

Neural Mechanisms of Novel Word Learning Through Rhyme in Adults

Will Decker, Eileen Haebig, & Julie M. Schneider
Louisiana State University

Research Question

Does rhyme enhance phonological and semantic cues to improve word learning?

Background

- Strong word learning skills are contingent upon effective prediction and retrieval.
- Rhyme enhances recall from working memory and increases semantic predictability of upcoming information [1], by heightening phonological and semantic cues [2,3].
- Despite the promising role of rhyme in facilitating word learning, little is known about rhyme's ability to improve the speed and depth of word learning.
 - It can be difficult to capture the dynamic process of learning a new word in real-time with behavioral measures alone
 - The P2 and N400 ERP components can allow us to gauge an individual's ability to encode and retrieve semantic meaning, respectively [4,5,6,7,8].

Approach

- The current study examined whether the inclusion of rhyme facilitates encoding and retrieval during word learning as measured by changes in the N400 event-related potential (ERPs), a marker of semantic knowledge [4], and the P2 ERP, a marker of visual- and information processing [5,6,7,8].
- By investigating the physiological mechanisms behind rhyme's role in word learning, we can determine the neural architecture of rhyme's promoting role in word learning.

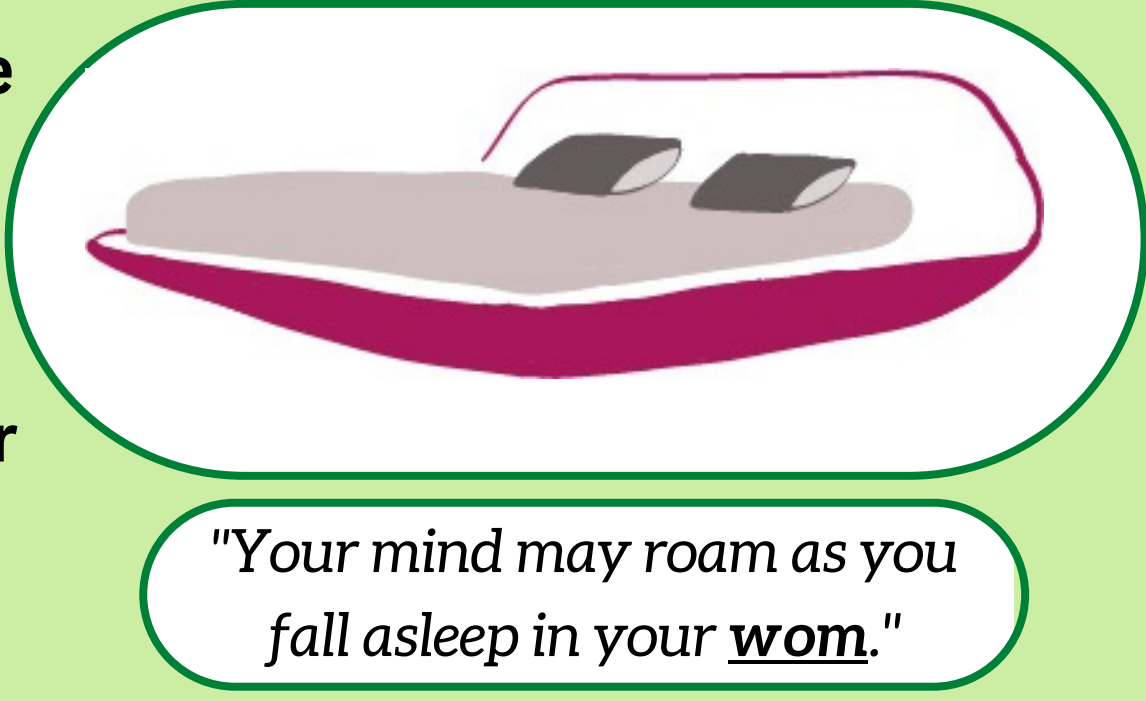
Methods

Participants
46 adults (37 female, 9 male; Mage = 19.41, SDage = 1.77) participated in this study. Participants' EEG was recorded as they completed a rhyme word learning task.

