Neural Correlates of Immersion in Virtual Reality: EEG Brain Source Analysis

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Introduction & Background

There is currently much interest in better understanding the neural basis of **Immersion,** the extent to which experiencing a virtual environment is enveloping and engaging (Nilsson et al., 2016). We manipulated 2 dimensions of immersion and recorded EEG while participants used a driving simulator with either VR or flat screen viewing.

Challenge Immersion
Increases with cognitive and motor demands

Physical Immersion
Increases with more realistic sensory input

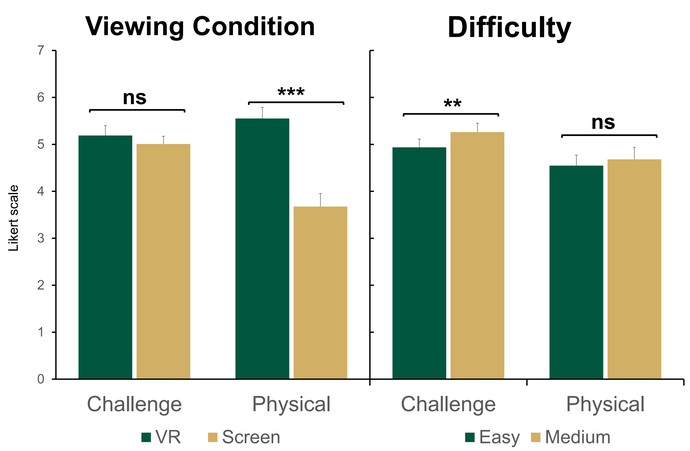
Objective

Pror work has focused on oscillatory neural signals over extended periods of time, comparing power in standard frequency bands,**Theta** (4-8 Hz), **Alpha** (8-12 Hz), **Beta** (12-30 Hz), and **Gamma** (30-100 Hz), across regional scalp electrode locations, e.g., frontal vs. parietal (e.g., Safikhani et al., 2024;Slobounov et al., 2015). Current study extends this approach to isolate independent neural signaling components and estimate their brain sources to better understand the neural regions involved in immersion processing

