



Reliability of EEG Phase Estimation in People Living With Dementia

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Background

- Electroencephalography (EEG) phase-dependent stimulation may improve aspects of cognition [1, 2]
- Timing transcranial magnetic stimulation (TMS) to specific prefrontal theta phase can enhance working memory in young adults [1]
- However, phase-dependent stimulation has not been applied in people living with dementia (PWD)
- Due to reductions in global power on EEG, PWD's EEG exhibits reduced signal-to-noise ratio [3]
- Target EEG bands for intervention are either in theta or alpha frequencies, with alpha power significantly reduced in PWD and theta being highly unstable [1, 2, 3]
- Documenting the reliability of phase estimation is necessary before applying phase-dependent stimulation in PWD
- Objective:** to measure the reliability of phase estimation in the EEG of PWD

Methods

- To measure reliability of phase estimation we measured accuracy in the theta and alpha bands
- We utilized the AHEPA EEG dataset, containing 88 individuals who were healthy, with Alzheimer's disease or frontotemporal dementia [4]
- EEG phase estimation and accuracy was computed using the open-source EEGPhasePy library [5]
- Two parameters are known to affect accuracy irrespective of signal-to-noise ratio: filter order and edge length
 - Higher orders result in cleaner signals but more edge effects
 - Larger edge lengths remove edge effect, but remove signal
- The AHEPA EEG was sampled at 500Hz, we upsampled to 1000Hz utilize higher order filters
- ETP accuracy was measured at various orders and edge lengths in theta and alpha
- We measured accuracy across mini-mental state examination (MMSE), age and clinical diagnosis

Results

Phase estimation is generally reliable in PWD

Band	N	Accuracy
Alpha (8Hz - 12 Hz)	88	0.711 ± 0.032
Theta (4Hz - 8 Hz)	88	0.628 ± 0.023

Table 1. Accuracy in alpha and theta is high in healthy and PWD. Accuracy across all participants averages to about 71% for alpha and 63% in theta. This is expected as theta is generally less stable than alpha, resulting in more phase slips and reduced predictor accuracy.

