Frequency and Imageability Effects on N400 Amplitudes in Adolescents with SLI

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ABSTRACT

Children with *Specific Language Impairment* (SLI) have smaller vocabularies and slower/less accurate word retrieval than typical peers (CA; Leonard, 1998). In addition, even when children with SLI have learned words, their representations may be less well specified relative to typical peers (Mainela-Arnold, Evans, & Coady, 2008). We examined N400 amplitudes during a lexical decision task in order to determine whether adolescents with SLI process high/low frequency words similarly to peers. While typical adolescents showed an effect of frequency in ERPs and accuracy, adolescents with SLI only showed an effect in accuracy. Overall findings indicate that although adolescents with SLI show similar behavioral responses as CA, they may be using a different strategy. Specifically, adolescents with SLI seem to rely on imageability, while CA peers use lexical and phonotactic frequency during lexical decision. Imageability may be less efficient for language comprehension and could be one indication why adolescents with SLI continue to have difficulty.

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BACKGROUND

- In addition to morphosyntactic deficits, children with SLI have lexical deficits. They have delayed acquisition and smaller vocabularies as compared to peers; require more exposure to learning novel words; are slower and less accurate accessing of words from memory (Leonard, 1998); and once acquired, their lexical representations are more vulnerable to lexical cohort competition effects (Mainela-Arnold, Evans, & Coady, 2008).
- Accuracy and reaction time are indirect measures of ease or difficulty of lexical processing, whereas event-related brain potentials (ERPs) provide direct measures of processing load.
- The N400 ERP component is a negative-going waveform peaking ~ 400 ms following a meaningful stimulus. The amplitude of the N400 is thought to reflect *ease of processing*, with lower amplitudes reflecting the facilitation of processing (Kutas & Federmeier, 2000).
- In typical adults, high frequency words elicited lower amplitude N400 amplitudes than low frequency words (Rugg, 1990) suggesting that word frequency affects processing load.

PURPOSE

This study examined the *ease of processing* of high and low frequency words by comparing N400 amplitudes in a lexical decision task for adolescents with SLI and age-matched peers.

METHOD

Participants

	SLI (N = 14)			TD (N = 14)		
	Mean	*SD*	Range	Mean	*SD*	Range
Age (years; months)	15;2	2;2	11;8-18;4	14;4	1;10	11;10-18;3
Leiter-R						
Nonverbal IQ[a]	104*	15	82-127	113	10	100-127
Figure Ground[b]	10.1	3	5-16	11.4	2	8-15
Form Completion[b]	10.9	3	7-14	11.5	2	7-14
Sequential Order[b]	11	3	5-15	12	2	8-16
Repeated Patterns[b]	9.9**	2	6-13	12.4	2	9-14
CELF-4[c]						
Formulated Sentences	6.9**	3	2-11	13.2	1	10-15
Recalling Sentences	2.6**	2	1-6	11.9	2	8-14
CASL[d]						
Nonliteral Language	74.5**	10	52-92	102.8	10	81-118
Meaning from Context	77.5**	12	60-93	110.7	13	88-129
CREVT-2[e]						
Expressive Vocabulary	81.7**	10	63-100	105.1	9	90-115
Receptive Vocabulary	85**	12	66-101	107.1	11	80-118

* $p = .05$, ** $p < .01$

[a] Leiter International Performance Scale-Revised (Roid & Miller, 1997), standard scores ($M = 100$, $SD = 15$)

[b] Leiter-R subtest standard scores ($M = 10$, $SD = 3$)

[c] Clinical Evaluation of Language Fundamentals - 4th Edition (Semel, Wiig, & Secord, 2003), subtest standard scores ($M = 10$, $SD = 3$)

[d] Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999), subtest standard scores ($M = 100$, $SD = 15$)

[e] Comprehensive Receptive Expressive Vocabulary Test (Wallace & Hammill, 2002), standard scores ($M = 100$, $SD = 15$)

Stimuli

Word Frequency

	High (N = 100)			Low (N = 100)			*p*
	Mean	*SD*	Range	Mean	*SD*	Range	
Word Frequency[a]	208.74	200.88	40-1207	2.41	2.01	1-9	<0.001
Phonotactic Probability[b]	0.0111	0.0099	0.0013-0.0461	0.0082	0.007	0.0009-0.0392	0.02
Imageability[c]	5.07	1.11	2.2-6.9	5.15	0.96	2.2-6.9	0.57
Neighborhood Density[d]	21.73	6.56	4-36	21.73	6.22	9-35	1.00

[a] Ku-era & Francis, 1967 (MRC Psycholinguistic Database, www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm)

[b] Vitevitch & Luce, 2004 (Phonotactic Probability Calculator, www.people.ku.edu/~mvitevit/PhonoProbHome.htm)

[c] Cortese & Fugett, 2004 (http://myweb.unomaha.edu/~mcortese/norms link.htm)

[d] Nusbaum, Pisoni, & Davis, 1984 (Washington University in St. Louis Speech & Hearing Lab Neighborhood Database, http://128.252.27.56/Neighborhood/Home.asp)

Imageability (Post-hoc analysis)

	High (N = 103)			Low (N = 97)			*p*
	Mean	*SD*	Range	Mean	*SD*	Range	
Word Frequency[a]	97.26	170.94	1-1207	114.40	180.55	1-967	0.49
Phonotactic Probability[b]	0.0096	0.0084	0.0011-0.0392	0.0096	0.0091	0.0009-0.0461	0.99
Imageability[c]	5.93	0.57	5.1-6.9	4.24	0.63	2.2-5.0	<0.0001
Neighborhood Density[d]	21.49	6.35	8-35	21.99	6.43	4-36	0.58