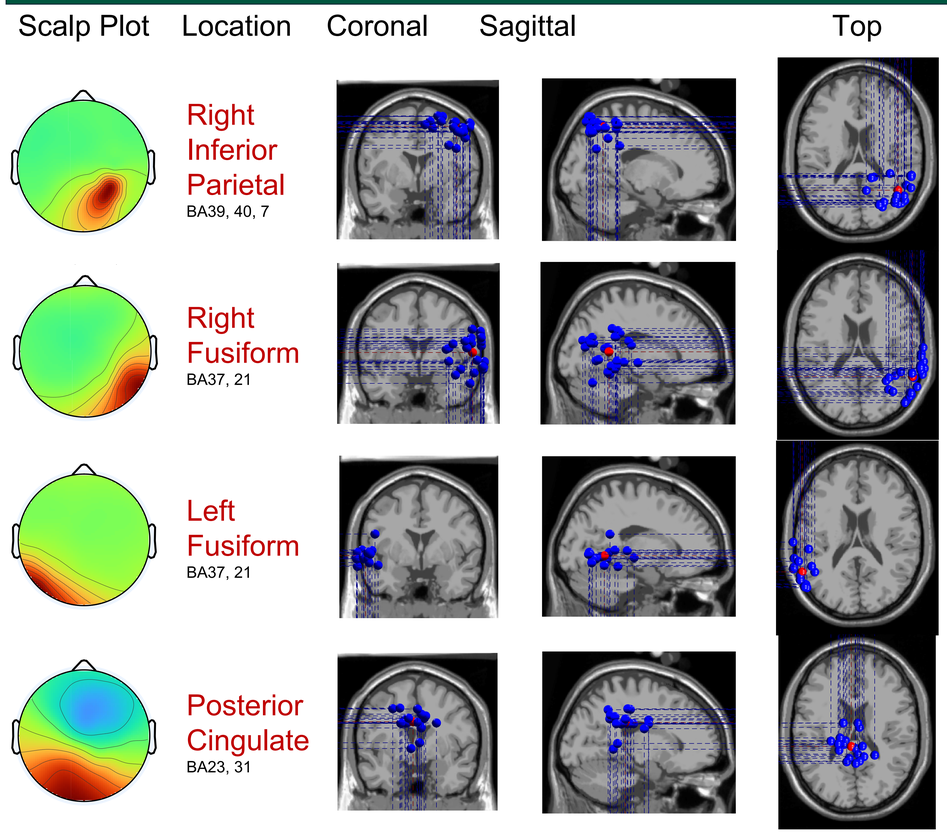
Hypotheses

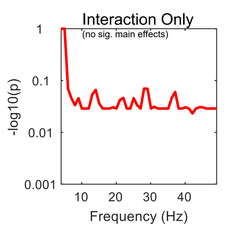
- Prefrontal regions will be modulated by difficulty
- Inferior parietal lobule will be modulated by viewing tech.
- Viewing x difficulty interactions will indicate core regions
- Viewing condition & difficulty will selectively modulate physical and challenge immersion subjective ratings, respectively

Immersion Subscale Analysis



Results: Immersion-related Dipole Clusters

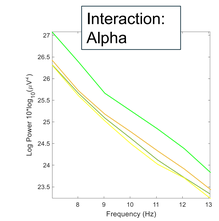


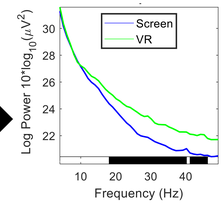


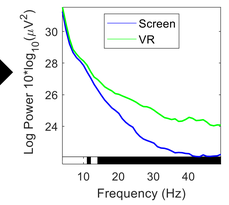
Main Effects *(only)* Viewing **Technology** *(left column)* **Difficulty** *(right column)*

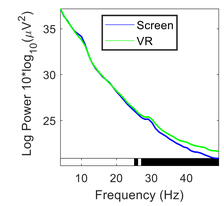
Note: Permutation p-values with FDR

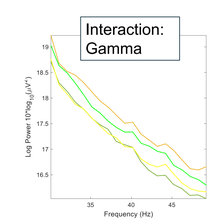
Supplement
References

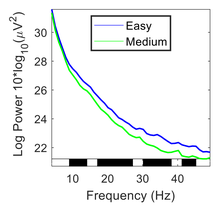


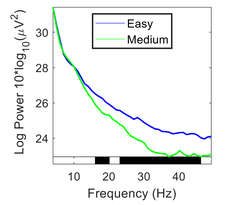


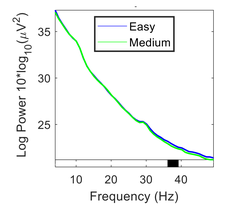




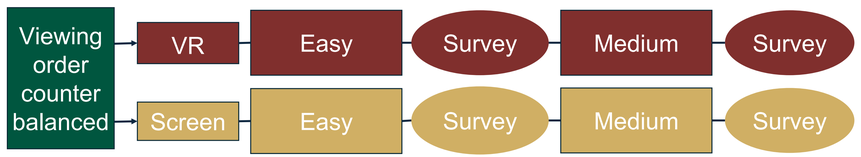




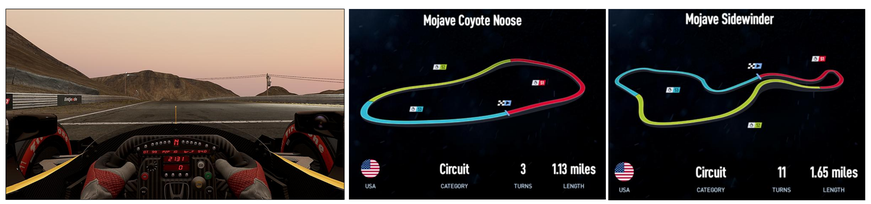




Experimental Design (N= 21)



Driving Simulator Conditions



Discussion & Future Directions

- Physical & challenge immersion ratings selectively modulated (by view and difficulty)
- Both the right and left lateral fusiform yielded broadband beta and gamma band increases with VR, and decreases with the easy track
- Though smaller, the posterior cingulate showed this same pattern
- Fusiform and PCC are directly connected and part of the DMN
- The right, but not left, inferior parietal lobule yielded a novel cross-over interaction pattern in alpha and gamma
- This region acts as a hub for external and internal attention, and may play an important role in immersion
- These results suggest that immersion may depend on regions that interface internal and external attention