

Overcoming the challenges of electrophysiology recordings during multi-word speech production

Svetlana Pinet¹, Nazbanou Nozari¹, Robert T. Knight², Stephanie K. Ries³

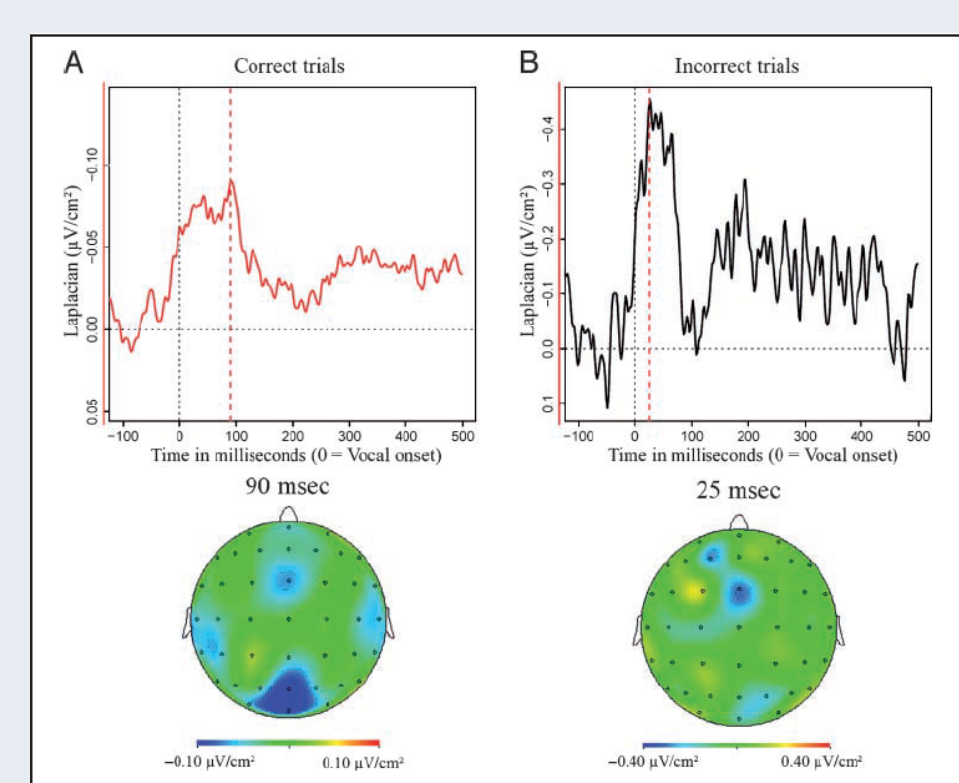
1- Johns Hopkins University, 2- University of California, Berkeley, 3- San Diego State University

Introduction

Executive processes during language production control accurate production and resolve potential conflicts. Sentences and word sequences are particularly conflicting situations, since several words must be processed and produced in a short period of time. Studying sequential speech production can be challenging due to the potential mixture of processes.

Error-related negativity (ERN)

- Response-related component, used to study conflict with EEG
- Higher amplitude when higher conflict (e.g., for errors compared to correct trials)
- Used in single word production [2, 4]

