Neural processing of written language in deaf readers: An event-related potential analysis

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Introduction

Reading can be difficult for many deaf individuals – but some do become skilled readers

- 60% of deaf high school graduates read at or below a 4th grade reading level[11]
- But: 10% read above an 8th grade level[11]

Why? Phonological difficulties or lack of early language proficiency?

- Understanding phonology is important for hearing children learning to read
  - Also important for deaf children?
  - Lack of hearing → harder to learn about phonology
  - In deaf, better phonological knowledge sometimes associated with better reading skill[2,5]
- Many deaf children not proficient in any language when they learn to read
  - Need to know <u>any</u> language to learn to read another?
  - Deaf children, when raised in a sign language-rich environment, learn a signed language naturally – but most not raised this way
  - Sign language skill sometimes associated with better reading skill[1,3]
- Meta-analysis[6] - variance in reading proficiency in deaf individuals is predicted:
  - 11% by phonological knowledge
  - 35% by overall language ability (in a signed or spoken language, independent of reading)
- Why this matters → What are the best ways to teach deaf children to read?

Objective: Use real-time measures of language processing (ERPs) to better understand how some deaf individuals read more proficiently than others

Individual ERP responses change with language proficiency and exposure

- Children with dyslexia & poor phonological skills show reduced or altered N400 priming to phonologically related words[4,8]
- Size of P600 to grammatical violations increases with L1 proficiency[10]
- Size of N400 to semantic violations changes with L1 proficiency[9,13]
- Some early L2 learners show N400s to grammatical violations[7,12]

Research questions:

1) Do deaf and hearing individuals read proficiently using the same online language processing mechanisms?
2) Do deaf individuals <u>from different language backgrounds</u> (spoken vs. signed) read proficiently using the same online language processing mechanisms?

Methods

Participants: Severely/profoundly prelingually (<2 years of age) deaf adults (n=16), Age-matched hearing controls (n=15)

Procedure: Visual word-by-word presentation of stimuli, continuous EEG recorded from 19 scalp electrodes (10-20 system)

Sentence Violations (30 sentences/condition)

Well formed:	The huge house still <u>belongs</u> to my aunt.
Agreement violation:	The huge houses still <u>belongs</u> to my aunt.
Semantic violation:	The huge house still <u>listens</u> to my aunt.
Double semantic & agreement violation:	The huge houses still <u>listens</u> to my aunt.

Acceptability judgment at end of sentence. ERPs computed to onset of critical (underlined) word. Words presented for 600ms, 200ms ISI.

Word Pairs (30 pairs/condition)

Unrelated	raid – pear
Phonologically related	lair – pear
Orthographically related	dear – pear
Phonologically & orthographically related	wear – pear

