Brain-based individual difference measures of reading skill in deaf adults

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Introduction

How do we teach children to read?

- Usually based on the sounds of language

What if those children are deaf?

Reading can be difficult for many (but not all) deaf individuals:

- 60% of deaf high school graduates read at or below a 4th grade level[3]
- But: 10% read above an 8th grade level[3]

Why? There is disagreement[2]. The reasons matter for determining the best educational strategies and language environments for deaf children.

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

Specifically:

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

Methods

Participants: Severely/profoundly prelingually (<2 years of age) deaf adults (n=40), Age-matched hearing controls (n=22)
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 houses still belongs to my aunt.
Semantic violation:	The huge house still listens to my aunt.
Double semantic & agreement violation:	The huge houses 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	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.

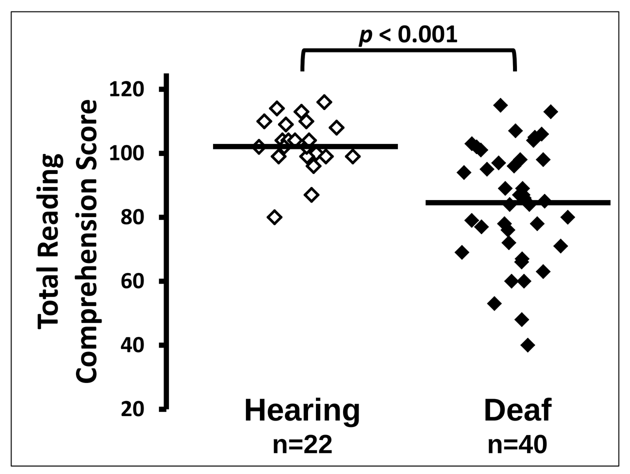
Subject/behavioral data:

- **Standardized reading comprehension**: Woodcock Reading Mastery Test word and passage comprehension
- **Language background:** Self-rated ASL proficiency, language usage and history (1-7 scale, 1=all spoken, 7=all manual/signed)