Stimuli/Word Learning Task

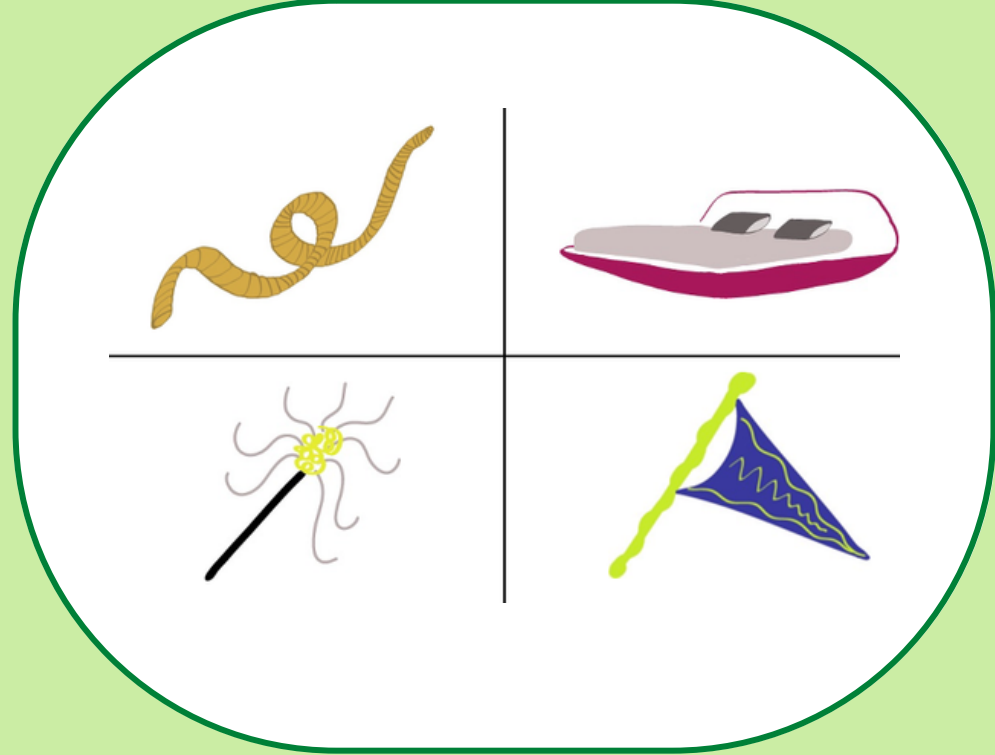
Exposure:

- Participants listened to sentences ending with a novel word (NW).
- The NW was defined contextually in the sentence and was paired with a representative image (RI).
- Upon hearing the sentence and seeing the RI, participants were asked whether or not they knew what the NW meant.
- Participants were exposed to 15 NWs; each NW was heard four times; the learning judgement was presented after each sentence.



Post-Test:

- To test recall of NWs, participants engaged in a four-alternative forced choice task.
- Four images appeared on the screen as a NW was presented auditorily.
- Participants were asked to choose which of the four images represented the NW they heard.
- Average accuracy across all trials was computed.