MMSE, age and clinical diagnosis don't affect accuracy

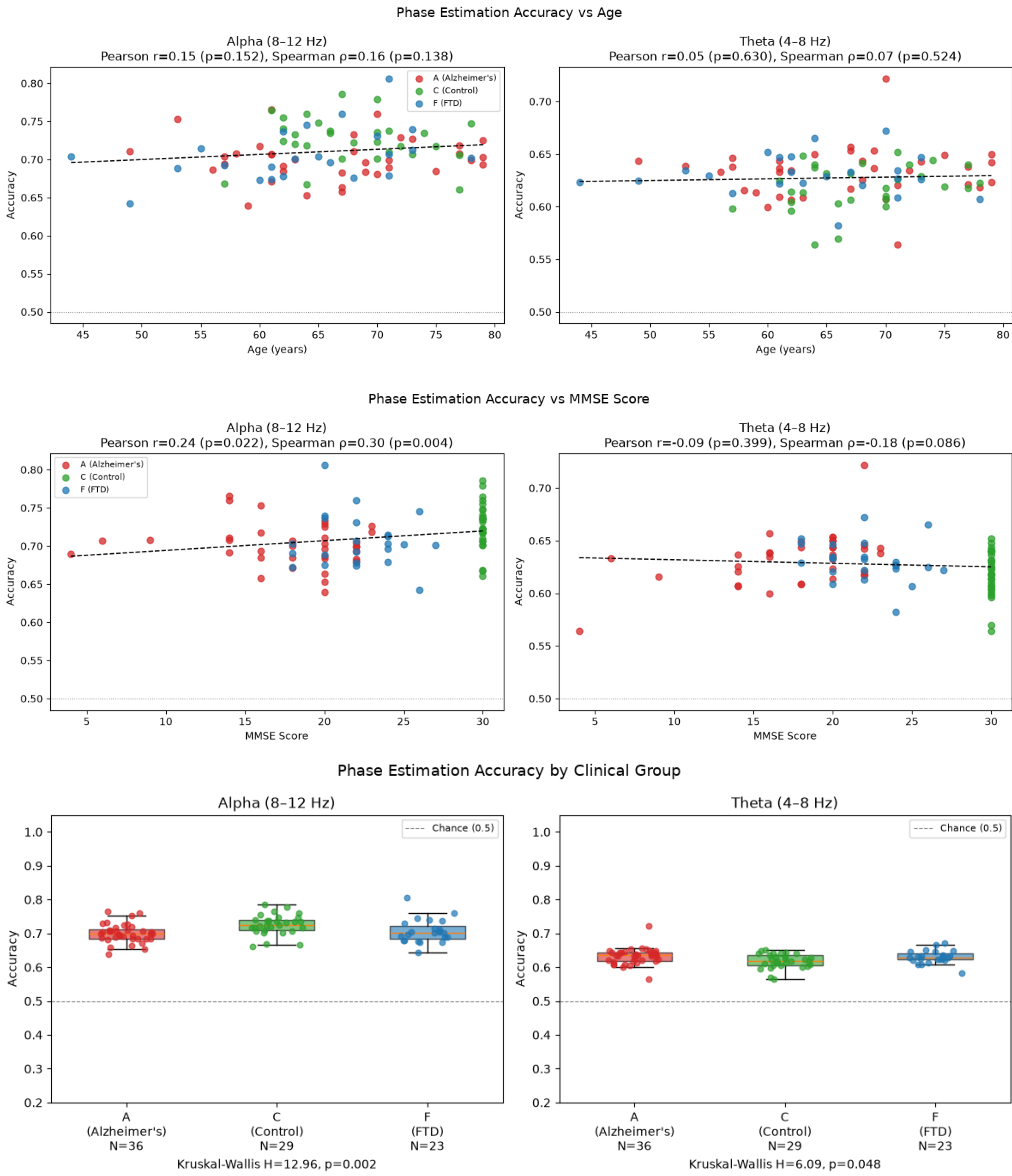


Figure 1. Accuracy in alpha and theta across age, MMSE, and clinical diagnosis. The top panel shows phase phase estimation accuracy in alpha (left) and theta (right) as a function of age. The middle shows the same thing but with MMSE and the bottom panel by clinical group.

Frontal alpha phase appears to be more anti-correlated to occipital alpha

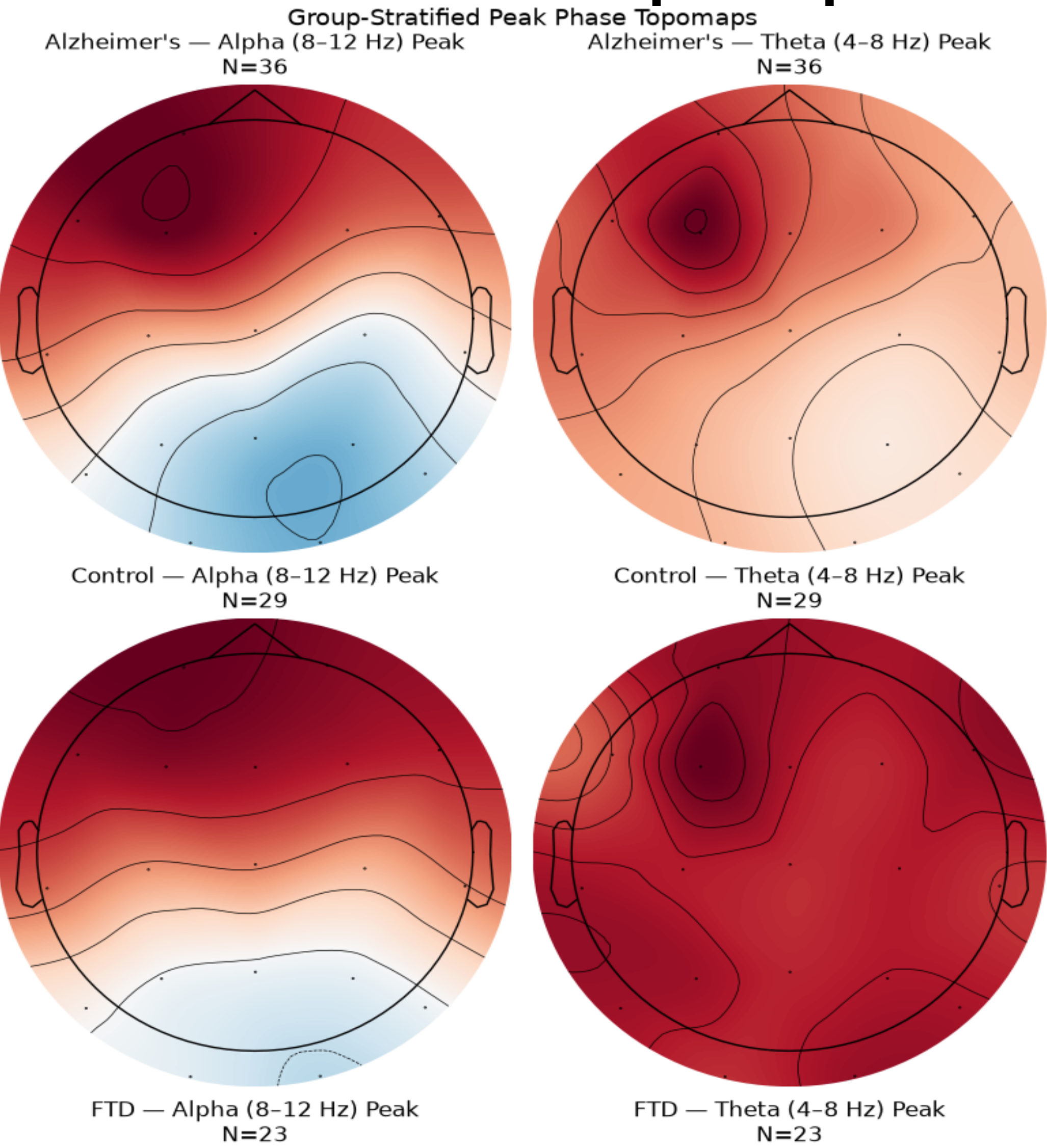


Figure 2. Topographical voltage maps of peak detections. Red indicates positive voltage and blue indicates negative. In Alzheimer's it appears that alpha peaks in the frontal typically coincide with alpha troughs in the occipital cortex. This may suggest an anticorrelation between activity in the two regions.