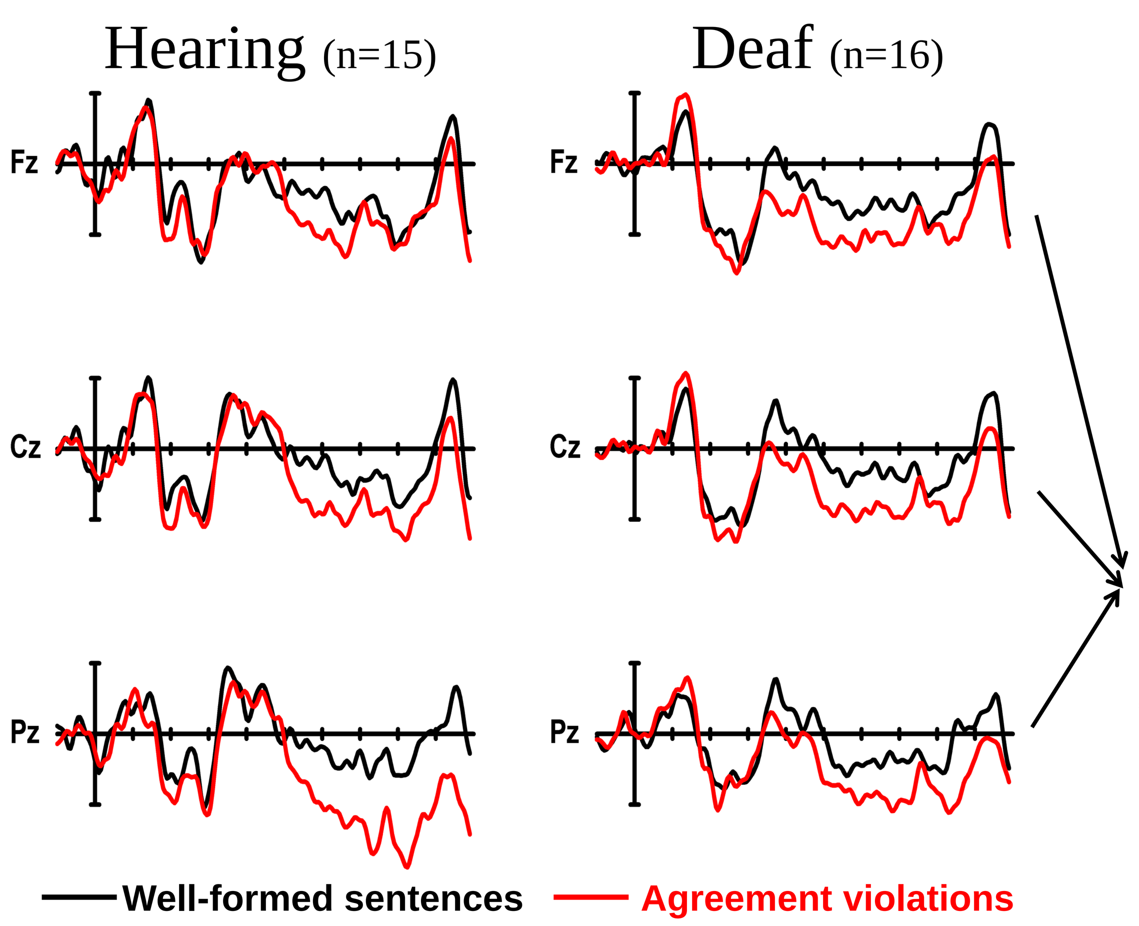
Lexical decision judgment after both words. ERPs computed to onset of target word. Prime presented for 600ms, 200ms ISI, target 800ms.

Subject/behavioral data:

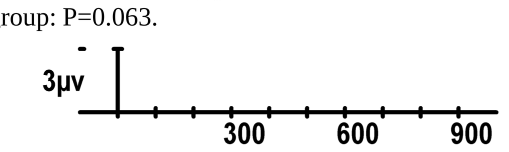
- **Standardized reading comprehension**: Woodcock Reading Mastery Test word and passage comprehension (max score: 124). **Results**: <u>Hearing</u>: mean=103.33, SD=7.29, range: 87-116; <u>Deaf</u>: mean=88.75, SD=22.04, range: 40-115 (means significantly different, P<0.05)
- **Language background:** Self-rated American Sign Language (ASL) proficiency, language usage and history (1-7 scale, 1=all spoken, 7=all manual/signed)