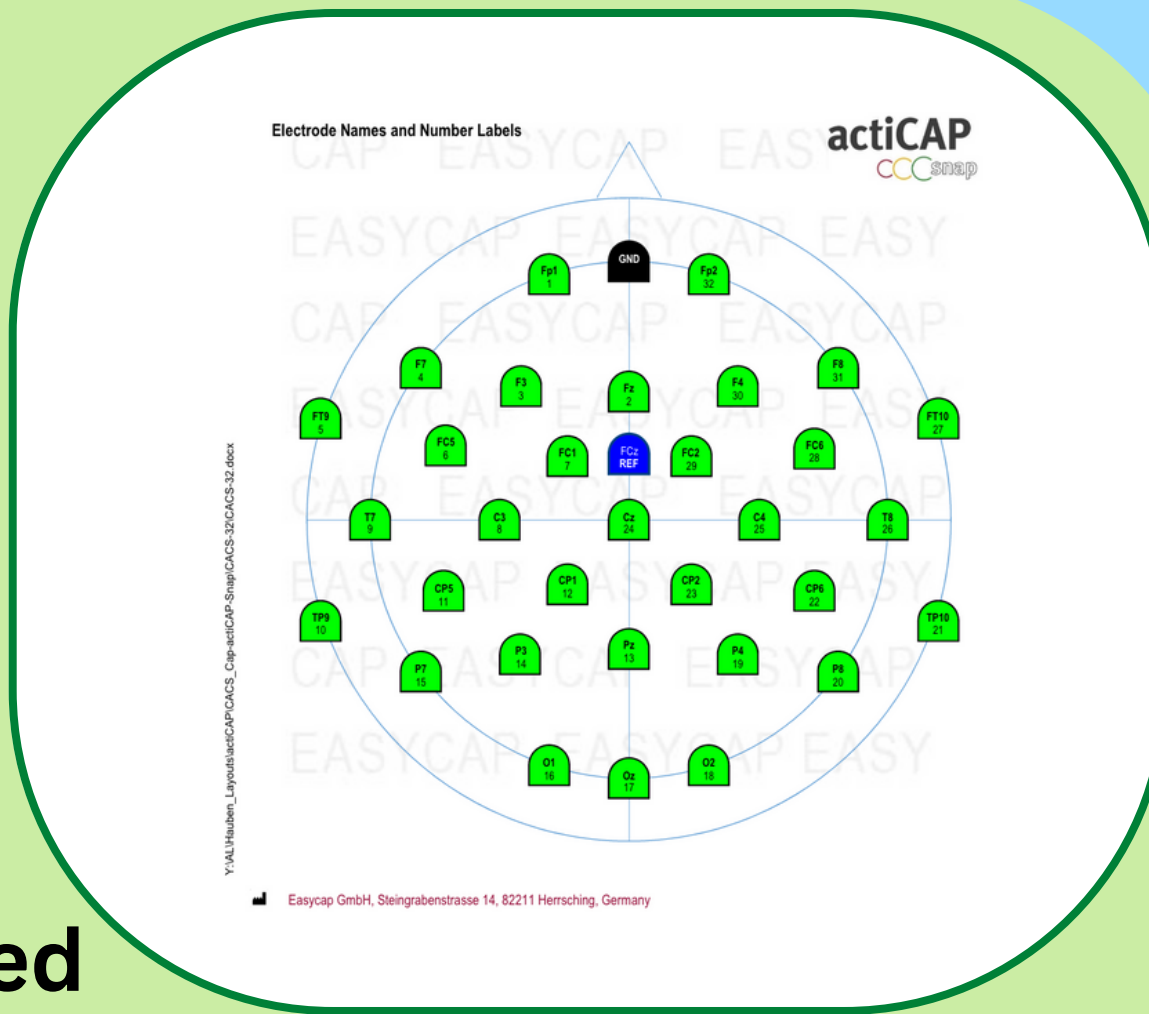
References

- Frishkoff, G. A., Perfetti, C. A., & Collins-Thompson, K. (2010). Lexical Quality in the Brain: ERP evidence for robust word learning from context. *Developmental Neuropsychology*, 35(4), 376–403. <https://doi.org/10.1080/87565641.2010.480915>
- Gordon, K. R., Lowry, S. L., Ohlmann, N. B., & Fitzpatrick, D. (2022). Word Learning by Preschool-Age Children: Differences in Encoding, Re-Encoding, and Consolidation Across Learners During Slow Mapping. *Journal of Speech, Language, and Hearing Research*, 65(5), 1956–1977.
- Read, K. (2014). Clues cue the smooze: Rhyme, pausing, and prediction help children learn new words from storybooks. *Frontiers in Psychology*, 5. <https://www.frontiersin.org/articles/10.3389/fpsyg.2014.00149>
- Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event related brain potential (ERP). *Annual Review of Psychology*, 62, 621–647. <https://doi.org/10.1146/annurev.psych.093008.131123>
- Tremblay, K., Ross, B., Inoue, K., McClannahan, K., & Collet, G. (2014). Is the auditory evoked P2 response a biomarker of learning? *Frontiers in Systems Neuroscience*, 8. <https://www.frontiersin.org/articles/10.3389/fnsys.2014.00028>
- Luck, S. J., & Hillyard, S. A. (1994). Electrophysiological correlates of feature analysis during visual search. *Psychophysiology*, 31(3), 291–308. <https://doi.org/10.1111/j.1469-8986.1994.tb02218.x>