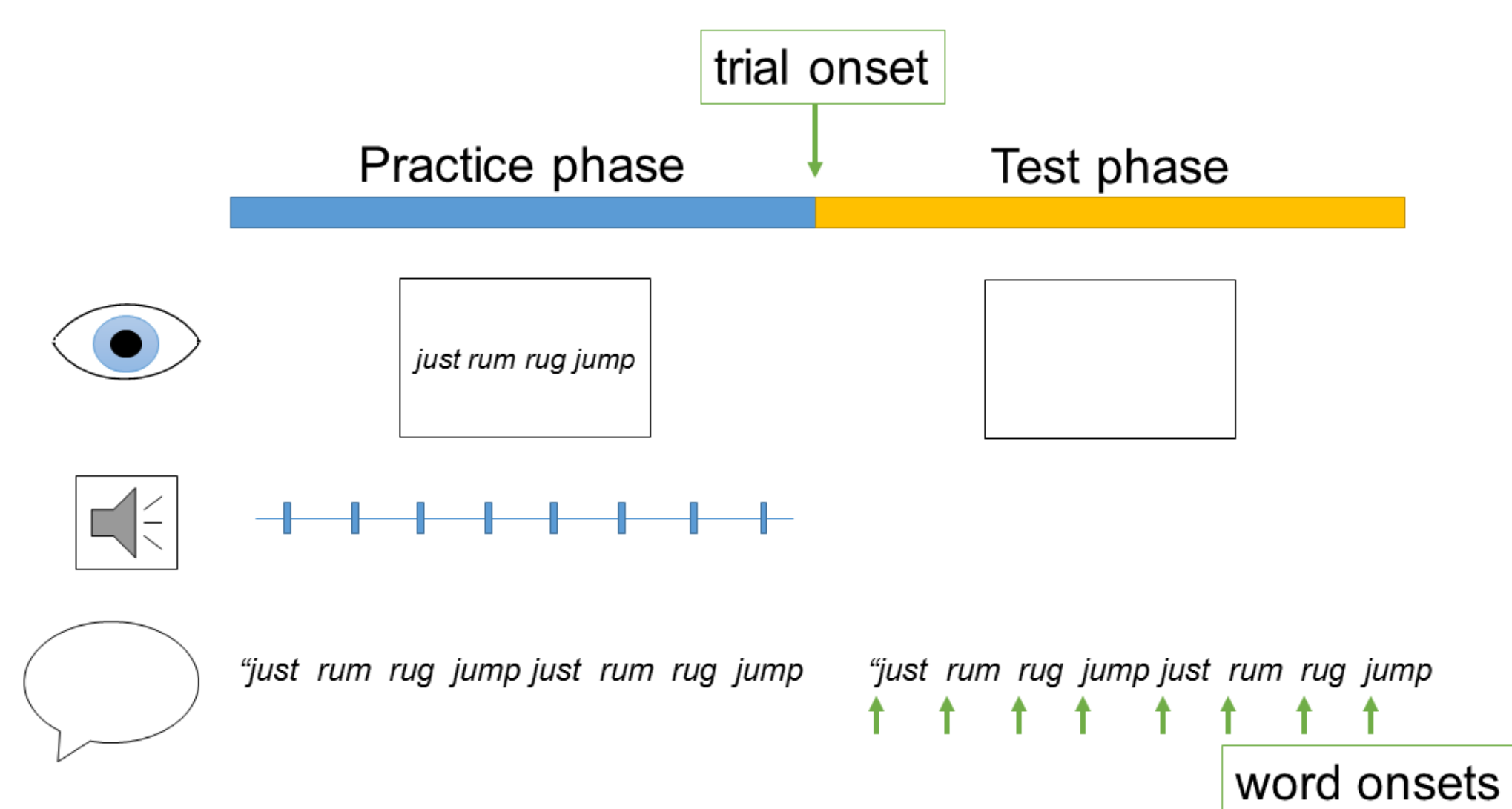


Ries et al., 2011 [4]

The aim of this study was to:

- Evaluate the feasibility of EEG recordings for continuous multi-word sequences
- Isolate component for each item in the sequence

Method



- 10 participants
- Tongue-twister paradigm [3]
- 32 sequences of 4 words, ABBA pattern for onset consonant: e.g., *just rum rug jump*
- Continuous EEG recordings
- ICA for ocular artefacts, BSS-CCA for muscular artefacts, Laplacian transform as a spatial filter
- Statistical analyses on mean amplitude over specific time-windows