*No correlation between Word Frequency and Imageability: r = -.092, p = .193

Procedure

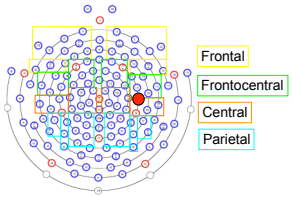
- Lexical decision task; participants heard a series of words and nonwords (*Example: HF "boat" [bot], LF "gourd" [gord]*)
- Participants were instructed to press left button if they heard a word and right button if they heard a nonword
- ERPs recorded with 128-channel Hydrocel Geodesic Sensor Net (Electrical Geodesics, Inc.), Cz reference during acquisition, re-referenced offline to an average of left and right mastoid electrodes
- Epochs of 1300ms (-100 to 1200ms relative to stimulus onset) were averaged and analyzed separately for HF and LF words following artifact rejection and blink correction

Event-Related Potentials

N400

Regions of Interest (ROIs):
- Frontal
- Frontocentral
- Central
- Parietal

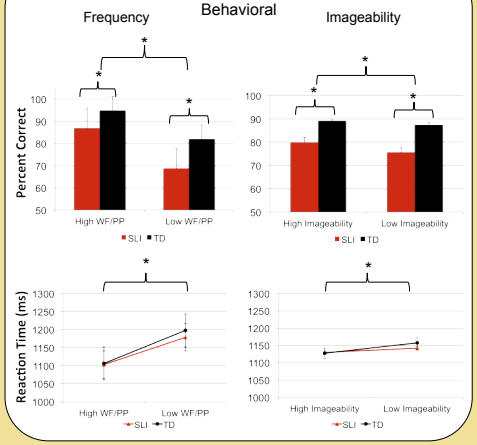
Dependent measure:
- Mean amplitude between 350-1200ms

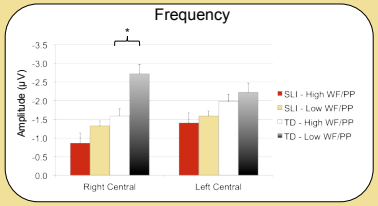


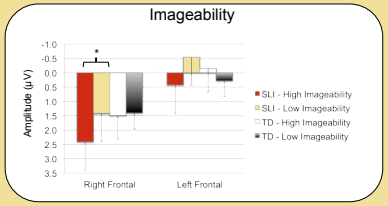
- Frequency by Laterality repeated measures ANOVAs performed on each group separately within each ROI
- Prior research indicates (Rugg, 1990; Kutas & Federmeier, 2000) that High WF/PP words should elicit lower amplitude N400s than Low WF/PP words, if they are easier to process or are facilitated.

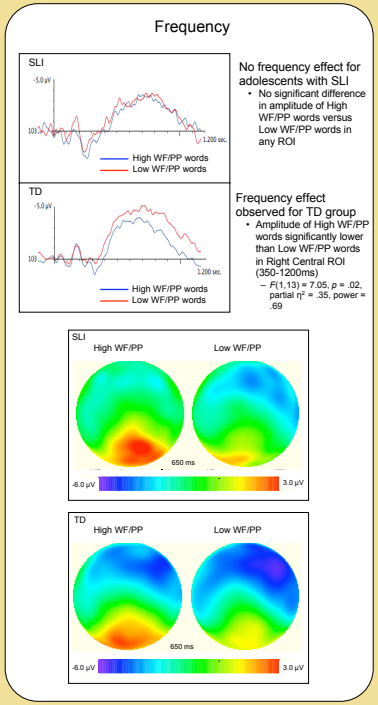
RESULTS

Behavioral



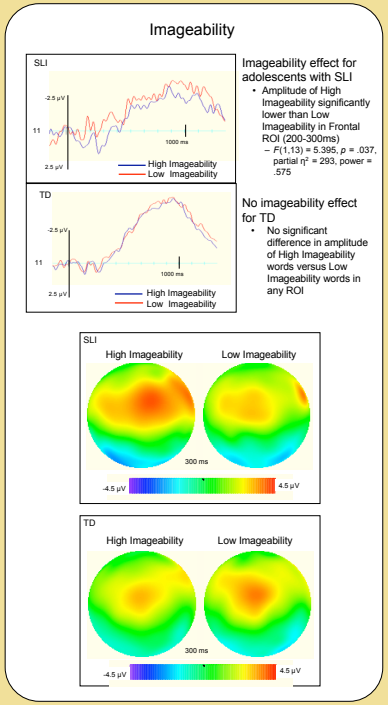






No frequency effect for adolescents with SLI
- No significant difference in amplitude of High WF/PP words versus Low WF/PP words in any ROI

Frequency effect observed for TD group
- Amplitude of High WF/PP words significantly lower than Low WF/PP words in Right Central ROI (350-1200ms)
  - $F(1,13) = 7.05$, $p = .02$, partial $\eta^2 = .35$, power = .69



Imageability effect for adolescents with SLI
- Amplitude of High Imageability significantly lower than Low Imageability in Frontal ROI (200-300ms)
  - $F(1,13) = 5.395$, $p = .037$, partial $\eta^2 = 293$, power = .575

No imageability effect for TD
- No significant difference in amplitude of High Imageability words versus Low Imageability words in any ROI

SUMMARY

- TD adolescents receive facilitation in processing high frequency words, reflected in reduced N400 amplitude of high frequency as compared with low frequency words.
- Adolescents with SLI do not -- there is no evidence of facilitation in processing high frequency words in their N400s.
- Instead, they may be relying on different lexical-semantic networks to make lexical decisions.
- By the time they reach adolescence, individuals with SLI are still having difficulty processing words - even simple, one-syllable, high frequency words.