Stroke training assessment using fNIRS-informed EEG source localization strategy

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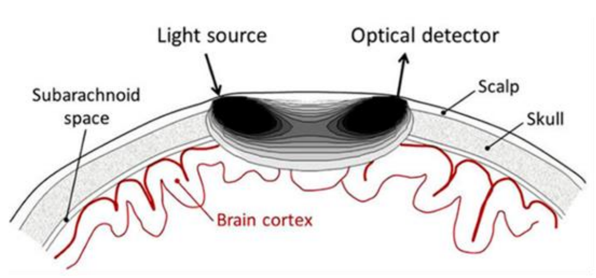
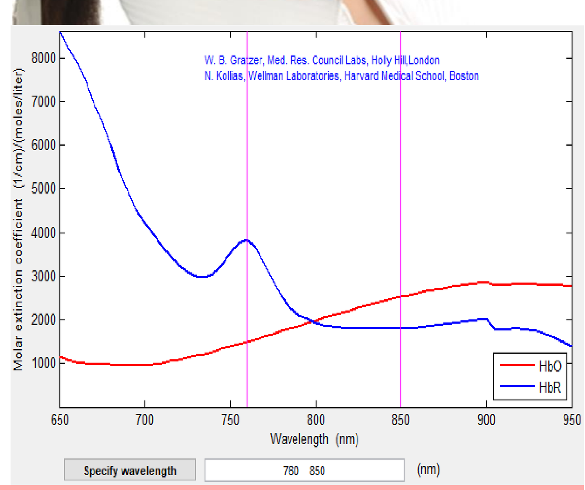
Background

Multimodal Neuroimaging



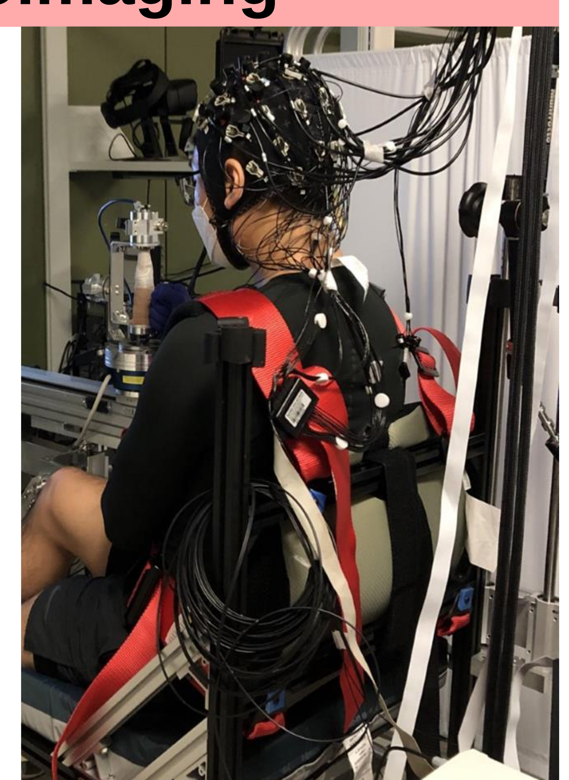
Multimodal neuroimaging systems such as the one featured in this study provide various advantages over single-modality methods by combining the strengths of each technique. In the case of EEG-fNIRS, the multimodal system integrates the high temporal resolution of EEG and the high spatial resolution of fNIRS to produce more robust and accurate imaging results.

The rationale behind the integration of these two imaging techniques relies on the physiological phenomenon known as neurovascular coupling. An increase in neural electrical activity increases the demand of glucose and oxygen in the brain, resulting in the fluctuation of oxygenated blood (HbO) and deoxygenated (HbR) blood concentrations in the area, which can be detected by indirect neuroimaging techniques such as fNIRS.



