

Is Temporal Order Essential For EEG-based Diagnosis Of Alzheimer’s And Frontotemporal Dementia?

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Alzheimer’s (AD) EEG biomarkers are largely spatial/spectral: AD remains highly identifiable (82.4% accuracy) even when temporal order is completely destroyed. **Frontotemporal Dementia (FTD) relies on temporal dynamics:** Accurate diagnosis of FTD depends heavily on temporally organized neural activity.

INTRODUCTION	METHODS	RESULTS	CONCLUSIONS	REFERENCES
EEG biomarkers for neurodegenerative diseases are often assumed to be temporally encoded, with signatures such as spectral slowing and altered oscillatory dynamics playing a central role in Alzheimer’s disease (AD) and Frontotemporal Dementia (FTD). However, recent deep learning approaches have demonstrated strong EEG classification performance even when emphasizing spatial feature extraction. This raises a fundamental question: to what extent does temporal order contribute to disease separability in resting-state EEG? We address this question using the OpenNeuro ds004504 dataset, which contains resting-state EEG recordings from AD, FTD, and control (CN) subjects.	The EEG Signals were z-score normalized per channel and segmented into fixed-length windows with overlap. To remove temporal information while preserving spatial structure, random temporal shuffling was applied: for each window, a single random permutation of time indices was generated and applied identically across all channels. This operation destroys temporal order while maintaining instantaneous cross-channel relationships. A transformer-based encoder architecture, identical to that used for temporally intact signals, was trained separately on the original and shuffled datasets.	With intact temporal structure, classification is near-perfect across all classes, with negligible cross-class confusion. After temporal shuffling, the confusion structure changes in a class-dependent manner. AD remains the most robust class, with 82.4% of samples correctly classified. In contrast, FTD shows pronounced asymmetric confusion, with 30.6% of samples misclassified as AD and only 6.6% as CN. CN is most affected, with only 43.1% correctly classified and 45.8% misclassified as AD.	The observed confusion patterns suggest that diagnostic information in EEG is encoded differently for Alzheimer’s disease and Frontotemporal Dementia. Alzheimer’s disease remains identifiable after temporal shuffling, indicating that its EEG biomarkers are largely captured by temporally unordered spatial and spectral characteristics such as diffuse slowing. In contrast, Frontotemporal Dementia depends more strongly on temporally organized neural dynamics for separability, and disrupting temporal order causes FTD samples to collapse toward the more spatially stereotyped AD class, which acts as an attractor under temporal uncertainty.	Chetty et al. 2024. EEG biomarkers in Alzheimer’s and prodromal Alzheimer’s: a comprehensive analysis of spectral and connectivity features. Alzheimer’s Research & Therapy 16 (10 2024) Miltiadiouse et al. 2024. "A dataset of EEG recordings from: Alzheimer’s disease, Frontotemporal dementia and Healthy subjects" CONTACT  Linkedin: Aryan Kashyap Naveen  ALZHEIMER’S ASSOCIATION 