Assessing the Relationships Between English Linguistic Frequency and the Mismatch Negativity Response

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INTRODUCTION

- Learning letters and their respective speech sounds is one of the earliest and most vital steps in learning to read.[1]
- The ability to learn associations between letters and their speech sound can be impacted by the orthography of a language. Alphabetic languages with more pairings between a grapheme and possible phonemes, such as English, are often more complex and difficult to learn to read and spell.[2]
- Prior research has used electroencephalogram (EEG) data to explore these perceptions using the mismatch negativity (MMN) signal.[3]
- The MMN signal is an event related potential (ERP) in brain activity that fires in response to a violation of a memory standard that generally appears 150-300ms after stimulus onset.[4]
- Reading ability can be indicated at a pre-attentive level using the MMN component. The MMN signal has shown that audiovisual integration occurs automatically in those with typical reading abilities, whereas dysfluent readers have diminished MMN responses.[5, 6]
- Because of the complex orthography in English, sounds have a different linguistic frequency or likelihood to be paired with a specific letter.[7]

Figure 1. Example MMN Visualization[4]

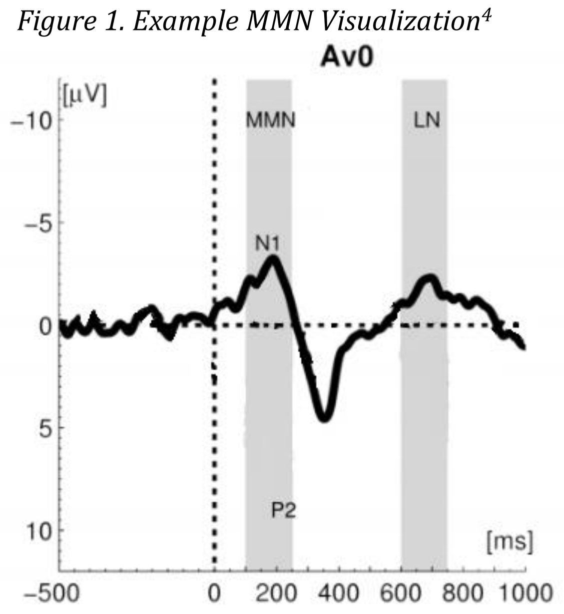


Figure 2. Stimuli Sounds, Examples, and Types

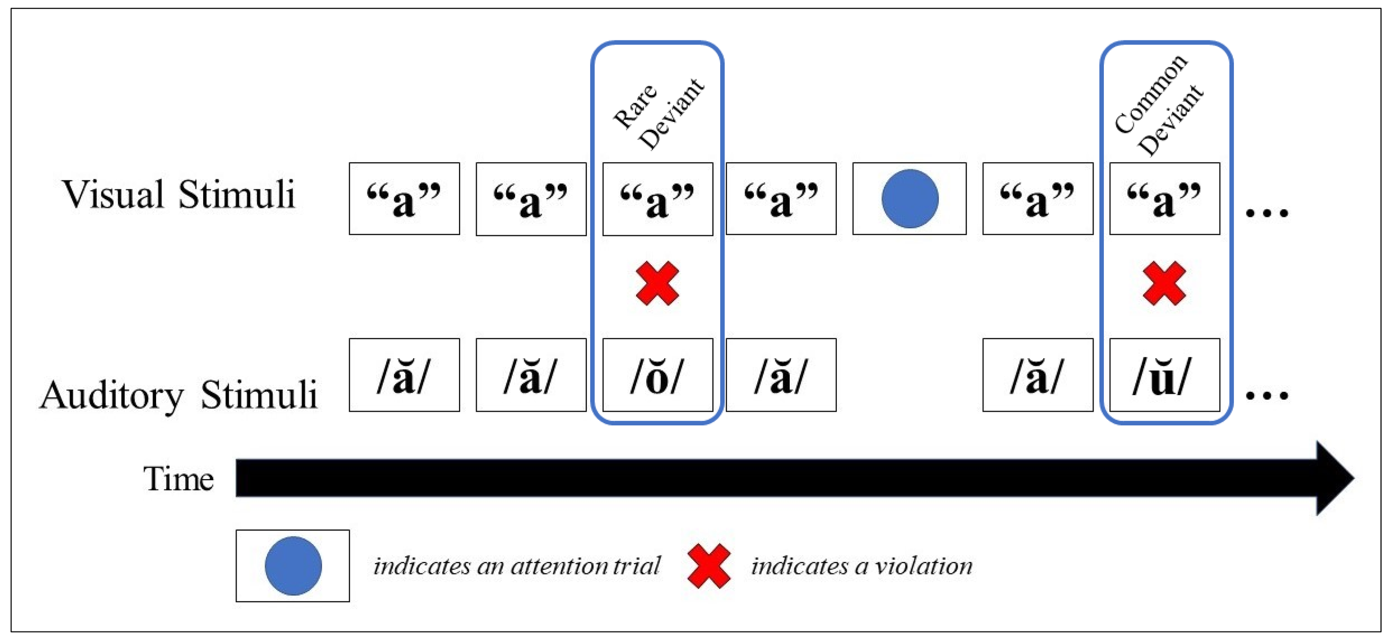
Letter Sound	Example Word	Stimuli Type
/a/	cat	Standard
/o/	father	Rare Deviant
/au/	what	Common Deviant

