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May 7th, 11:00 AM - 1:00 PM

An Ocean of Brain Waves: Analyzing Methods to Find ERP Signals in the Noise

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Hamblen, Andrea; Owen, Mallary; Robb, Lindsay; Wiggins, Susan; and Key-DeLyria, Sarah, "An Ocean of Brain Waves: Analyzing Methods to Find ERP Signals in the Noise" (2019). *Student Research Symposium*. 6.

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Questions & Hypotheses

Questions

Will the N400 ERP be observed when participants read word pairs that are either related (semantically, causally, hierarchically, or associatively) or unrelated?

Will a replication of a study using word pairs with varying degrees of relatedness produce similar results to the model study in terms of N400 latency and amplitude?

Can results from a robust, easily-recognizable ERP be used to validate methods for the discovery of more subtle ERP's?

Hypotheses

It is expected that our results will mirror the findings of our model study, revealing significant negative-going neural activity between 200 and 500ms after seeing the stimulus. We anticipate this effect to be robust enough to identify as the N400 ERP. Further, we expect to be able to use these findings in later studies as a means of validating the methods and procedures for investigating more subtle ERP-related neurolinguistic events.

Introduction

- ERPs: Event Related Potentials are manifestations of brain activities that occur in preparation for or in response to a discrete event. They are electrophysiological responses to a stimulus which can be studied in a noninvasive way.
- The P and N refer to a positive or negative-going wave, and the following number refers to the time reference. An example of this is the P600 and N400.
- N400: The N400 is a negative-going deflection that peaks around 400 milliseconds. It is one of the most robust ERPs, meaning it is easiest to elicit. N400s are typically elicited with semantic anomalies, and have been extensively studied. The N400 is the brain's natural response to varying stimuli, including words (presented both aurally and visually), ASL, pictures, smells, etc.
- P600: Like the N400, this ERP is linked to language and is elicited through grammatical and syntactic anomalies. The Neurolinguistics lab at PSU has been studying the P600 in typical adults and adults who have experienced traumatic brain injury (TBI). By comparing P600s between these two groups we can begin to understand the more subtle areas of language that are affected by neurological events.
- After moving locations and receiving a new sound booth, the Neurolinguistics lab wanted to test the new equipment before further data collection and to validate the methods of that study, thus the current experiment was developed. As previously mentioned, the N400 is a more robust ERP that is easily elicited, so we selected an N400 research study to replicate.

Methods

Participants:

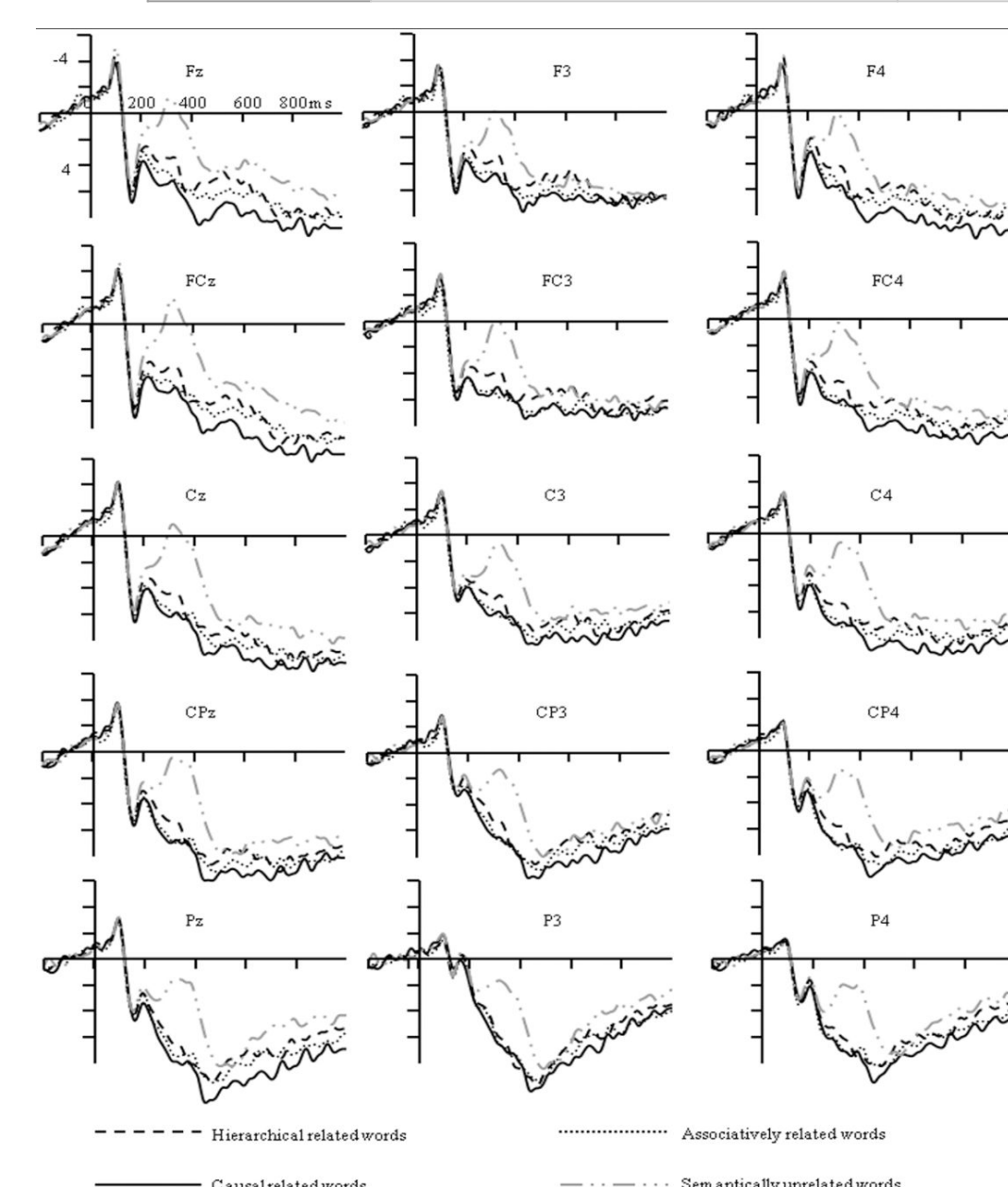
- Six female undergraduate volunteers in the Portland Metro area.

Materials:

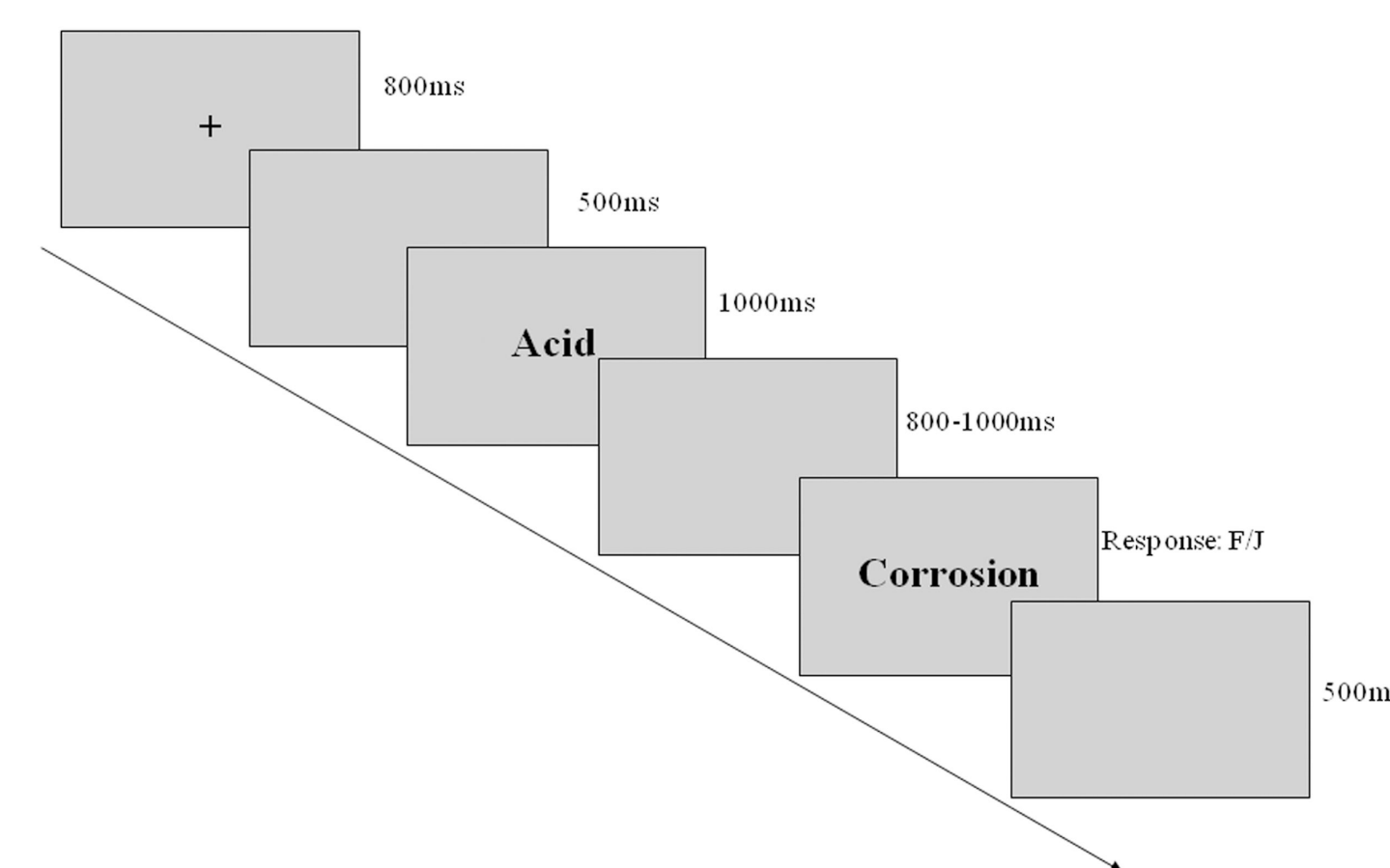
- Participants wore an electroencephalography (EEG) net with 64 hydrocel electrodes and sat at a computer in a soundbooth for the duration of the experiment.
- Using a computer, participants were presented 200 pairs of words that fell into one of five conditions (unrelated, causally related, hierarchically related, associatively related, and filler words) and indicated whether or not the two words were related in any way using a two-choice button box.
 - Unrelated: gymnastics, vegetables
 - Causally related: bacteria, infection
 - Hierarchically related: tools, hammer
 - Associatively related: town, city
 - Filler: organ, distrust
- The current experiment differs from the model study in a few ways, including fewer stimuli (200 vs. 480), a smaller sample size (6 vs. 16), impedances (70 kΩ or lower vs. 10 kΩ), and processing program used (NetStation vs. Brain Vision). Further, some word pairings were changed to account for linguistic differences between General American English and Chinese.

Procedures:

Pre-Data Collection		
Stimuli List	200 TOTAL (40 unrelated, 40 filler, 40 causal, 40 associative, 40 hierarchical). Some words were changed to accommodate General American English-speakers (e.g. seaman was changed to sailor)	
Repetition of Pairs	No	
Number of Participants	6	
Data Collection		
Visual Display	E-prime software	
Electrodes	64 Hydrocel	
Reference Recording	Ref (Cz)	
Impedances	70 kΩ or lower	
Sample Rate	1000 Hz	
Data Processing		
Processing Program	NetStation	
Filter Type	FIR	
Filter Settings	0.1-35 Hz, 99.88 % bandpass gain, 1% stopband gain, 2 Hz rolloff	
ICA for Blinks & Eye Movements	No	
Segmentation	1000ms	
Baseline	200ms	
Artifact Detection	38% trials eliminated	