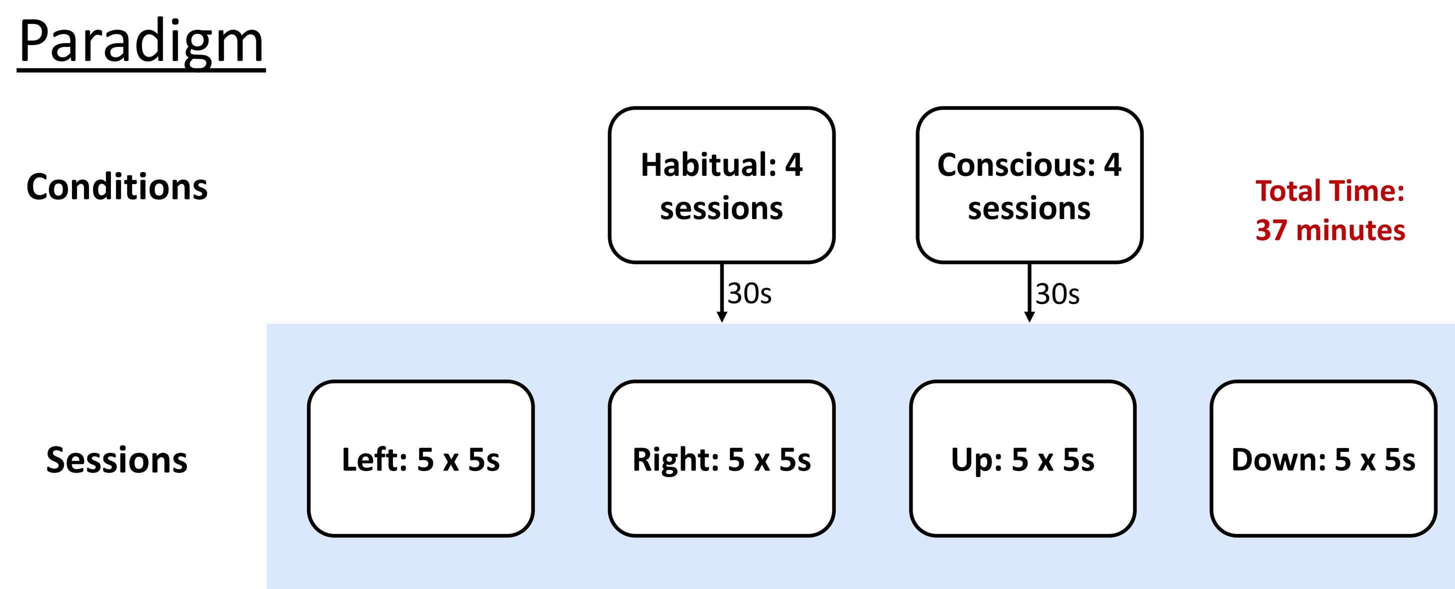
Stroke and Neuroimaging

A stroke occurs when the supply of blood and oxygen to the brain is completely interrupted or significantly reduced. This quickly leads to the death of brain cells and can result in neurological impairments and brain damage. Currently, approximately 50-60% of stroke patients report the persistence of motor impairment after conventional interventions[3]. This has led to an increased focus on the neural mechanisms of motor recovery following stroke and methods to enhance the effectiveness of rehabilitation therapy. Our goal is to use multimodal neuroimaging techniques to assess the efficacy of these rehabilitative techniques.