Results

1. Deaf readers: P600 to agreement violations; some individuals show an earlier positivity

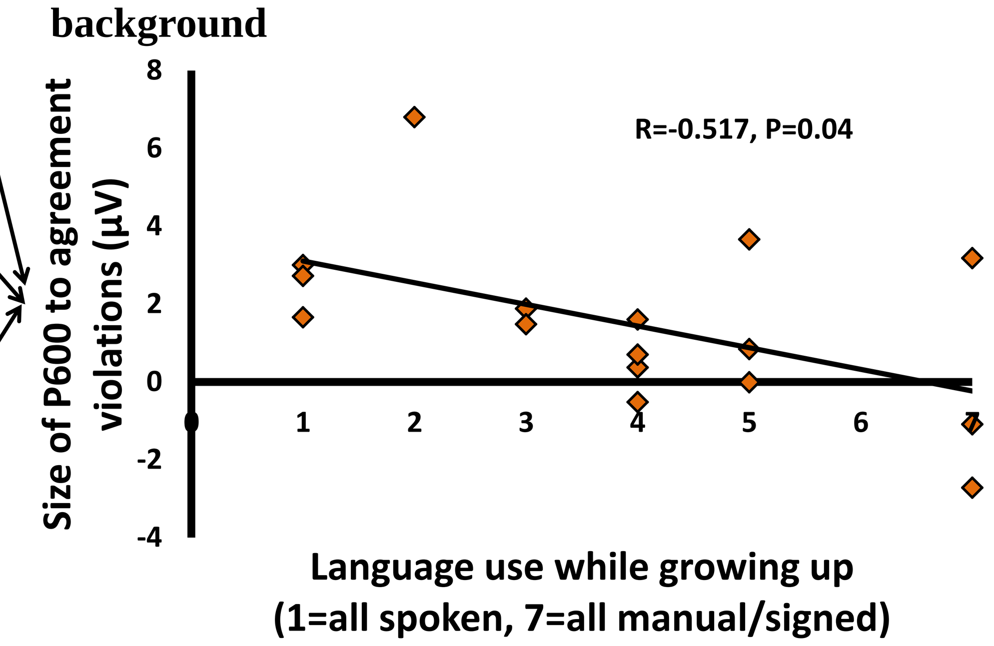


Significant difference between conditions in P600 (500-900ms) time window for both deaf (P<0.05) and hearing (electrode interaction, P<0.01) groups. Difference between conditions in 300-500ms time window for deaf group: P=0.063.

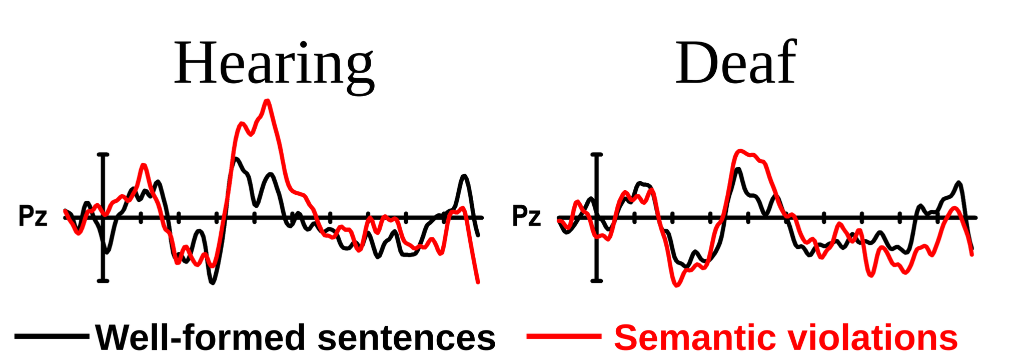


2. Growing up with more spoken English is correlated with larger P600s

Caveat: few participants from a sign-language rich background



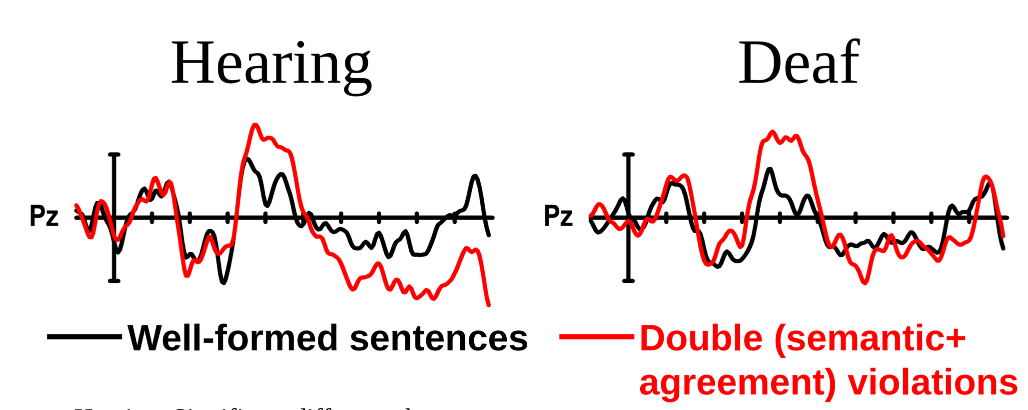
3. Deaf readers: Lack of robust N400 to semantic violations



Hearing: Significant difference between conditions in N400 (300-500ms) time window (P<0.05, across all midline electrodes)

Deaf: Difference between conditions in N400 (300-500ms) time window: P=0.053 (w/electrode interaction, larger posteriorly)