- The current study used the MMN signal to evaluate if individuals are sensitive to the statistical structure, i.e. the linguistic frequency, of the language.
- **QUESTION: Will the MMN effect be influenced by the likelihood of different letter-sound pairings occurring in English?**
- **HYPOTHESIS: A rare pairing deviant sound will generate a much larger MMN signal than a common pairing deviant sound.**

METHOD

- N= 31 undergraduate students, 18 female.
- Participants completed several reading tests before having EEG data recorded.
- EEG data was measured using a 64 electrode Neuroscan Hydronet Quik-Cap while Curry8 software and a Synamps2 amplifier recorded data.
- While EEG data was recorded, SuperLab Beta6 software presented the oddball paradigm designed to elicit the MMN.

Figure 3. Audiovisual Oddball Paradigm



RESULTS

Deviant 1 vs. Standard: This contrast compares the rare deviant, /o/, with the standard sound, /a/.

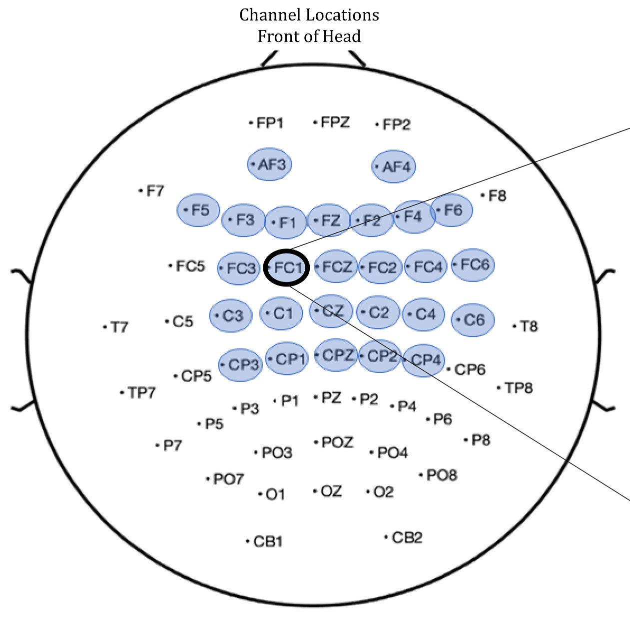


Figure 4. Significant Electrodes in Deviant 1 vs Standard Comparison. Highlighted electrodes are those that had significantly higher amplitudes for the uncommon /o/ sound than the standard /a/ sound.