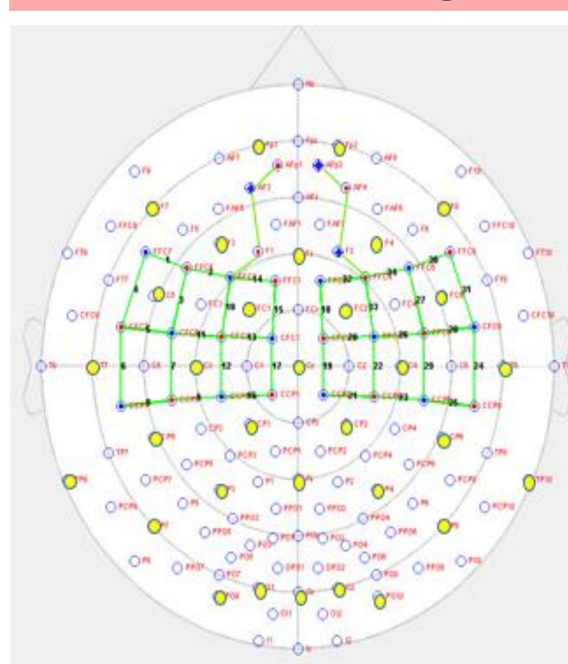


Experiment

Methodology

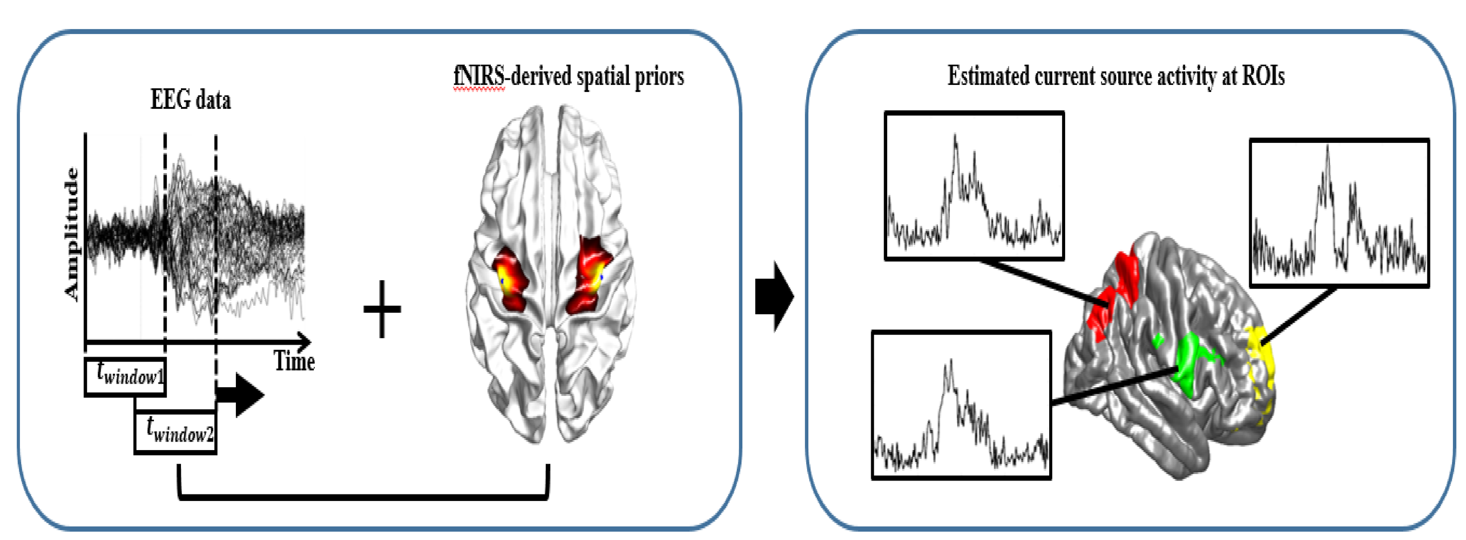


Montage and Imaging Modalities



Electroencephalography (EEG)	EEG is a non-invasive medical imaging technique used to read the electrical activity of the brain using metal electrodes placed on the scalp surface.
Functional Near-Infrared Spectroscopy (fNIRS)	fNIRS is a non-invasive neuroimaging technique used to measure the concentration changes of oxygenated and deoxygenated hemoglobin in the brain.

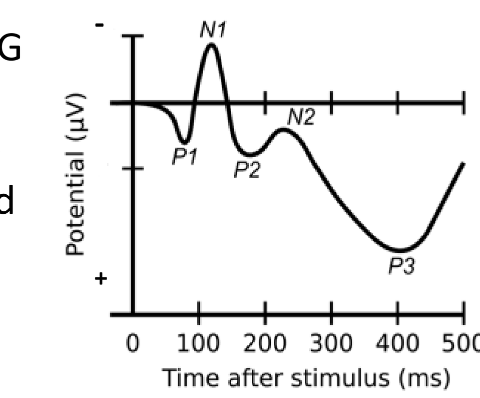
Analysis Pipeline



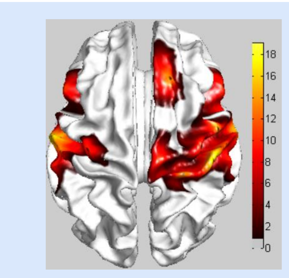
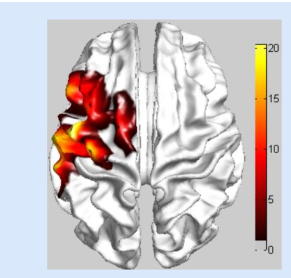
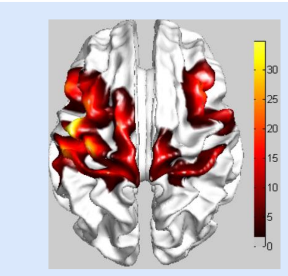
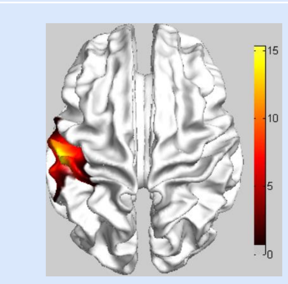
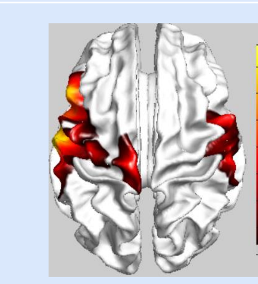
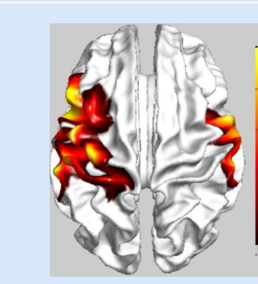
Results