- Federmeier, K. (2002). Picture the difference: Electrophysiological investigations of picture processing in the two cerebral hemispheres. *Neuropsychologia*, 40(7), 730–747. [https://doi.org/10.1016/S0028-3932\(01\)00193-2](https://doi.org/10.1016/S0028-3932(01)00193-2)
- Federmeier, K. D., Mai, H., & Kutas, M. (2005). Both sides get the point: Hemispheric sensitivities to sentential constraint. *Memory & Cognition*, 33(5), 871–886. <https://doi.org/10.3758/BF03193082>
- Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(1), 9–21. <https://doi.org/10.1016/j.jneumeth.2003.10.009>
- Abel, A. D., Sharp, B. J., & Konja, C. (2020). Investigating Implicit and Explicit Word Learning in School-age Children Using a Combined Behavioral-Event Related Potential (ERP) Approach. *Developmental Neuropsychology*, 45(1), 27–38. <https://doi.org/10.1080/87565641.2019.1709465>

EEG & Data Processing

Equipment

BrainVision EEG System
EasyCap; 32 Electrodes



Data Processing

- Raw files were filtered from 0.1-30 Hz and re-referenced to the average.
- Bad channels were manually inspected and then interpolated.
- Bad components were identified using MARA, manually inspected, and then removed.
- Data was epoched from -500 to 1000 ms. and baseline corrected to the pre-stimulus interval.
- Single trials were averaged together to obtain a stable waveform ERP for each condition.
- All analyses occurred in the EEGLAB Toolbox in MATLAB [9].

Results

ERPs

To address our research question, a cluster-corrected ($p < 0.05$) permutation test ($N = 500$) was implemented and applied to a 2(Groups: rhyme, no rhyme) x 2(Presentation: 1&2, 3&4) ANOVA.