ERN at the onset of each word

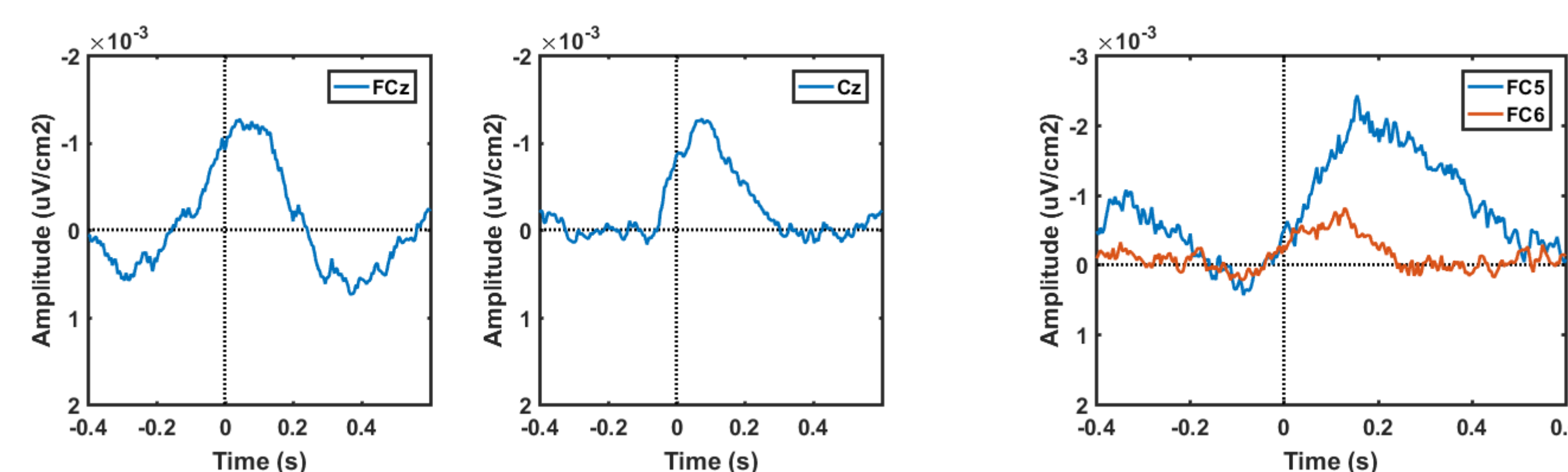


Figure: ERN locked to onset of each word. Left: midline electrodes (FCz, Cz). Right: FC5/FC6, fronto-lateral electrodes.

- Midline (FCz): No significant differences before [-300:-200ms] and after [+300:+400ms] each word onset, $z = -1.17$, $p = 0.24$
- Left lateral (FC5): Less straightforward, $z = 1.89$, $p = 0.059$, suggesting more overlap between processes (*motor preparation*)