Observed ERP waves from model study

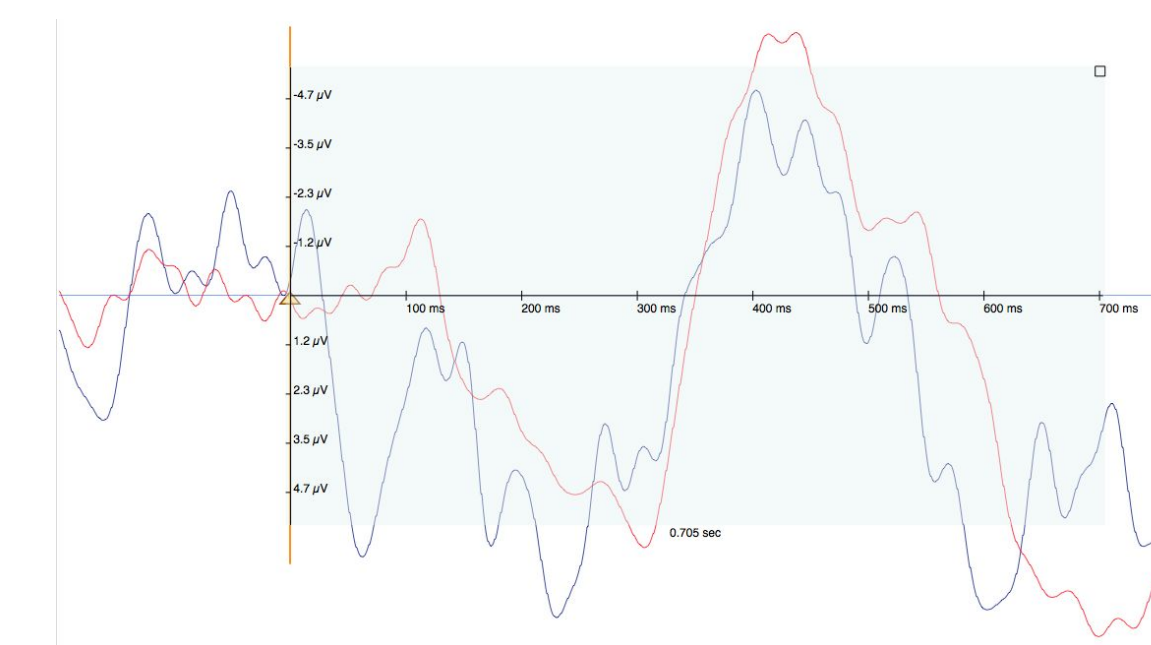


Study design as seen in e-prime software

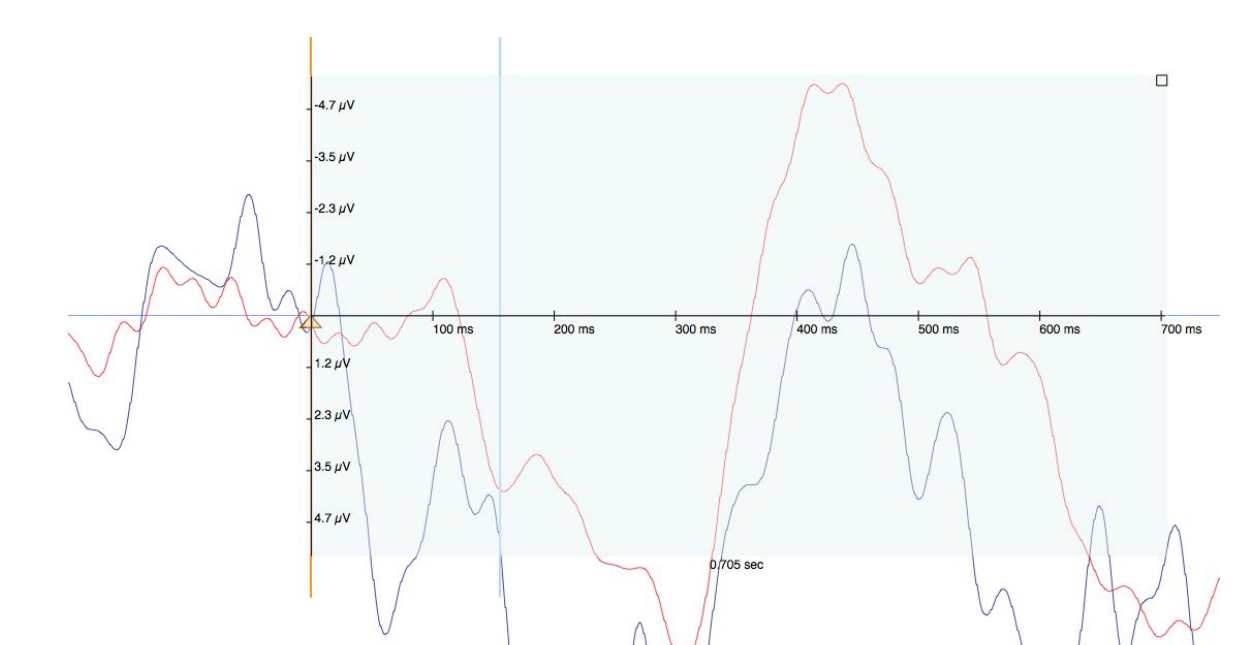
Results

- Following visual inspection and filtering in NetStation, a repeated measures ANOVA was conducted using SPSS and no significant N400 effect was found ($p = .494$).
- It is likely that the sample size was too small to find any significant N400 ERP due to the elimination of many trials for several participants. In the case of one participant 72% of the data was unusable due to artifacts in the EEG file. Other factors could also explain these results including the filtering options in Netstation.
- While there is evidence of some negative-going neural activity in the data of several participants, this does not present a strong enough case to constitute a true N400 event-related potential.
- Until more data is collected, the hypothesis cannot be supported.

PARTICIPANT 6 - ELECTRODE 46 (CP4)