Minor variation in optimal ETP parameters across participants

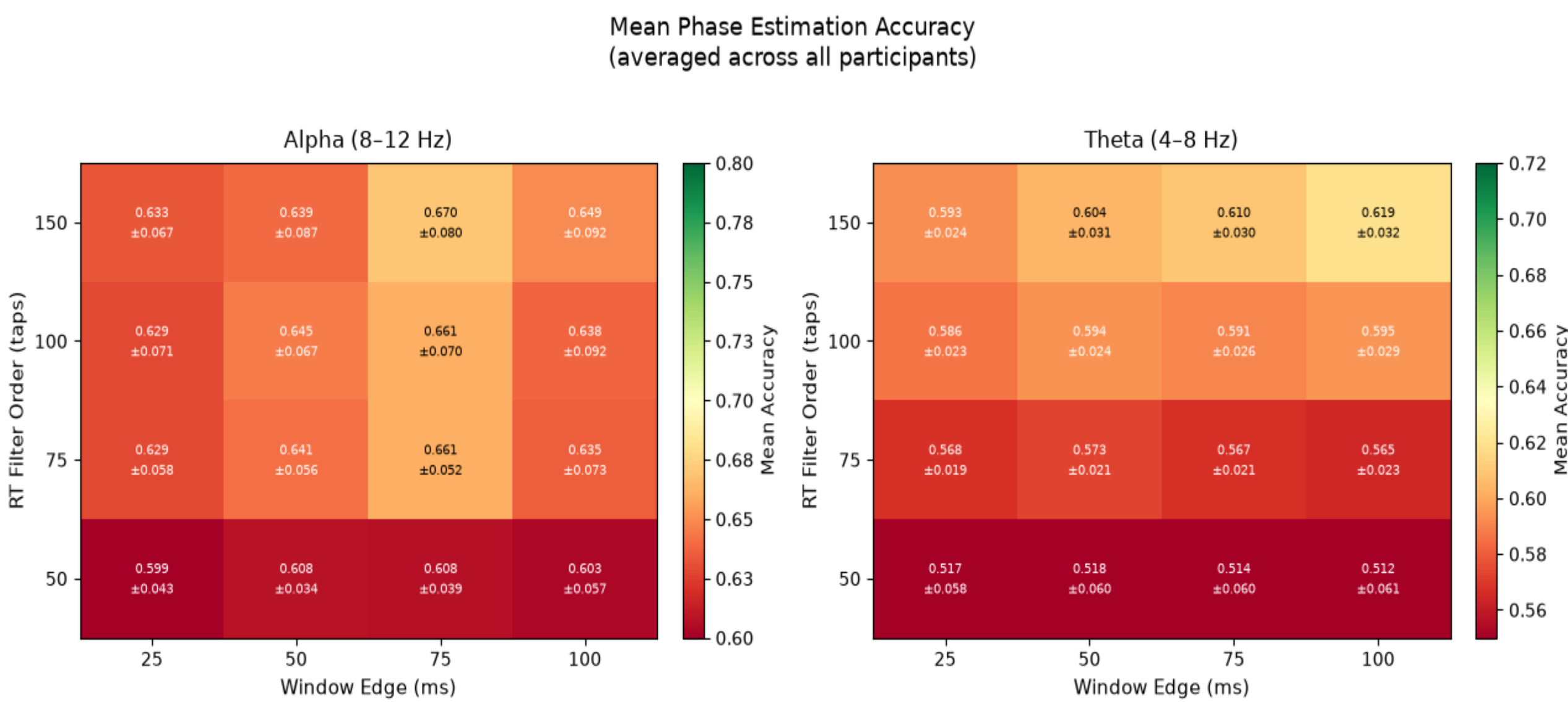


Figure 3. Mean accuracy across filter order and window edge. Accuracy of the model was averaged across all participants with the differences in filter order and window edge measured. Red indicates lower accuracy and yellow higher.

Discussion

- This work demonstrates that EEG phase estimation can be reliably done in PWD in both alpha and theta
- Further, we showed that ETP parameters do not require significant personalization to accurately estimate phase
- These findings demonstrate that phase-dependent stimulation, which has shown promise at improving cognition in healthy participants, can be applied in dementia
- By establishing reliability of phase estimation, new interventional clinical trials testing phase-dependent stimulation can be initiated
- Additionally, validation was done using an open-source EEG phase estimation library making future studies easier to complete [5]

References

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Acknowledgments



The Neurophysiology and Imaging Lab