



Modulation of N400 by Word Frequency: The Role of Vocabulary Knowledge and Phonological Working Memory in Adolescents with SLI

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ABSTRACT

This study investigated the relationship between modulation of N400 by word frequency, vocabulary knowledge and phonological working memory in adolescents with and without Specific Language Impairment (SLI). ERP studies have shown significant positive correlations between listening comprehension ability and semantic modulation of N400 (Henderson et al. 2011) in typical children and less semantic modulation of N400 for children with poorer digit span and poorer receptive vocabulary in children with and without SLI (Sabisch et al. 2006). However, to date, the relationship between modulation of N400 by word frequency and vocabulary knowledge and working memory has not been examined. In the present study, children completed a lexical decision task where ERPs were recorded to HF and LF words. N400 word frequency effects were significantly correlated with vocabulary in both groups, although in different regions. However, N400 word frequency effects were correlated with phonological working memory in adolescents with SLI, but not in TD peers.

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BACKGROUND

Children with SLI have smaller vocabularies and slower/less accurate word retrieval than chronological age-matched typical peers (TD; Leonard, 1998). Similar to typical children, children with SLI are faster and more accurate in processing high versus low frequency words (e.g., Leonard et al., 1983; Mainela-Arnold, Evans, & Coady, 2008, 2010).
 Phonological working memory has been proposed as a mechanism to support lexical acquisition in typical language development and in children with SLI (Gathercole, 2006). However, to date, attempts to demonstrate the relationship between phonological working memory and vocabulary knowledge has remained elusive. 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, and cognitive processing load (Kutas & Federmeier, 2000).
 In typical adults, N400 amplitude is lower for high frequency words than low frequency words (Rugg, 1990). N400 amplitude is similarly modulated by word frequency in TD controls but not in SLI (Sizemore, Polse, Burns, & Evans, 2011).

ERPs may provide a more sensitive measure of the relationship between phonological working memory and word knowledge in children with SLI

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		
NRT ^b								
Total % phonemes correct	84.8**	9.5	65.6-98.9	95.1	4.6	87.5-100		
4-syllable % phonemes correct	70.0**	15.8	41.7-97.2	89.3	10.4	69.4-100		
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 Letter International Performance Scale-Revised (Roid & Miller, 1997), standard scores (M = 100, SD = 15)
^b Nonword Repetition Task (Dollaghan & Campbell, 1998), percent correct
^c Clinical Evaluation of Language Fundamentals - 4th Edition (Semel, Wiig, & Secord, 2003), subtest standard scores (M = 100, 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

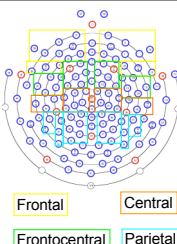
Word Frequency	High (N = 100)				Low (N = 100)				p
	Mean	SD	Range	Mean	SD	Range			
Phonotactic Probability ^a	208.74	200.88	40-1207	2.41	2.01	1-9	<0.001		
Imageability ^b	5.07	1.11	2.2-6.9	5.15	0.96	2.2-6.9	0.57		
Neighborhood Density ^c	21.73	6.56	4-36	21.73	6.22	9-35	1.00		

^a Kucera & Francis, 1967. NRC Psycholinguistic Database, www.psy.uwa.edu.au/motbasebase/uwa_mrc.htm
^b Mullen & Luca, 2004. Psychometric Probability Calculator, www.people.siu.edu/~mullen/PhonProbCalculator.htm
^c Cortese & Fugère, 2004. <http://myweb.ucsb.edu/~mccorces/home.htm>
^d Nusbauer, Pisoni, & Davis, 1984. <http://128.252.27.56/Neighborhood/home.asp>

Procedure

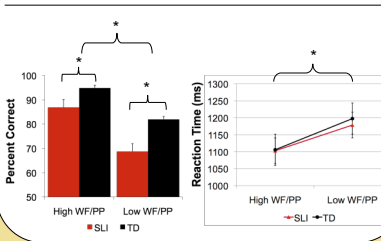
- Lexical decision task; participants heard a series of words and nonwords
 - Example:
 HF "boat" [bot]
 LF "gourd" [gord]
- Participants were instructed to press a button after each item
 - left button = word
 - right button = nonword

Event-Related Potentials

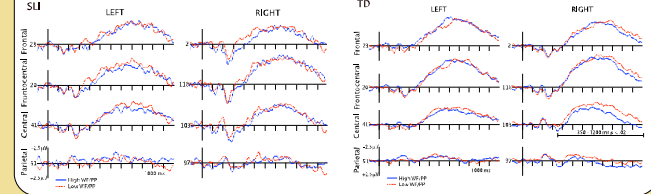


- ERPs recorded with 128-channel HydroCel Geodesic Sensor Nets
- Cz reference during acquisition, re-referenced offline to average of mastoid electrodes
- Epochs of 1300ms (~100 ms to 1200 ms) analyzed following artifact rejection and blink correction

RESULTS - Behavioral



RESULTS - ERP



CORRELATIONS

SLI	LEFT				RIGHT			
	Frontal	Frontocentral	Central	Parietal	Frontal	Frontocentral	Central	Parietal
NRT - Total	.024	.161	.381	-.136	.244	.539*	.454	-.061
NRT - 4 syllable	-.172	.280	.424	-.147	.368	.612*	.440	-.025
CREVT-Rec	.140	.298	.661*	.459	.316	.484	.384	.315
CREVT-Exp	.259	.500	.694**	.399	.242	.472	.475	.458

* p < .05, ** p < .01

TD	LEFT				RIGHT			
	Frontal	Frontocentral	Central	Parietal	Frontal	Frontocentral	Central	Parietal
NRT - Total	-.378	-.142	.052	-.183	.166	.210	.326	.047
NRT - 4 syllable	-.413	-.166	-.024	-.262	.137	.181	.304	.011
CREVT-Rec	.332	.358	.329	.384	.517	.534*	.614*	.184
CREVT-Exp	-.024	.105	.240	.318	.277	.299	.422	.283

* p < .05

Note: Correlations between peak amplitude differences (LF-HF) between 350-1200ms and raw test scores examined separately for each group in each region.

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.
- Higher receptive vocabulary scores were associated with larger magnitude word frequency effects -- greater difference in amplitude of HF and LF N400s -- in both groups, though in different regions. For adolescents with SLI, higher expressive vocabulary was also associated with larger N400 word frequency effects. N400 effects were correlated with nonword repetition performance for SLI group, indicating that individuals with better NRT performance showed larger N400 effects.
- ERP modulation by word frequency is sensitive to differences in lexical knowledge and phonological working memory in adolescents with and without SLI and suggests qualitative differences in lexico-semantic organization in adolescents with SLI as compared to TD peers.