Movement-Related Cortical Potential

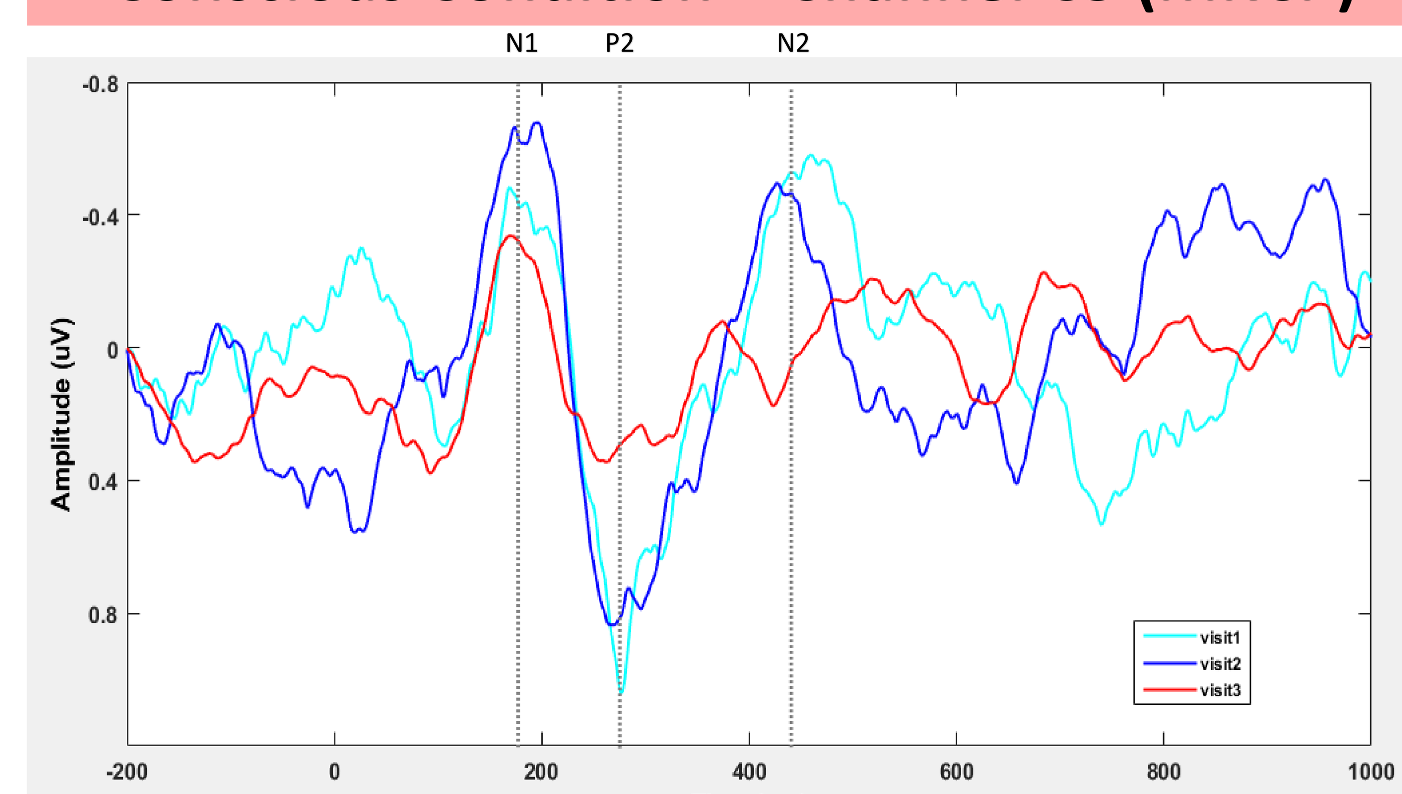
Movement-related cortical potential (MRCP) is an event-related potential that represents averaged EEG activity before and after the onset of a voluntary movement. In this experiment, we focused on three components: N1 (150-200 ms), P2 (150-275 ms), and N2 (200-400 ms). Following the patients' motor training, we anticipated decreased MRCP, reflecting decreased activity at the motor cortex. Results are averaged over all directions.



