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Examining sEEG Traveling Wave Instances During Speech Production and Auditory Perceptual Contexts

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Introduction: Invasive brain-computer interfaces (BCIs) leverage a range of electroencephalographic (EEG) biomarkers across various contexts [1-3]. Identifying and characterizing additional unique EEG biomarkers could prove useful for the continued development of BCI technology. Recent studies suggest that traveling waves (TWs) observed in EEG may be predictive of cognitive and behavioral outcomes in specific instances [4-6]. However, to fully understand the potential role of TWs as biomarkers in BCI applications, they must be more comprehensively characterized across cognitive, behavioral, and sensory modalities.

Materials, Methods, and Results: In this preliminary study, we identified traveling waves in patients undergoing stereo-electroencephalography (sEEG) monitoring for intractable epilepsy at UCSD and VCU Health. Seven sEEG patients performed a cued speaking task and an additional nine patients performed a passive listening task. Traveling waves were identified using a uniform detection pipeline across tasks and participants. This pipeline first identified consecutive neighboring electrodes along a given sEEG shaft that share a common dominant spectral peak. Narrowband filtering at this dominant spectral peak and a Hilbert transform was then applied to extract instantaneous phase characteristics and confirm coordinated phase progression among the channels. Instances meeting these propagation and frequency criteria were tested for statistical significance via permutation testing. Statistically significant ($p < 0.05$) traveling waves were observed in the theta (3–8 Hz), alpha (7–13 Hz), low-beta (12–21 Hz), and high-beta (20–31 Hz) frequency bands. Preliminary results suggest that theta-band TWs occur more frequently at specific instances of the tasks such as during the onsets of speech or the acoustic stimuli.

Discussion and Significance: Previous studies have linked intracranial EEG traveling waves to predictive outcomes in specific cognitive and behavioral tasks. In this work, traveling waves were detected and characterized in sEEG recordings during both speech and auditory tasks. Further investigation is needed to fully elucidate the relationship between TWs and these tasks, including an examination of the directionality and brain regions associated with the traveling waves.

References:

[1] Herff, C., Krusienski, D. J. & Kubben, P. The Potential of Stereotactic-EEG for Brain-Computer Interfaces: Current Progress and Future Directions. *Front. Neurosci.* **14**, 123 (2020).

[2] Luo, S., Rabbani, Q. & Crone, N. E. Brain-Computer Interface: Applications to Speech Decoding and Synthesis to Augment Communication. *Neurotherapeutics* **19**, 263–273 (2022).

[3] Guger, C., Grünwald, J. & Xu, R. Noninvasive and Invasive BCIs and Hardware and Software Components for BCIs. in *Handbook of Neuroengineering* (ed. Thakor, N. V.) 1193–1224 (Springer Nature Singapore, Singapore, 2023)

[4] Mohan, U. R., Zhang, H., Ermentrout, B. & Jacobs, J. The direction of theta and alpha travelling waves modulates human memory processing. *Nat Hum Behav* **8**, 1124–1135 (2024).

[5] Das, A., Zabeh, E., Ermentrout, B. & Jacobs, J. Planar, Spiral, and Concentric Traveling Waves Distinguish Cognitive States in Human Memory. *bioRxiv* (2024).

[6] Bhattacharya, S., Brincat, S. L., Lundqvist, M. & Miller, E. K. Traveling waves in the prefrontal cortex during working memory. *PLoS Comput Biol* **18**, e1009827 (2022).

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