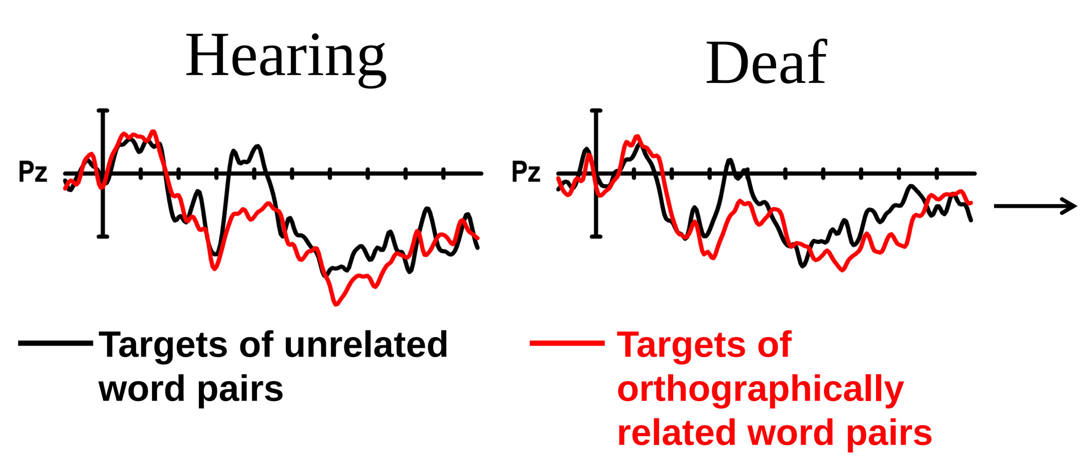
4. Deaf readers: Large N400 to combined semantic+agreement violations; no P600

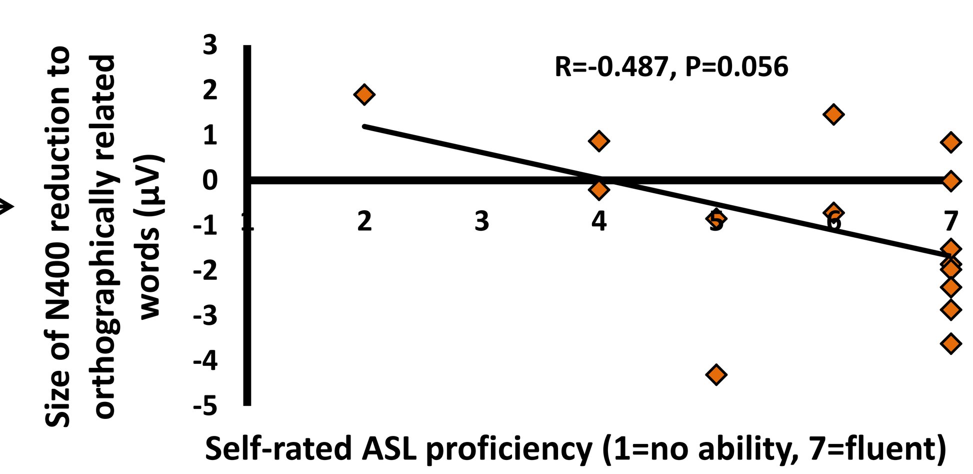


Hearing: Significant difference between conditions in N400 (300-500ms, P<0.01) and P600 (500-900ms, P<0.05 w/electrode interaction) time windows.

Deaf: Significant difference between conditions in N400 (300-500ms, P<0.01 w/electrode interaction) time window.

5. Deaf readers: Larger N400 priming response to orthographically related words correlated with greater self-rated ASL proficiency





Conclusions

Deaf readers can develop robust neural representations of English grammar

- Growing up in a spoken language environment is correlated with more robust representations.
- We have few participants from a rich sign language background, so cannot make conclusions about English syntactic understanding in that population.

Semantic violations do not elicit robust responses in our deaf participants

- May be a function of reading comprehension skill; will become clearer with a larger sample size

Combined semantic and agreement sentence violations elicit larger responses than semantic violations alone, but not in semantic- and agreement-specific ways.

- The sentence is recognized as "more wrong" (larger N400 than to semantic violations alone), but not specifically wrong in both semantics and agreement (no P600).
- Curious that P600s are elicited by agreement violations alone, but less to semantic+agreement violations

Proficiency in ASL is associated with a greater sensitivity to English orthography

- Experience with a visual language may enhance sensitivity to visual aspects of other languages.

Future Directions

Increase sample size in order to:

- Analyze relationships between online language processing and reading skill
- Better compare differences between deaf readers with different language backgrounds (especially growing up in a sign language-rich environment)
  - Can phonology and orthography be processed differently and still lead to the same reading comprehension skill?

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