fNIRS Activation Map Results

Visit	1	2	3
Left			
Upward			

Conscious Condition – Channel C3 (MRCP)



Future Research and Applications

Limitations and Further Research

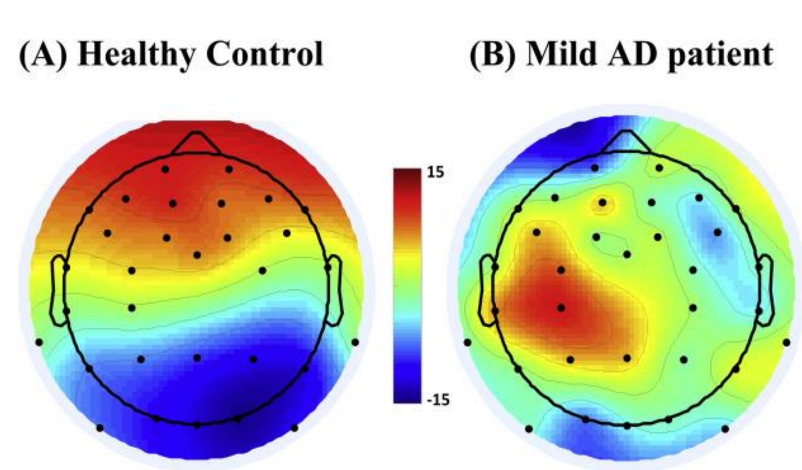
Limitations:

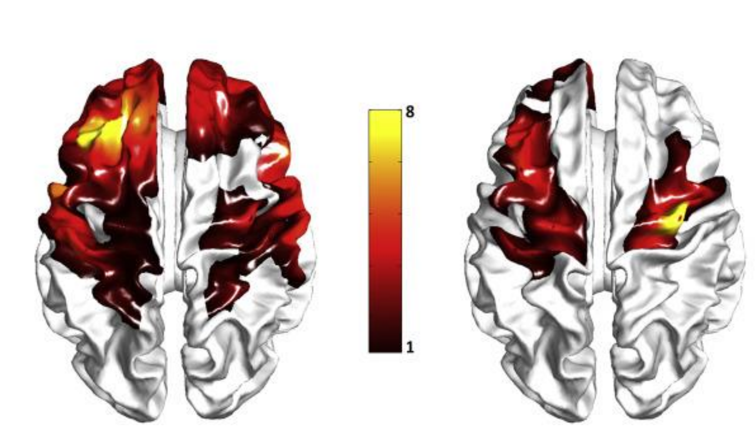
Due to COVID-19 and the current social distancing guidelines, our lab was only able to assess a small number of participants. Additionally, we were unable to recruit post-stroke patients to compare to our healthy controls and are thereby unable to make any observations or draw any conclusions regarding the cortical reorganization experienced by stroke patients.

Further Research:

Further research is needed to arrive at generalizable results. Once possible, the Zhang lab plans to recruit more control subjects and carry out more trials in order to increase the validity of the preliminary findings. In order to improve our understanding of the cortical reorganization suffered by stroke patients and gather post-stoke patient data, the lab plans to collaborate with physicians and compare the results to those of our healthy controls. The ultimate objective of this research is to facilitate the advancement and evaluation of modern stroke rehabilitative techniques. Once COVID-19 restrictions are lifted and it is safe to resume testing, the evaluation of post-stroke patients will be prioritized.

Additional Applications





Alzheimer's Detection, Assessment, and Monitoring

Evidence indicates that the cognitive decline experienced by those diagnosed with AD is linked with abnormal cortical activity and organization. The use of integrated EEG-fNIRS could aid in the assessment and treatment of these patients. The system's high spatial and temporal resolution could help physicians and researchers track the disruptions in the brain network and further the community's understanding of the advancement of AD[4].

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