Lexical Deficits in SLI: Evidence from Auditory N400 ERPs

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ABSTRACT

Lexical processing is important for monitoring comprehension of spoken language. There is evidence that lexical representations in adolescents with *Specific Language Impairment* (SLI) may be different from their typical age-matched peers (Mainela-Arnold, Evans, & Coady, 2008). We investigated lexical processing using event-related potentials (ERPs) in adolescents with and without SLI. While typical adolescents showed an effect of frequency in ERPs and accuracy, adolescents with SLI only showed an effect in accuracy. Accuracy and ERP waveforms indicate, consistent with prior work, that lexical representations of individuals with SLI may be degraded and may require greater resources to manipulate than typical peers.

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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).
- In addition to reduced working memory capacity and speed of processing (Leonard, et al., 2007), children with SLI have deficits in cognitive mechanisms believed to support word learning (Coady & Evans, 2008; Evans, Saffran, & Robe-Torres, 2009).
- Accuracy and reaction time are indirect measure 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 List						
	HF (N = 100)			LF (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] Kucera & 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)

Procedure

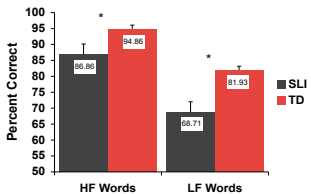
- Lexical decision task; participants heard a series of words and nonwords *Example: HF "boat" [bot]. LF "gourd" [gord]*
- Participants were instructed to press left button if they heard a word and right button if they heard a nonword
- ERPs recorded with 128-channel Hydrocel Geodesic Sensor Net (Electrical 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

RESULTS

Behavioral

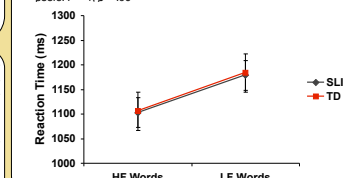
Accuracy

- Both groups of adolescents were significantly more accurate at responding to HF words than LF words
  - $F(1,25) = 5.14$, $p = .03$, partial eta squared = .17, power = .59
- Adolescents with SLI were significantly *less* accurate than TD peers
  - $F(1,25) = 6.3$, $p = .02$, partial eta squared = .20, power = .68



Reaction Time

- No difference in either group of adolescents' reaction time to HF words versus LF words: $F < 1$, $p = .54$
- No difference in reaction time between adolescents with SLI and TD peers: $F < 1$, $p = .96$

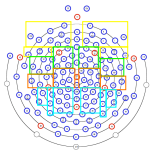


RESULTS

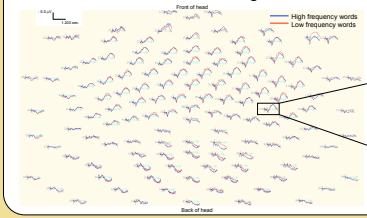
Event-Related Potentials

N400

- Regions of interest: Frontal, Frontocentral, Central, Parietal
- Dependent measure: Mean amplitude between 350-1200ms
- Frequency x Laterality repeated measures ANOVAs performed on each group separately within each region
- Prior research indicates (Rugg, 1990; Van Petten & Kutas, 1990; Kutas & Federmeier, 2000) that HF words should elicit lower amplitude (i.e., less negative) N400s than LF words, if HF words are easier to process or are facilitated due to their ease of processing.

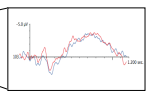


Adolescents with SLI: Grand Average

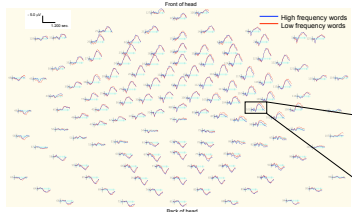


No N400 word frequency effect for SLI

- No significant difference in amplitude of HF words versus LF words in any region

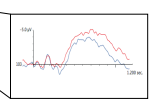


TD Adolescents: Grand Average



N400 word frequency effect observed for TD group

- Amplitude of HF words significantly lower than LF words in Right Central region
  - $F(1,13) = 7.05$, $p = .02$, partial eta squared = .35, power = .69



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.
- By the time they reach adolescence, individuals with SLI are still having difficulty processing words, even simple, one-syllable, high frequency words.