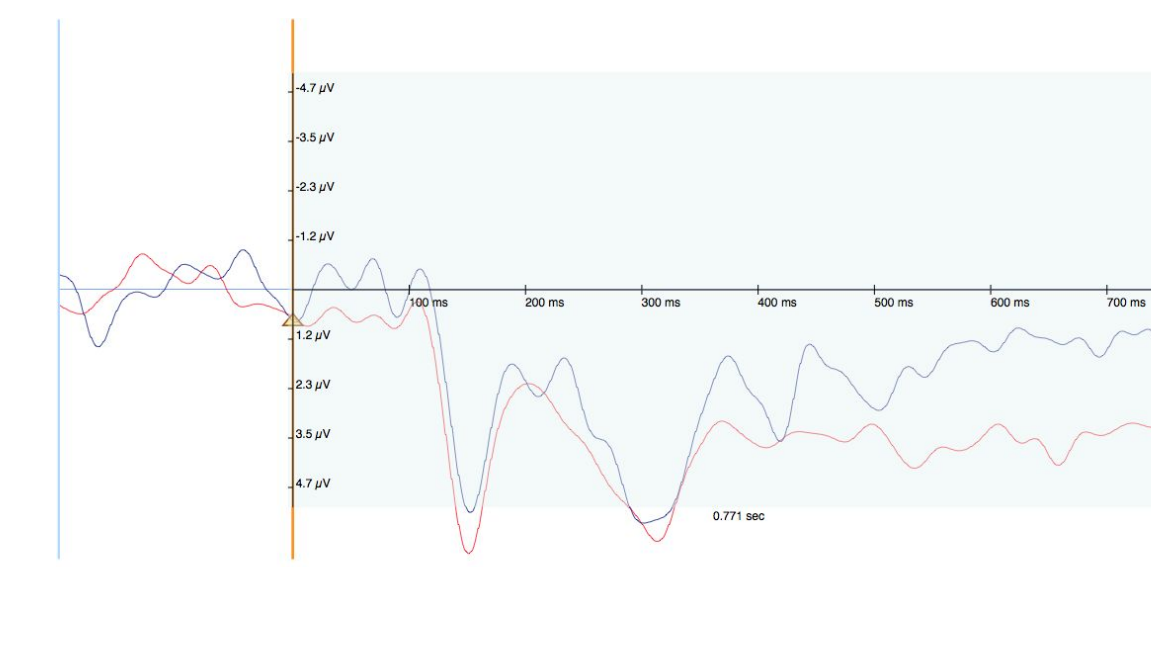


PARTICIPANT 6 - ELECTRODE 50 (C4)

