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.
- But: 10% read above an 8th grade level.

Why? Phono-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.

Many deaf children not proficient in any language when they learn to read:

- Need to know any language to learn to read another.
- Even so, 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.

Meta-analysis — 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.
- Size of P600 to grammatical violations increases with L1 proficiency.
- Size of N400 to semantic violations changes with L1 proficiency.
- Some early L2 learners show N400s to grammatical violations.

Research questions:

1. Do deaf and hearing individuals read proficiently using the same online language processing mechanisms?
2. Do deaf individuals 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 belongs to my aunt. |
| Agreement violation | The huge house still belongs to my aunt. |
| Semantic violation | The huge house still listens to my aunt. |
| Double semantic & agreement violation | The huge house still listens 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 | Fund – pear |
| Phonologically related | ear – ear |
| Orthographically related | ear – pear |
| Phonologically & orthographically related | ear – ear |

Lexical decision judgment after both words. ERPs computed to onset of target word. Primes 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: Hearing: mean=103.3, SD=7.29, range: 87-116. Deaf: mean=68.75, 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/signing) |

Results

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

- Hearing (n=15)
- Deaf (n=16)

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

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

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?

References


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