N400 Results

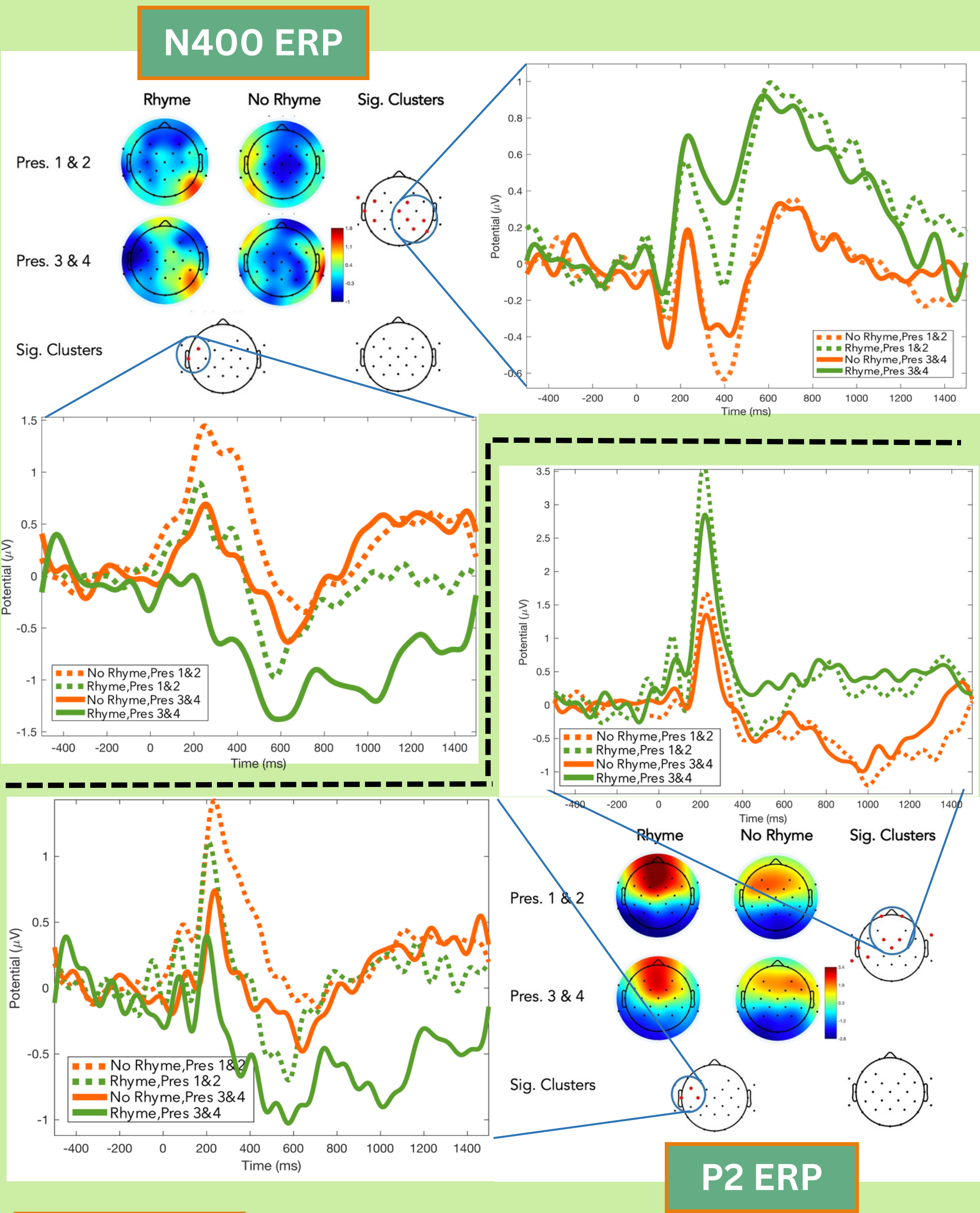
Main effect of group ($p < 0.05$): Individuals in the rhyme group exhibited a greater N400 effect at widespread electrodes compared to individuals in the no rhyme group.

Main effect of presentation ($p < 0.05$): An attenuation in N400 amplitude was observed across presentations at left fronto-temporal electrodes.

P2 Results

Main effect of group ($p < 0.05$): Rhyme individuals had a larger P2 effect compared to no rhyme individuals at fronto-central and left temporal electrodes.

Main effect of presentation ($p < 0.05$): An attenuation in P2 amplitude was observed between presentations at left fronto-temporal electrodes.



Behavior

Participants demonstrated significant learning across both groups ($t(44) = 10.26$, $p < 0.001$).

Despite marginal gains, participants in the rhyme group ($M = 67.6\%$) did not perform significantly better on the post-test than those in the no rhyme group ($M = 62.1\%$; $t(41.27) = -0.69$, $p = 0.49$)

Discussion

- Our findings in adults support research in children showing that differences in implicit word learning, as measured by the P2 and N400, may precede explicit behavioral differences [10].
- P2 ERP results indicate that rhyme may better prime our working memory and reduce its load during sentence processing. Moreover N400 ERP results suggest that rhyme aids in word predictability (ERP onset) and depth of learning (mean amplitude).
- Future applications should aim to investigate when and how this implicit role changes to an explicit expression of word learning.