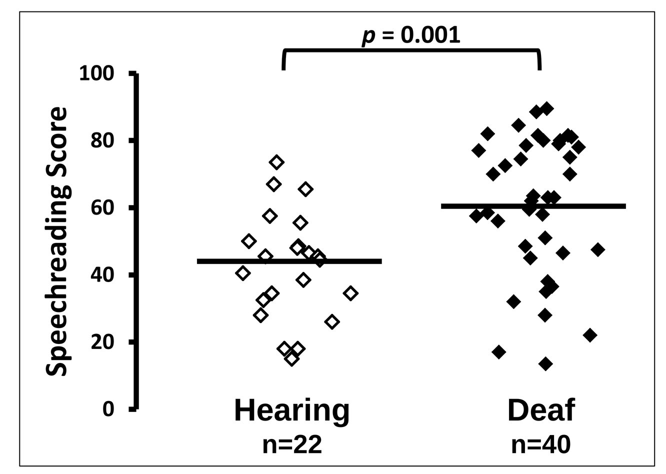
Results

1. Participant characteristics

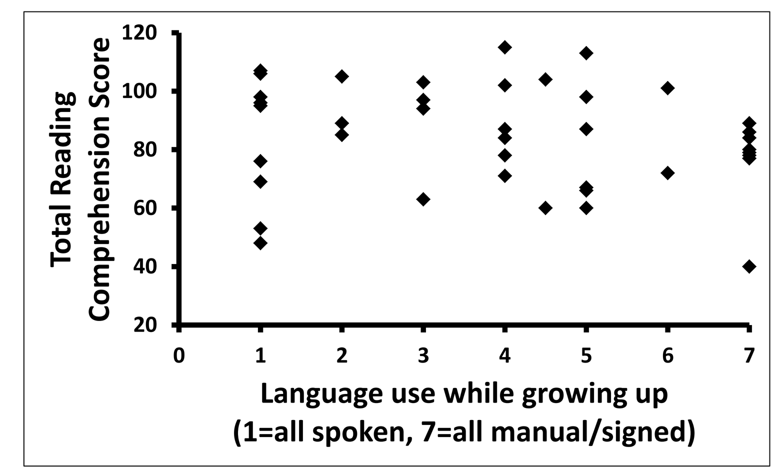
Reading comprehension



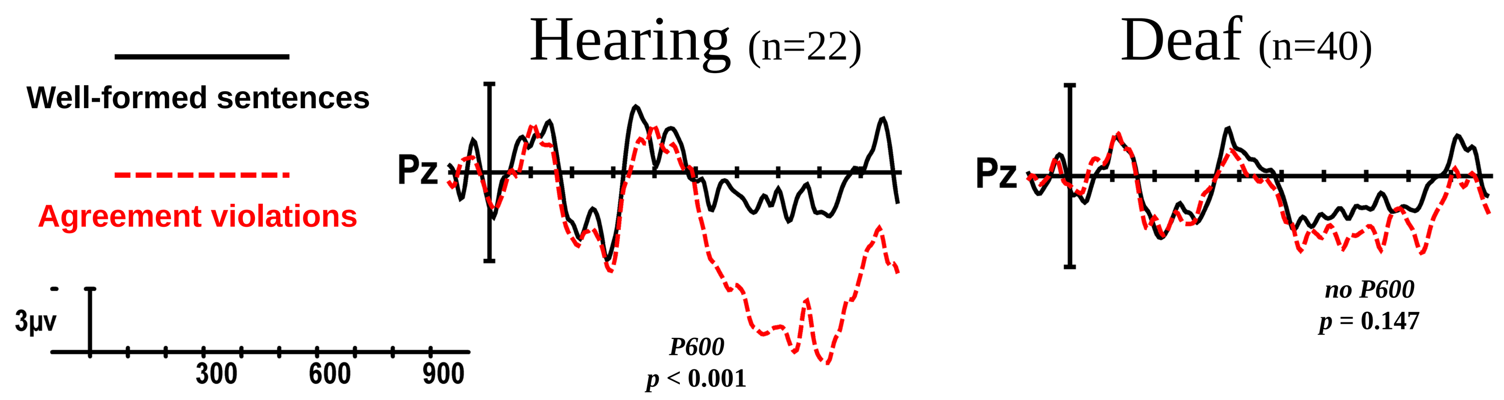
Speechreading



Deaf readers: language background

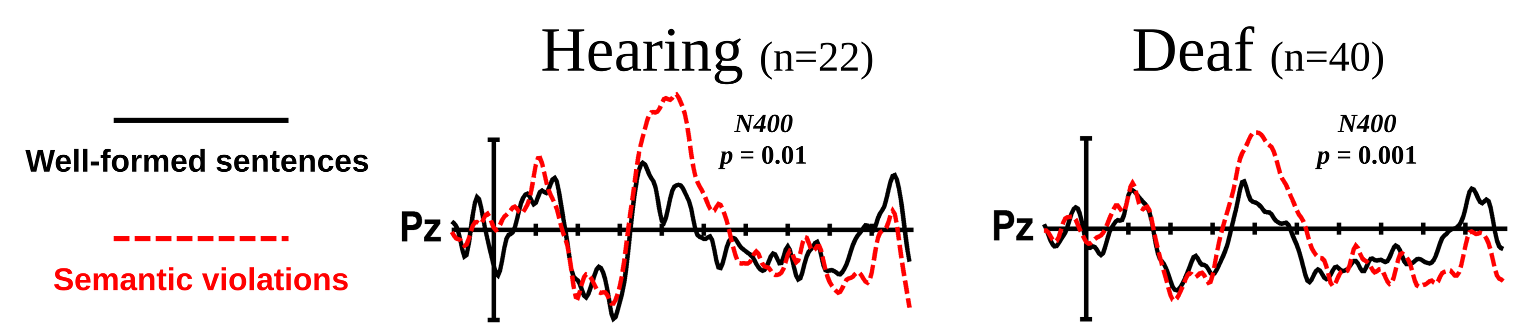


2. Syntactic (agreement) violations in sentences



Some deaf individuals show P600s to syntactic violations, but not as a group overall.