ERN by word position

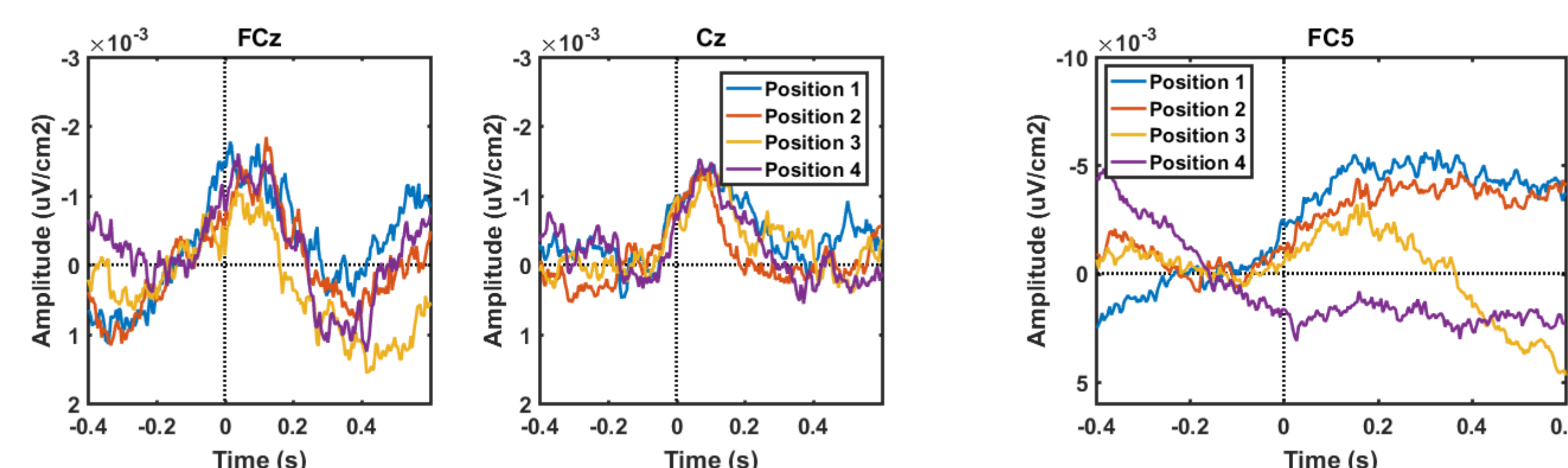


Figure: ERN locked to onset of each word. Left: midline electrodes (FCz, Cz). Right: FC5.

- After onset of **each word**: negative component, peaking at 80 ms
- Left lateral (FC5): overlap between word positions
- Continuous signal over the whole sequence:

