ERP evidence for both similar and distinct cortical networks underlying semantic integration in adolescents with Specific Language Impairment (SLI).

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Abstract

It has recently been suggested that the pattern of syntactic, morphological, and phonological deficits seen in children with Specific Language Impairment (SLI) is consistent with abnormalities in the brain structures that support procedural sequential learning and memory; whereas lexical knowledge and the supporting declarative-memory system, is not only spared in SLI, but may function as a compensatory learning mechanism for these children [6,7]. N400 studies of lexical processing of words in sentences suggest that lexical semantic processing may differ for children with SLI as compared to typically developing peers, however, and suggest that they may experience greater effort integrating lexical semantic information as compared to their peers [4,5,8].

Children as young as 5 evidence clear modulation of the N400 in lexical processing of words in sentences with behavioral accuracy being greater than 95% in both visual and auditory modalities [2], yet children with SLI are significantly less accurate in judging whether sentences make sense or not as compared to normal language controls regardless of whether sentences are in written or spoken formats [4,5,8].

Ullman and colleagues argue that children with SLI may *appear* to have lexical semantic processing deficits if experimental conditions provide little or no contextual support and/or force children with SLI to rely heavily on their impaired procedural memory system [7].

In this study we ask if the N400 is modulated in a similar manner for school-aged children with SLI and typically developing peers when they correctly comprehended the questions. To ensure that the words are in the lexicons of children with SLI, we used the same simple declarative sentences used in Holcomb et al (1992) that were modeled after those used by Kutas & Hillyard (1980) but with vocabulary appropriate to readers in first and second grade.

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References

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Background

•Modulation of the N400 during sentence processing in children with SLI is inconsistent:

– Sabisch et al. (2006). Using auditory stimuli, no N400 modulation in SLI.

–Neville et al. (1993). Using written stimuli, significantly greater N400 modulation for SLI as compared to CA group.

–Weber-Fox et al. (2010). Using auditory stimuli, no modulation of N400 for either SLI or CA groups.

• Behavioral accuracy of SLI in these studies significantly worse than CA controls.

•At the lexical level, for highly familiar, early AOA words, modulation of N400 the same for SLI and CA controls (Cummings et al., 2011).

Purpose

In this study we ask whether the modulation of N400 is the same SLI and CA controls when behavioral accuracy is high in both groups.

Method

Participants

• Two Groups:
  •Adolescents with documented history of Specific Language Impairment (SLI)
  •Age-matched (CA) typical controls.

	SLI (N = 14)		CA (N = 14)		
	Mean	*SD*	Mean	*SD*	*p value*
Age (years; months)	15;2	2;2	14;4	1;10	ns
Leiter-R					
Nonverbal IQ[a]	104*	15	113	10	$p < .05$
CELF-4[c]					
Formulated Sentences	6.9**	3	13.2	1	$p < .01$
Recalling Sentences	2.6**	2	11.9	2	$p < .01$
CASL[d]					
Nonliteral Language	74.5**	10	102.8	10	$p < .01$
Meaning from Context	77.5**	12	110.7	13	$p < .01$
CREVT-2[e]					
Expressive Vocabulary	81.7**	10	105.1	9	$p < .01$
Receptive Vocabulary	85**	12	107.1	11	$p < .01$

[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

• Auditory sentence from Holcomb et al (1992).
• Simple declarative auditory sentences.
• Ranging in length from 3-13 words.
• Contained topics and vocabulary appropriate for 6;0-7;0 (e.g., *Giraffes have long necks/scissors*).
• Total of 160 sentences.

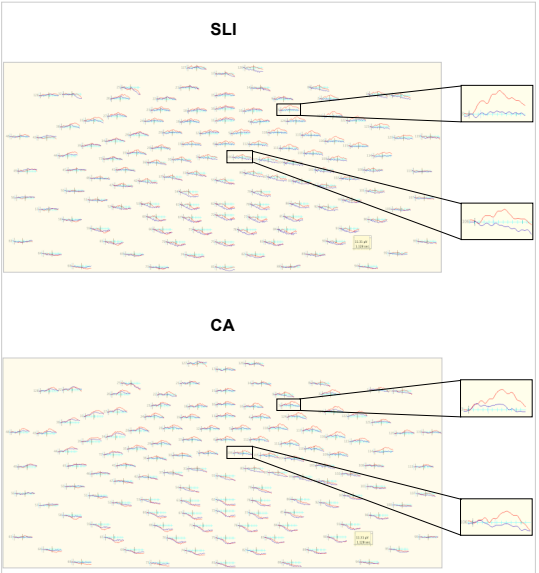

Figure 1. Grand average waveforms for the entire epoch, -100ms-1200ms for the SLI and CA groups. Selected channels are magnified to show greater detail.