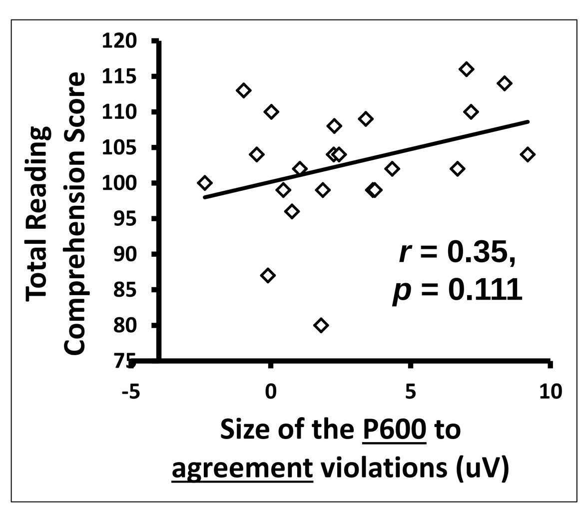
3. Semantic violations in sentences



Both groups show an N400 to semantic violations in sentences.

4. What predicts better reading skill – responses to syntax or semantics?

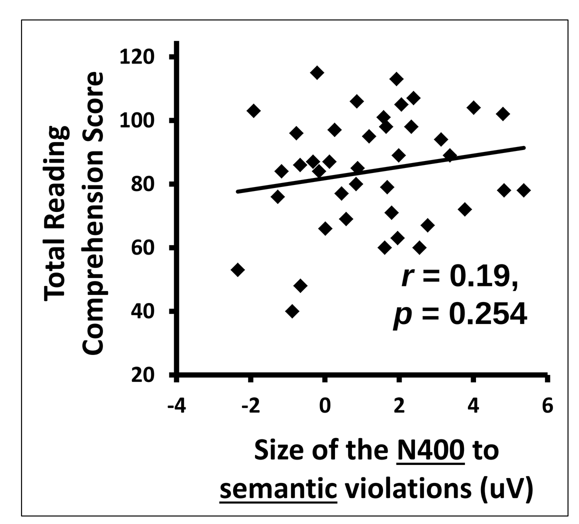
Hearing readers: Larger P600 to syntactic violations predicts better reading skill?



Multiple regression

Outcome:	R^2total	R^2adj	F_{total}	p	
Reading Comprehension Score	*0.178*	*0.041*	*1.299 (3, 18)*	0.305	
Predictors	b	(SE)	t	p	β
P600 size: syntactic errors	1.00	0.57	1.75	0.097	0.38
Speechreading	0.01	0.11	0.13	0.901	0.03
Years Education	1.07	0.97	1.11	0.283	0.24

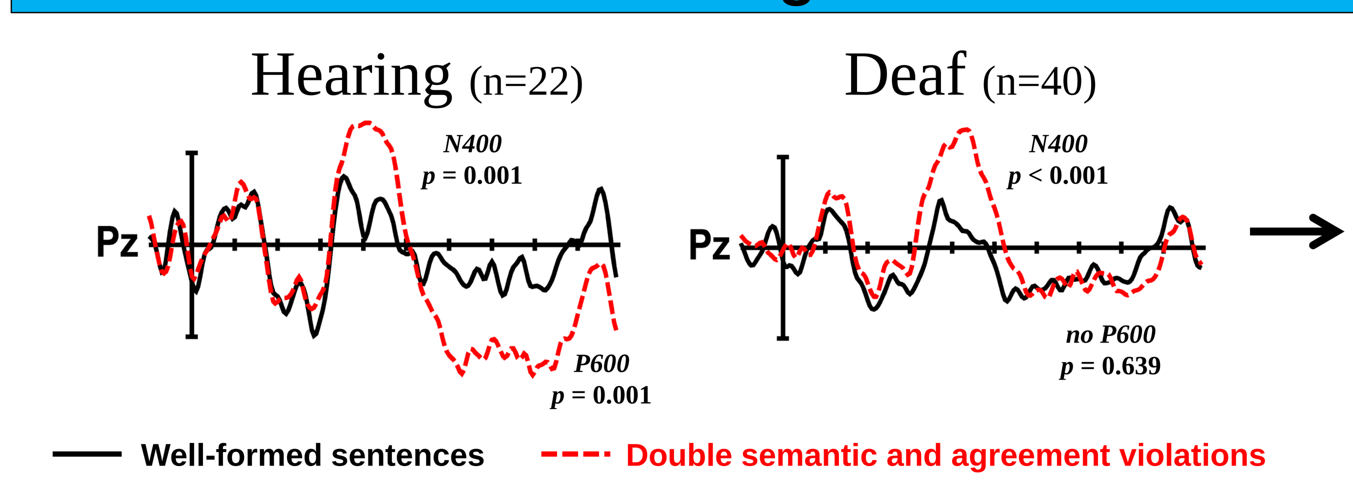
Deaf readers: Larger N400 to semantic violations predicts better reading skill