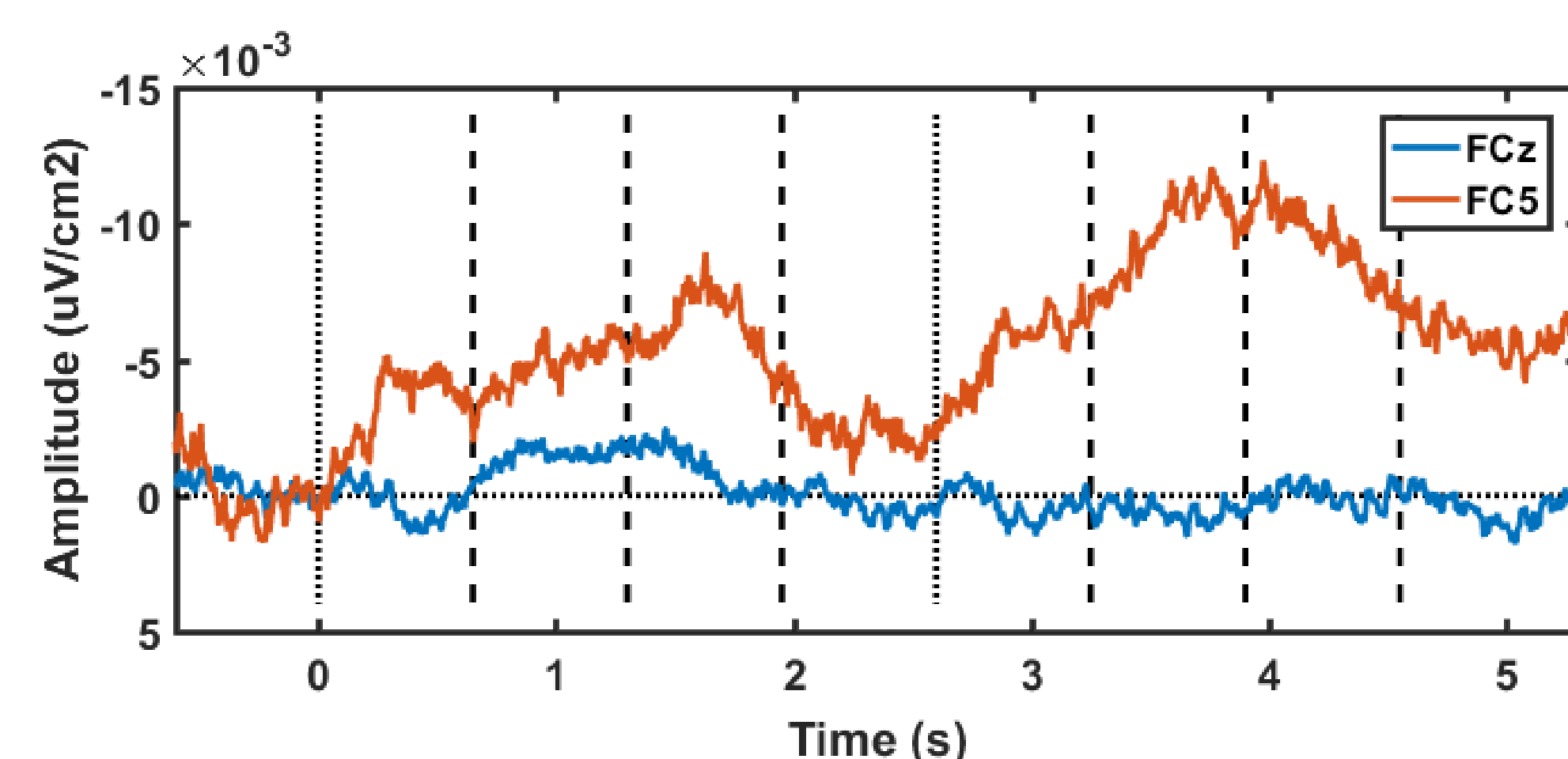


Figure: Vertical lines represent metronome frequency

Effect of sequence repetition

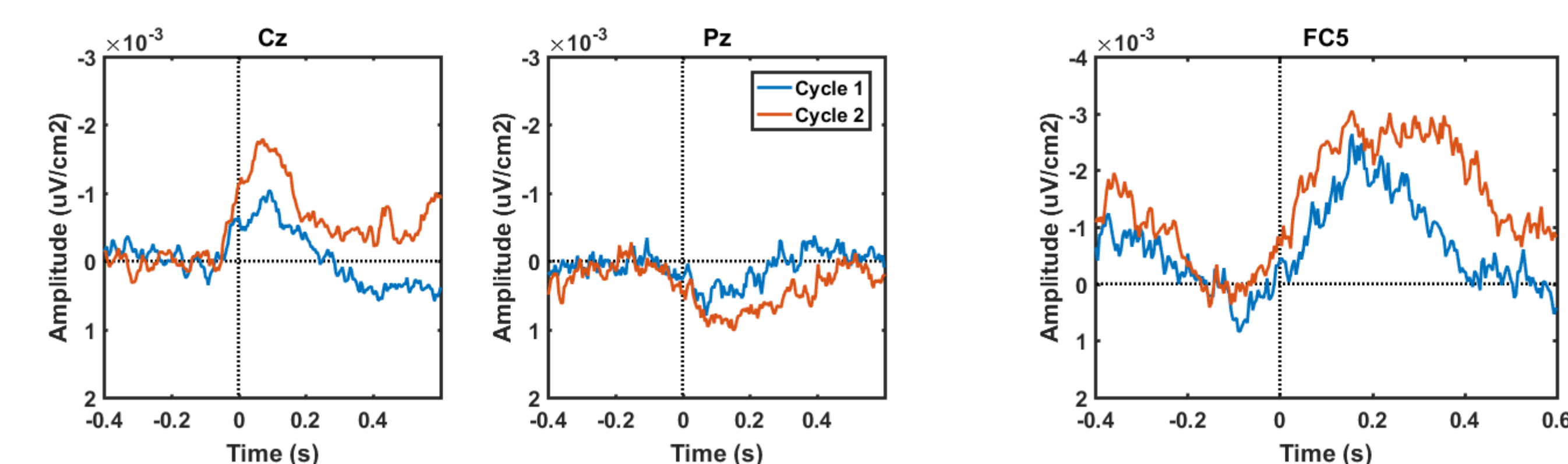


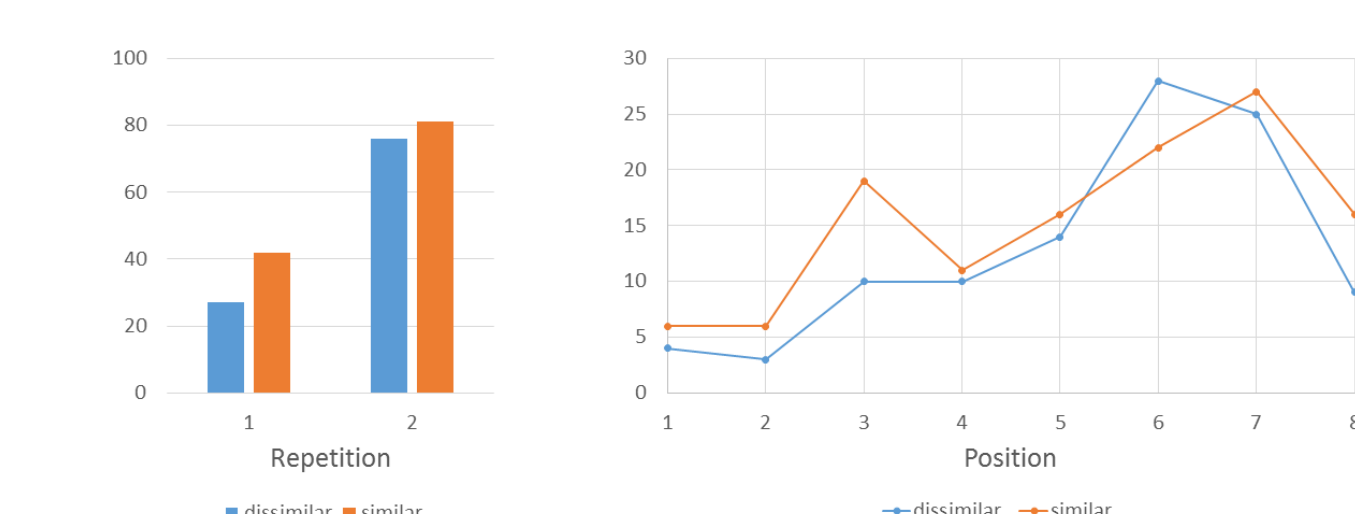
Figure: Effect of sequence repetition. Left: midline electrodes (Cz, Pz). Right: FC5.

- Increased amplitude for second cycle, Cz - $z = 2.19$, $p = 0.028$ [50:150ms], FC5 - $z = 2.08$, $p = 0.037$ [300:400ms]

Conclusion

- Feasibility of EEG recordings for multi-word sequence
 - Midline electrodes show clear return to baseline between each word
 - Fronto-lateral electrodes could index sequence-wise motor preparation
- Some indication of a repetition effect: second cycle is more demanding
- Next steps: running more subjects with similarity manipulation to contrast conflicting situations

Phonemic Similarity



- Onset consonants with one (*similar*) or two (*dissimilar*) phonetic features apart
- Prediction: similar consonants enhance conflict within the sequence

References

[1] D. Acheson and P. Hagoort (2014). Twisting tongues to test for conflict-monitoring in speech production. *Frontiers in Human Neuroscience*, 8(206):1-16.
 [2] H. Masaki, H. Tanaka, N. Takasawa, and K. Yamazaki (2001). Error-related brain potentials elicited by vocal errors. *Neuroreport*, 12(9):1851-1855.
 [3] G. M. Oppenheim and G. S. Dell (2008). Inner speech slips exhibit lexical bias, but not the phonemic similarity effect. *Cognition*, 106(1):528-537.
 [4] S. Riès, N. Janssen, S. Dufau, F.-X. Alario, and B. Burle (2011). General-purpose monitoring during speech production. *Journal of cognitive neuroscience*, 23(6):1419-36.

Contact Information



Email: spinet1@jhmi.edu