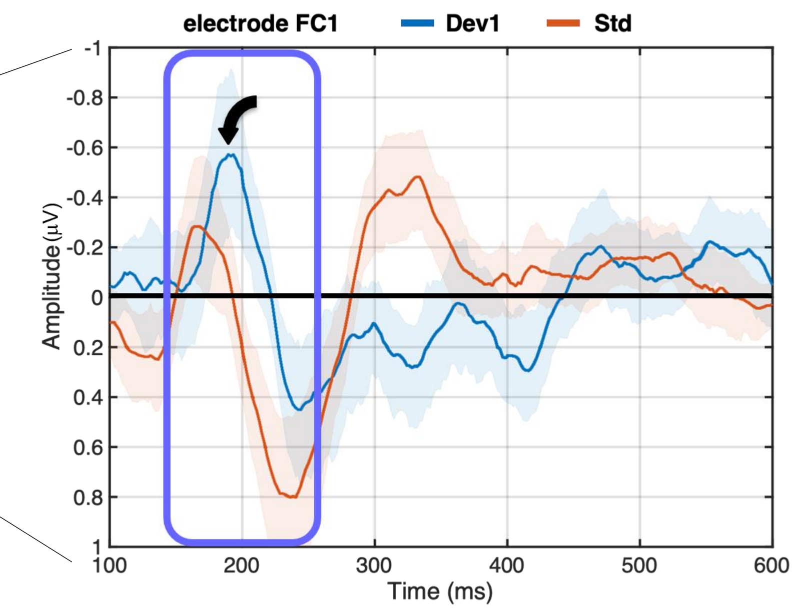


Figure 5. Electrode FC1 Amplitude after Stimulus Onset. The purple box indicates the MMN range with the black arrow identifying the MMN peak where significance lies.

Deviant 2 vs. Standard: This contrast compares the common deviant, /u/, with the standard sound, /a/.

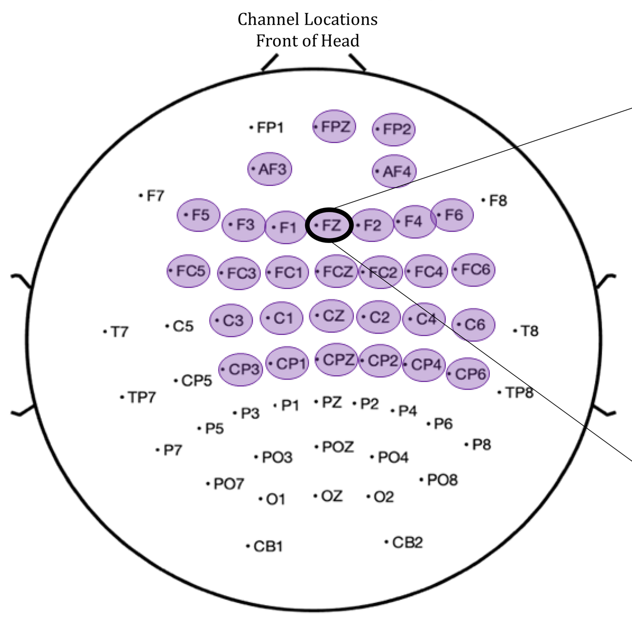


Figure 6. Significant Electrodes in Deviant 2 vs Standard Comparison. Highlighted electrodes are those that had significantly higher amplitudes for the common /u/ sound than the standard /a/ sound.

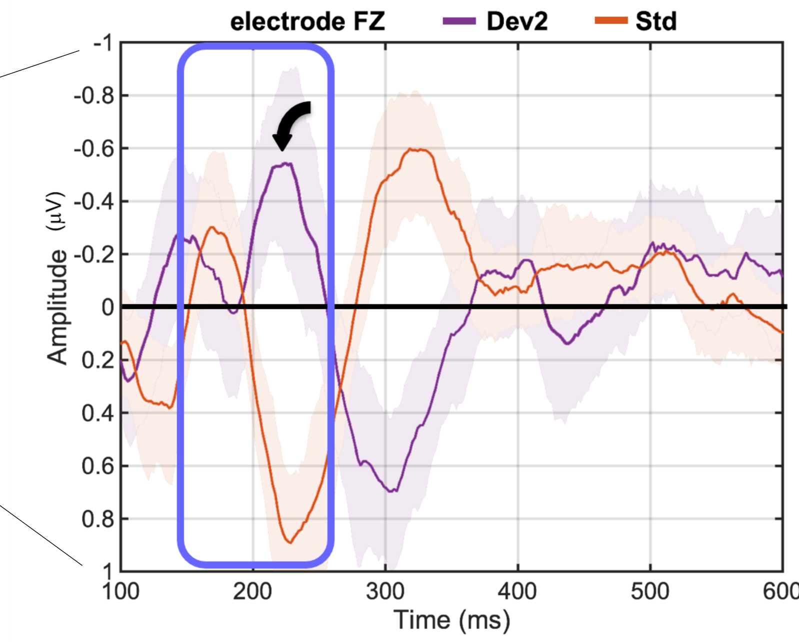


Figure 5. Electrode FZ Amplitude after Stimulus Onset. The purple box indicates the MMN range with the black arrow identifying the MMN peak where significance lies.

Deviant 1 vs. Deviant 2: This contrast compares the rare deviant, /o/, with the common deviant, /u/.