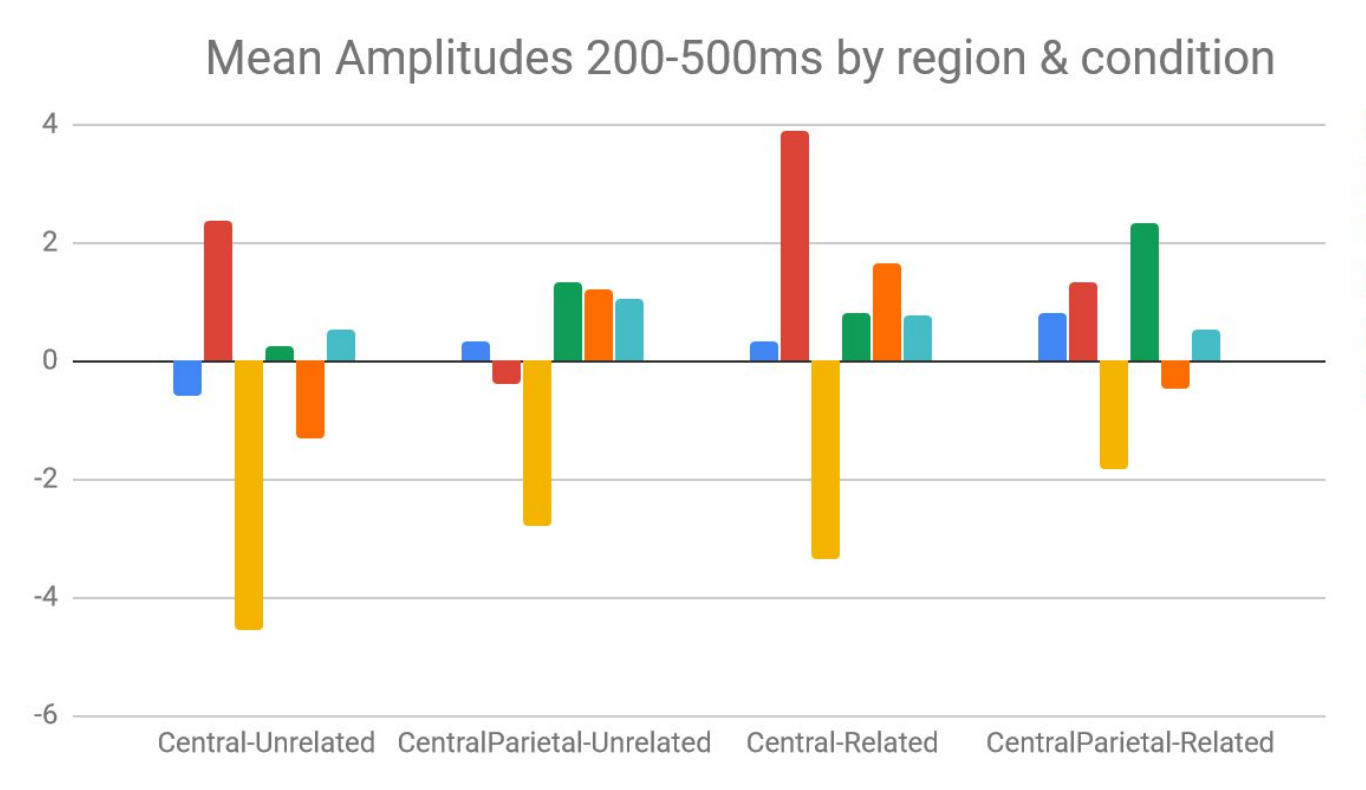
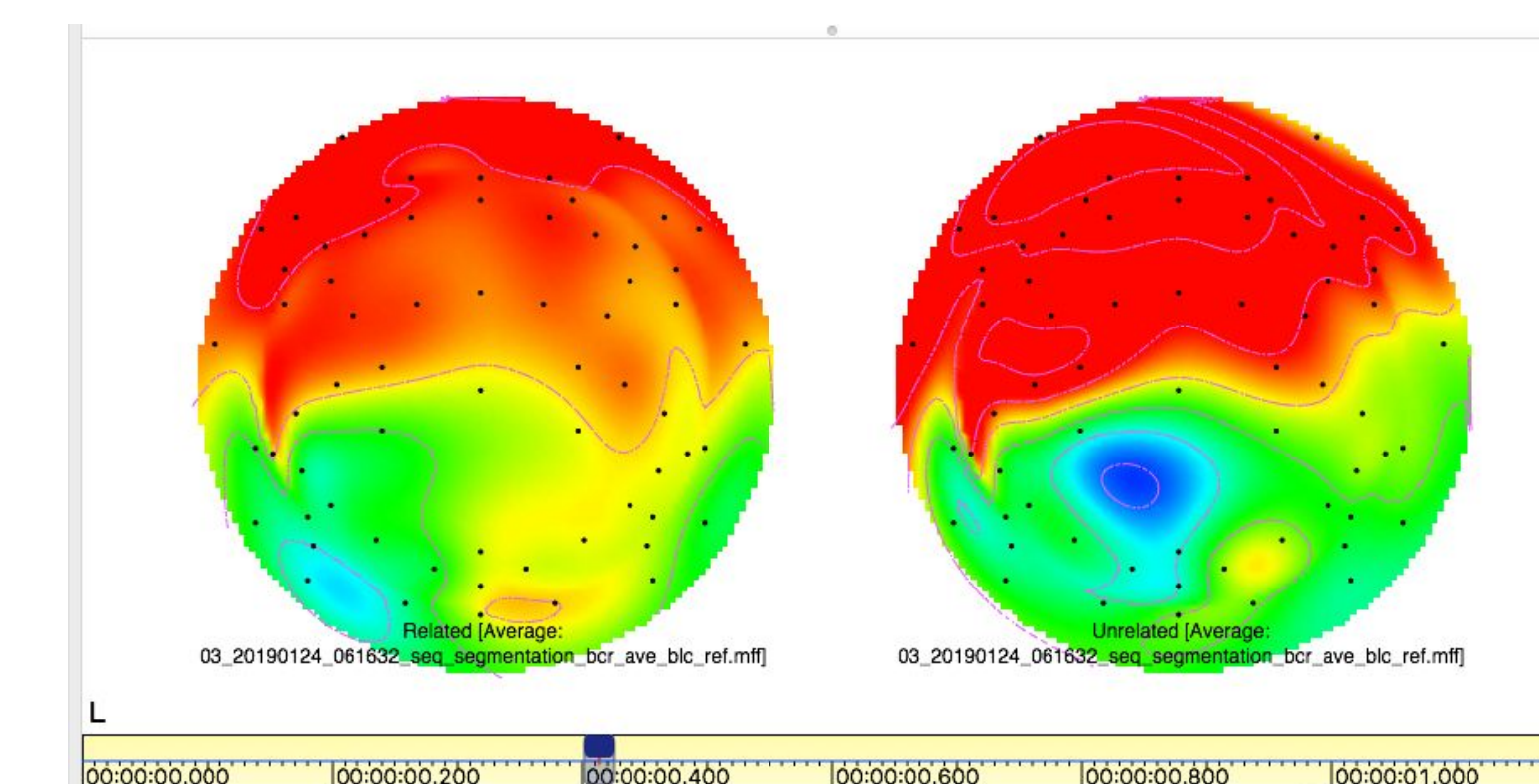
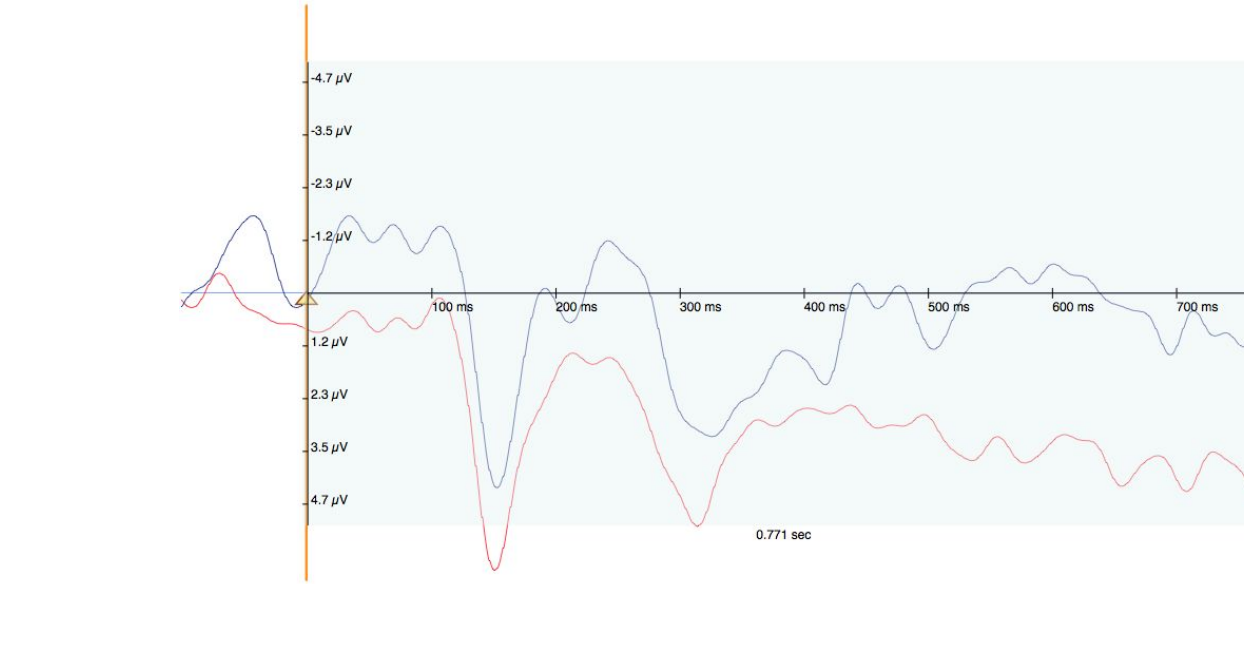


The red line indicates related stimuli, while the blue line indicates unrelated stimuli

PARTICIPANT 5 - ELECTRODE 46 (CP4)



PARTICIPANT 5 - ELECTRODE 50 (C4)



Discussion

Overall, there was no significant evidence to determine whether the negative-going neural activity observed was the N400 ERP or not. It is clear that a larger pool of participants must be run before conclusions can be drawn, and we propose adding an ICA correction for blinks and eye movements in order to preserve more of the trials that were eliminated before data analysis. However, we are hopeful that once more ICA-controlled data is collected and analyzed, the initial negative-going activity we have seen will prove to be the full N400 ERP, therefore validating our methods and providing confidence that they can be used to identify more subtle ERPs that are useful in neurolinguistics research, such as the P600 ERP.

References & Acknowledgements

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Many thanks to the Key-DeLyria Neurolinguistics Lab for ongoing mentorship and support, Dr. Carolyn Quam and the Child Language Learning Center for ample guidance and recruitment assistance, and Dr. Aaron Roussell for help with data analysis.