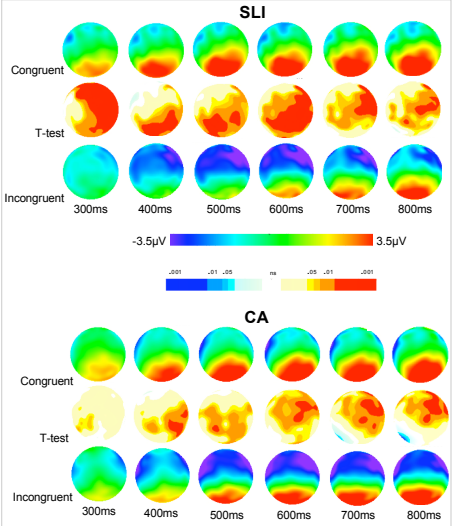

Figure 2. Topographic plots of grand averages for congruent (top row) and incongruent (bottom row) conditions for each group. Darker colors represent more negative waveforms whereas brighter colors represent more positive wave forms. The Student t-test whole head plots represent the differences between congruent and incongruent conditions (middle row), where red is incongruent > congruent and blue is congruent > incongruent.

Results

Behavioral Performance

• Accuracy was high well above chance and did not differ (SLI *M* = 95.61, *SD* = .041; *M* = 97.92, *SD* = .016)
• $F(1, 26) = 3.92$, p = ns.

Event Related Potentials

300-500ms

• Frontal/Frontocentral ROI
  ▪ SLI group - N400 distributed in right frontal and right frontocentral regions (Figure 1).
  ▪ CA group - no modulation of N400
▪ Central
  ▪ N400 bilaterally distributed for both SLI and CA groups
  ▪ Mean amplitude for congruent and incongruent conditions same for SLI and CA groups $F(1, 26) = .09$, p =.76
▪ Parietal ROI
  ▪ N400 bilaterally distributed for both SLI and CA groups
  ▪ Mean amplitude for congruent condition same for SLI and CA groups $F(1, 26) = .10$, p =.74
  ▪ Mean amplitude for incongruent significantly greater for SLI than CA groups $F(1, 26) = 5.03$, $p < .03$, partial $h2 = .16$, observed power = .57.

500-800ms

• Frontal/Frontocentral ROIs
  ▪ SLI & CA groups: N400 distributed in right frontal and right frontocentral regions.
  ▪ Mean amplitude for congruent and incongruent conditions same for SLI and CA groups $F(1, 26) = .48$, p = .49
▪ Central ROI
  ▪ SLI & CA groups: N400 bilaterally distributed
  ▪ Mean amplitude for congruent and incongruent conditions same for SLI and CA groups $F(1, 26) = .03$, p = .85
▪ Parietal ROI
  ▪ N400 evident in right hemisphere for SLI group only.

Results(cont)

Animated topographies

- Grand average waveforms only represent the central tendency of the data
- Potential differences in the temporal aspects of the N400 between the CA and SLI groups may be lost with ROI analysis.
- Data were also interpolated onto two-dimensional scalp topographies for congruent (top row) and incongruent (bottom row) conditions (Figure 2).
- Student's t-test -- a mean normalized by its standard error -- topographic maps (a = .05) were also calculated between congruent and incongruent conditions (middle row) across the 300 - 800ms time window for each group.

Summary & Implications

1. Despite similar behavioral accuracy, modulation of N400 appears qualitatively different for SLI as compared to CA controls.
2. Findings suggest that process of semantic integration for children with SLI may be qualitatively different from that of their typically developing peers.

Procedure

- Semantic judgment task
- Participants pressed right button for "good" sentences, left button for "bad" sentences.
- ERP's recorded 128-channel Hydrocel Geodesic Sensor Nets (Electrical Geodesics Inc.).
- Referenced online to vertex (Cz),referenced offline to an average of left and right mastoids.
- 1300ms epochs (-100 to 1200ms) relative to target onset.
- Averaged separately for Cong/Incong following artifact rejection & blink correction.
- 10 ROIs: anterior, posterior, right/left frontal, right/left frontocentral, right/left central, right/left parietal regions.