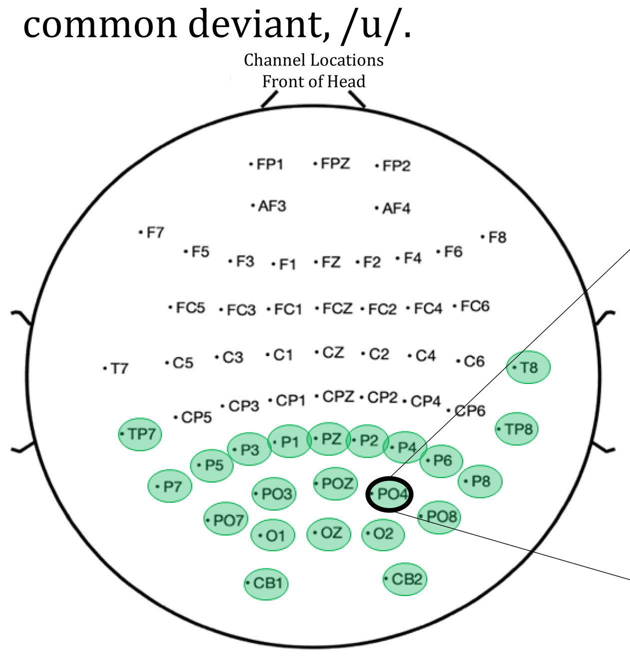


Figure 8. Significant Electrodes in Deviant 1 vs Deviant 2 Comparison. Highlighted electrodes are those that had significantly higher amplitudes for the uncommon /o/ sound than the common /u/ sound.

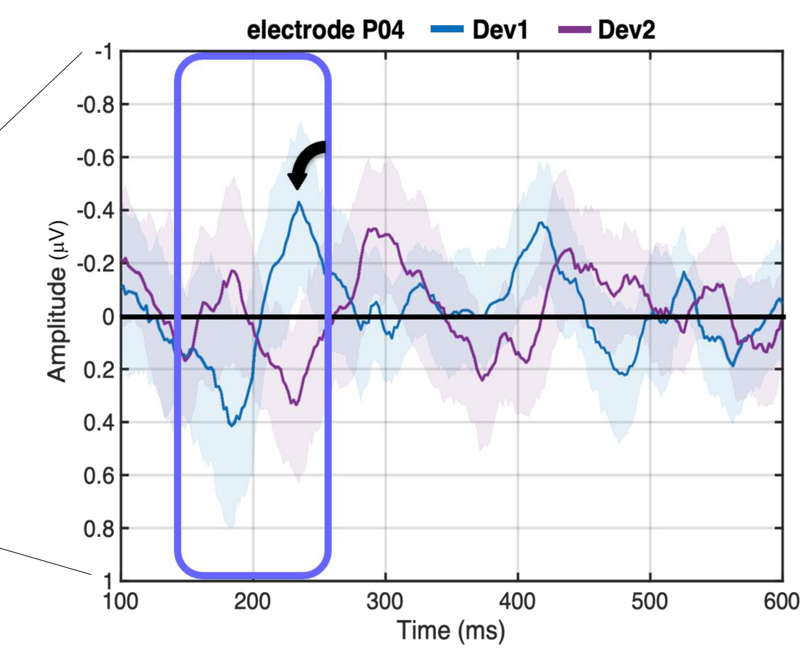


Figure 5. Electrode FZ Amplitude after Stimulus Onset. The purple box indicates the MMN range with the black arrow identifying the MMN peak where significance lies.

DISCUSSION

- The MMN signal was found for both the rare and the common deviant pairings. For both pairings, the MMN appears similarly widespread throughout the frontocentral brain areas, which is consistent with prior research.[4]
- When comparing the rare and common deviant pairings to each other, the difference in MMN responses shifts in topography to the parietal areas. This could potentially indicate different attentional networks required to process these deviant pairings than the standard pairing.
- The presence of MMN in English shows it has potential to be used as an objective measure of letter-speech sound perceptions. With additional studies, this type of objective measure could be developed further as a biomarker to identify those with reading and language-based disorders, such as dyslexia.
- Future research can expand this line of questioning by exploring how stimulus presentation may affect the automaticity with which these letter-speech sounds are integrated. Future research should also look to explore these relationships with other vowel sounds or other more complex sounds in the English language.

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