VWM information (Lara et al., 2015)
- VWM system selects relevant visual information and suppresses distractors based on goal-oriented attentional controls dictated by the PFC
- **Distractor Suppression**: filtering out the task-irrelevant information that is obtained from visual stimuli
- Analyzing the subprocesses of WM is critical to the development of more effective treatments for neurological disorders that inhibit efficiency of VWM, such as **attention deficit hyperactivity disorder (ADHD)** (Kofler et al., 2008)
- Children with ADHD have been shown to score lower on working memory (WM) tests, aligning with lower WM capacity overall (Kofler et al., 2008)
- Seminal Paper: Pessoa et al., 2002
  - fMRI activity during a **VWM task** can **predict successful performance on a trial-by-trial basis** at various stages during the task

RESEARCH QUESTION

Are there any significant differences in the firing rates of individual LPFC neurons during the distractor presentation period of a VWM task between success and error trials that can predict the outcome of a trial?

METHODOLOGY

Statistical analysis of distractor specific neural activity from 202 cells from the LPFC of a rhesus macaque monkey during an oculomotor delayed response VWM task

- Success: microsaccade to correct location of target
- Error: microsaccade to any other location (within bounds of the screen)
- Analysis: Logistic regression, Decision Tree, Ramdom Forest, Neural Network

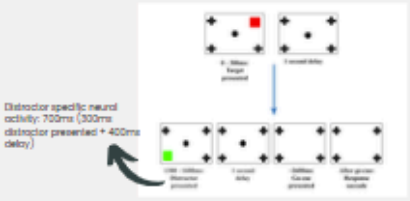

Fig 1. Diagram of VWM Task

RESULTS

- 51 out of the 202 cells recorded had a statistically significant difference in firing rates between success and error trials (independent two sample t-tests, $p < 0.01$)
- Logistic Regression: produced accuracy score of 63.01% (trained with 75% of the total data and tested with the remaining 25%, portions selected at random)
  - Precision: 60.63%
  - Recall: 33.46%
  - F1 Score: 42.58%

Fig 2. Heatmap of Logistic Regression Confusion Matrix

- Decision Tree: produced accuracy score of 68.04%
  - 14 features (700ms of distractor specific firing rates split into 14 bins of 50ms each)

Fig 3. Diagram of Decision Tree Feature Analysis

- Random Forest: produced accuracy score of 69.45% (100 decision trees)
- Neural Network: produced accuracy (training) score of 70.26%
  - 14 input nodes with 9 hidden layers arriving at a single output node
  - Rectified linear activation function (ReLU) was used for all hidden layers, "Swish" activation function was used for the input layer and standard sigmoid function was used for the output layer
  - Decay rate of 0.001 and three dropout layers to prevent overtraining

DISCUSSION/CONCLUSION

- Accuracy scores of all models indicate that the response of single neurons in the LPFC to the distractor does predict the behavioral outcome of the VWM task
- Efficiency of distractor suppression is based on the degree of neural response to a distractor
- Higher neural response (firing rate) associated with inefficient distractor suppression (error trials)
- Possible those with WM deficits, as seen in ADHD, and less efficient distractor suppression, have a greater single neuron response to task-specific distractors as well
- Klingberg et al., 2002: WM training may increase distractor suppression efficiency (for required tasks)

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