Impacts of Experimental and Linguistic Frequency: A P300 Analysis of Grapheme-Phoneme Correspondence

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INTRODUCTION

- Learning to read involves **incorporating letter-sound associations** into an existing speech framework [1]
- This is particularly challenging in English because of the **opaque** orthography where multiple phonemes can correspond with one grapheme [2-3]
- **Linguistic frequency** refers to how often a certain phoneme corresponds to a certain grapheme
- Previous research has examined brain activity associated with grapheme-phoneme correspondences using the **P300**, an **event-related potential (ERP)**
- P300 **amplitude** differences correspond with **reading ability**, and grapheme-phoneme **congruency** modulates the **latency** [4-6]
- Less research has examined whether **stimulus characteristics** affect the associated P300 response

Table 1. Example frequencies of phonemes for a given grapheme

Grapheme	Phoneme	Conditional Probability	Example
a	ae	.542	cab
	uh-	.186	canal
	ay	.129	angel
	ah	.077	wad
	aw	.021	also
	er	.021	coward
	eh	.020	many
	ih	.0005	spinach

Adapted from Berndt et al. (1987)

Research Objective:

- To determine the extent to which linguistic frequency affects the P300 response

METHOD

- *N* = 31 undergraduate students with a range of reading abilities
- Passive audiovisual oddball task with two auditory deviants
- EEG data collected with a 64-electrode Neuroscan Hydro-Net Quik-Cap and SynAmps2 amplifier
- Data preprocessed with EEGLAB and ERPLAB toolboxes in Matlab

Figure 1. Audiovisual oddball paradigm

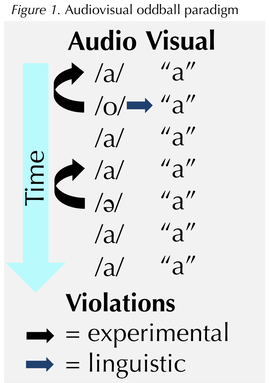


Table 2. Frequencies of standard and auditory deviants.

Experimental Frequency	Linguistic Frequency*	Phoneme	Example
Standard	Very Common	/a/	Cat
Deviant 1	Uncommon	/o/	Water
Deviant 2	Common	/ə/	What

* See Berndt et al. (1987) for this determination

RESULTS

Deviant 1 vs. Standard:

Figure 2. Topography of significant electrodes for contrast 1. Deviant 1 shows a P300 in both frontal and parietal areas.

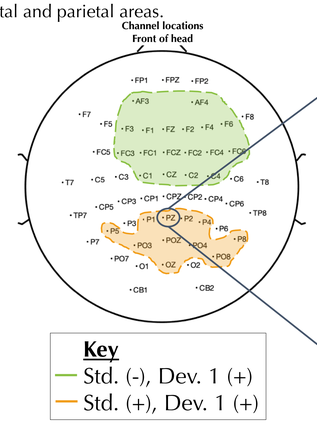
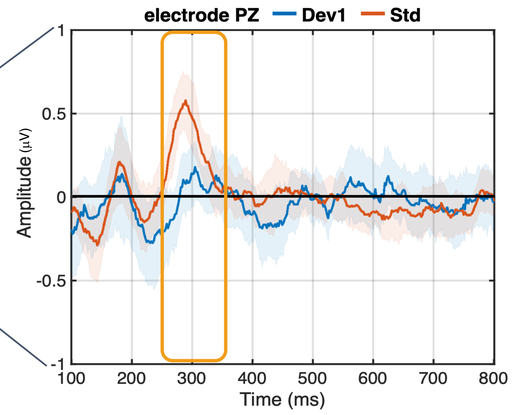


Figure 3. Trimmed means of Deviant 1 and Standard at the parietal midline electrode, PZ. The Standard shows a higher amplitude in the P300 time window than Deviant 1



Deviant 2 vs. Standard:

Figure 4. Topography of significant electrodes for contrast 2. Deviant 2 shows a P300 in the frontal area only.

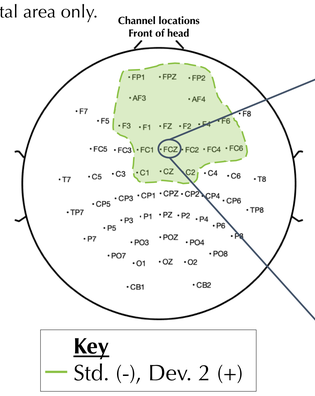
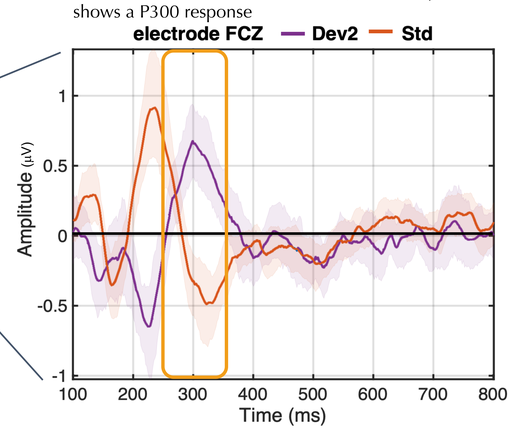


Figure 5. Trimmed means of Deviant 2 and Standard at the fronto-central midline electrode, FCZ. Only Deviant 2 shows a P300 response



Deviant 1 vs. Deviant 2:

Figure 6. Topography of significant electrodes for contrast 3. Deviant 1 and Deviant 2 show different topographical patterns in their P300s.

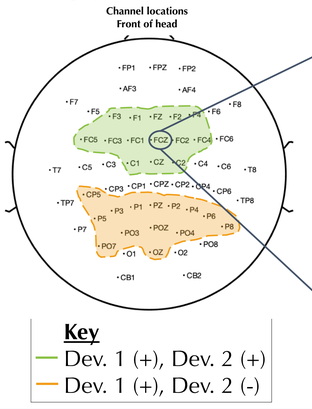
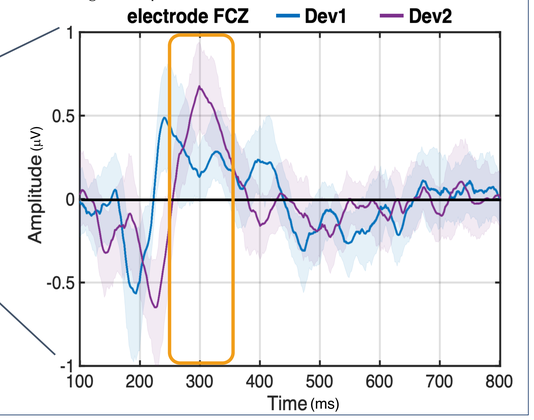


Figure 7. Trimmed means of Deviant 1 and Deviant 2 at the fronto-central midline electrode, FCZ. Deviant 2 has higher amplitude than Deviant 1 in the P300 window.



DISCUSSION

- **Both Deviant 1 and Deviant 2** show a P300 response, which is anticipated since they are unexpected stimuli at the experimental level
- **Only Deviant 1** extends to parietal areas, suggesting that **memory updating** may be occurring for the less common phoneme (i.e. this deviant is perceived as more novel)
- Taken together, these results suggest that **linguistic frequency does impact the P300 response**

Future Directions:

- **Latency effects** should be examined, particularly between the two deviants in frontal areas
- Other phonemes with **less congruency** should be considered (e.g. /e/ with "a")
- With larger sample size (for sufficient power), correlations between **brain activity** and **reading ability** should be examined

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