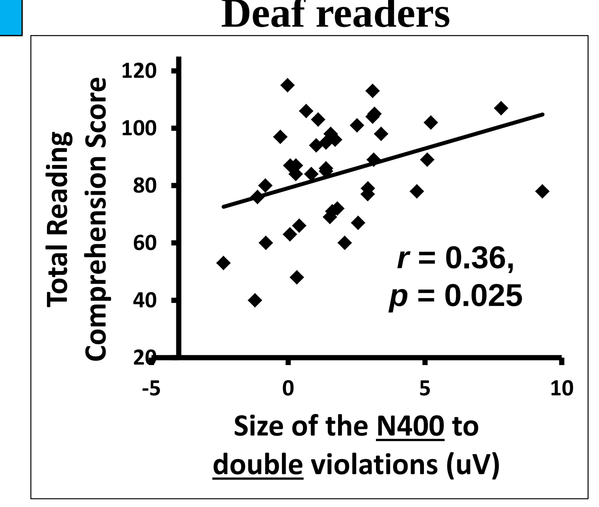
Multiple regression

Outcome:	R^2total	R^2adj	F_{total}	p	
Reading Comprehension Score	*0.62*	*0.58*	*14.273 (4, 35)*	<0.001	
Predictors	b	(SE)	t	p	β
N400 size: semantic errors	2.26	1.04	2.18	0.036	0.23
Speechreading	0.46	0.11	4.00	<0.001	0.53
Growing Up Language	0.21	1.03	0.20	0.841	0.02
Years Education	3.40	1.01	3.37	0.002	0.40

5. Double semantic and agreement violations



Deaf readers



Multiple regression – deaf readers

Outcome:	R^2total	R^2adj	F_{total}	p	
Reading Comprehension Score	*0.70*	*0.67*	*20.742 (4, 35)*	*<0.001*	
Predictors	b	(SE)	t	p	β
N400 size: combined errors	2.93	0.74	3.99	<0.001	0.38
Speechreading	0.43	0.10	4.19	<0.001	0.49
Growing Up Language	-0.02	0.90	-0.02	0.987	0.00
Years Education	3.60	0.89	4.03	<0.001	0.42

Conclusions

The best deaf readers have larger N400s to semantic and combined semantic+syntactic sentence violations.

This suggests that **the best deaf readers focus more on meaning than grammar**.

- Plausible: The "good enough" parsing strategy[1]

Hearing readers appear to be different. The best hearing readers seem to have the largest responses to grammatical violations.

This suggests teaching strategies that can be tested with deaf children. Focusing more on vocabulary and relationships between words rather than 100% precise grammatical parsing?

Also: Proof of concept that **individual ERP responses can predict reading comprehension** in highly variable populations. The variation is systematic.

Future Directions

Final sample size:

- 45 deaf participants
- 45 hearing participants

Final analysis:

- Multiple regression to find best predictors of:
  - Better reading skill
  - Larger ERP responses
- Include both groups in the same model

Future projects: Similar research in deaf children, in homogenous language groups…

References

[1]Ferreira, F. & Partson, N.D. (2007). The 'Good Enough' approach to language comprehension. *Language & Linguistics Compass*, *1*(1-2): 71-83.
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[3]Qi, S. & Mitchell, R.E. (2012). Large-scale academic achievement testing of deaf and hard-of-hearing students: Past, present, and future. *Journal of Deaf Studies and Deaf Education*, *17*(1): 1-18.

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