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Neural Dynamics of Cognitive Tasks in Human Prefrontal and Parietal Cortex

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Introduction: Many neurological conditions are associated with deficits in cognitive or executive function, including existing populations for implanted brain-computer interfaces (iBCIs) e.g. spinal cord injury, motor neurone disease, and beyond e.g. dementia, mood disorders. Human iBCIs with electrodes in higher order cortical areas offer the potential to further elucidate the neural mechanisms of cognitive function, with the potential of restoring cognitive deficit similarly to the restoration of sensorimotor deficit to date. Here we focus on intracortical electrode arrays implanted in dorsolateral prefrontal cortex (dlPFC) and supramarginal gyrus of parietal cortex (SMG) in one human participant. We use the Stroop task to identify and decode the neural dynamics of an aspect of cognitive control – response inhibition and interference control.

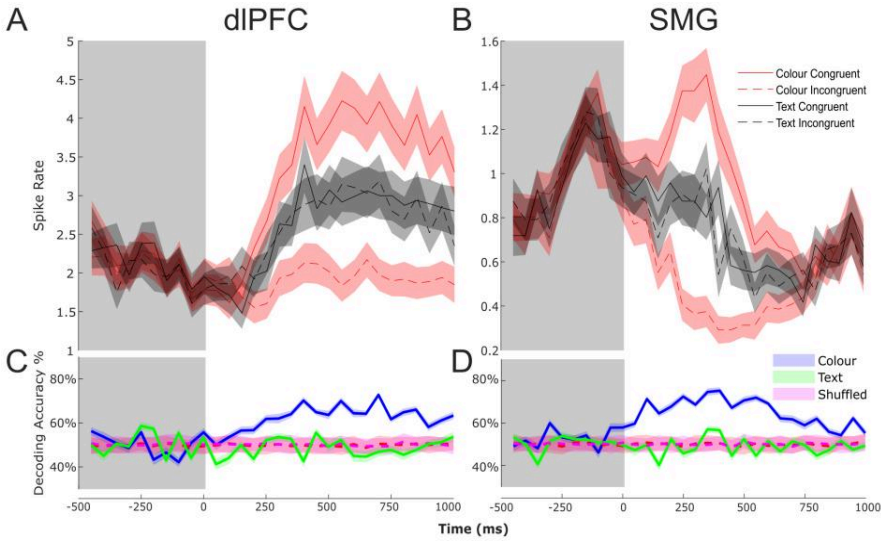

Figure 1: A-B Multi-unit activity of a single electrode in A) dlPFC and B) SMG to different confitions. C-D The LDA classification accuracy of congruent/incongruent from the population response in C) dlPFC and D) SMG.

Methods and Results: Neural recordings were made using Utah Arrays (Blackrock Neurotech, UT, USA) implanted in human prefrontal, parietal and sensorimotor cortices. The participant completed a Stroop task, in which presented text and text color differ, e.g. 'RED' shown in red or 'RED' shown in blue. Participants either reported the text (dominant response), or color (non-dominant) in congruent conditions, when the text and color match and incongruent, when they do not. We identified significant single-unit neurophysiological responses to the different color, text, congruent and incongruent conditions. In higher order cortical areas, the evoked neurophysiology for the dominant text response was indistinguishable between congruent and incongruent conditions. However, there were significant differences in the dynamics of the non-dominant color response, both compared to text response and within congruent and incongruent color response. Exemplary individual electrodes are shown in Figure 1A, B. To assess the whole neural population in each cortical area we used a linear discriminant analysis (LDA) to classify congruent and incongruent trials, for text and color responses, Figure 1C, D. There was no significant classification compared to a shuffle distribution during the dominant text response, but a significant classification for the non-dominant color response. No significant classification was found for any condition in primary sensorimotor areas.

Conclusion: These results demonstrate circuit level dynamics for response inhibition and interference control. Future work seeks to explore additional cognitive functions and assess the effects of closed-loop stimulation targeting these dynamics to alter performance in cognitive tasks.

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