The timecourse of anticipatory sentence comprehension in children with Specific Language Impairment (SLI).

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Abstract

Despite showing numerous deficits in spoken sentential comprehension (Montgomery, 2000) and processing speed (Windsor & Hwang, 1999), relatively little is known about how children with specific language impairment (SLI) comprehend lexical information as sentences unfold. Arguably, this task requires swift and efficient processing in order to successfully comprehend a continuously evolving sentential message. One remarkable characteristic of sentence comprehension in typically developing adults and children is the astonishing speed with which information is integrated across multiple lexical items to anticipate upcoming referents. In this study, we explore the possibility that sentence comprehension and processing deficits in SLI arise from a difficulty in efficiently combining lexical information across multiple words. Using a similar design to Kamide, Altmann and Haywood (2003), Experiment 2, we examined the timecourse of lexical activation to objects that varied in association to the Agent and Verb of a simple transitive sentence.

12 teenagers with a documented history of SLI and 14 typically developing (TD), age matched controls were tested. Participants' eye-movements were recorded as they looked at a four-alternative forced-choice display while they heard a sentence in which the object referred to one of the pictures (e.g. "The pirate hides the treasure"). The task was to select the picture that best matched the sentence. In addition to the target picture (Target; treasure), nontarget pictures were either related to the agent (Agent-Related; ship), related to the verb (Action-Related; bone), or Unrelated (cat). Pictures were rotated across stimuli so that, across all versions of the study, each picture appeared in all conditions, yielding a completely balanced within-subjects design. Our analysis focused on two goals: 1) to measure anticipatory looks directed to the target object and 2) compare the activation of looks to non-target items across the sentence.

We did not observe any group differences in anticipatory looks to the Target, nor were there group differences in looks to the Target while it was spoken, or with the speed at which participants initially generated anticipatory looks that differentiated between the Target and other items. Group differences did emerge post-verb onset in fixations to the Action-Related item. TD participants increased looks to the Action-Related item (compared to Unrelated) for a duration of 390 ms starting at 607ms after action onset, (much like adults and children do on this task) whereas the SLI group did not show this pattern for any period of time post action-onset. Together, these findings indicate that teenagers with SLI integrate lexical information across words to anticipate upcoming meanings with the same relative fluency and speed as their TD peers. However, the failure to find increased fixations to Action-Related items after action onset in the SLI group suggests that this group may consider fewer alternate sentential interpretations across the sentence and instead generate sentence continuations that correspond closely to event-level expectations. Therefore, these results fail to support general slowing accounts of SLI, and potentially support the idea that these participants might rely on compensatory mechanisms that recruit real-world knowledge to rapidly interpret spoken sentences.

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Purpose

To investigate incremental interpretation of simple transitive sentences in adolescents with SLI and age-matched typically developing (TD) peers via eye-gaze measures that reflect real-time linguistic processing.

Introduction

Children with SLI have numerous sentence comprehension difficulties.

1. They often perform more poorly on sentence tasks that index offline comprehension (Montgomery & Evans, 2009).
2. In online tasks, they are slower to identify words in sentences (Montgomery, 2006), and slower on numerous measures of linguistic and non-linguistic processing (Kail, 1994)
3. Little is known about how children with SLI interpret sentences in real-time.

Eye-movements are able to index rapid cognitive processing in sentence comprehension:

1. Eye-movements have been used extensively to investigate the time-course of word and sentence comprehension in adults and children.
2. This research indicates that adults and children incrementally interpret sentences as sounds unfold over time.
3. Additionally, adults (Kamide et. al. 2003; 1999) and children (Borovsky & Elman, in prep; Fernald, in prep; Nation et. al, 2003) are capable of using information that occurs earlier in a sentence to anticipate subsequent sentential objects.

Eye-movements measurements in typical children are sensitive to variations in linguistic skill, such as vocabulary level and reading comprehension.

1. Infants with larger vocabularies are faster to fixate on an object when hearing a preceding verb that primes its meaning (e.g. *drink the milk;* Fernald, in prep*)*
2. School-aged children who are less-skilled reading comprehenders show shorter and more numerous anticipatory eye-movements to a target after hearing a related verb.
3. Children and adults with lower vocabulary scores are slower to combine earlier information in sentences to anticipate sentence-final objects (Borovsky & Elman, submitted)

The Task

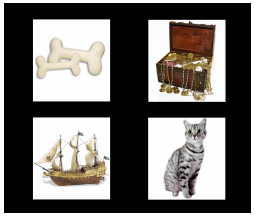

Figure 1. An example of a visual image in the experiment (right), and of two (out of four) auditory sentences paired with this image. The relationship between each sentence and the pictures was balanced such that each object appeared in all conditions across versions.

The pirate hides the treasure	
Target:	Treasure
Agent-Related:	Ship
Action-Related	Bones
Unrelated:	Cat

The dog chases the cat.	
Target:	Cat
Agent-Related:	Bones
Action-Related:	Ship
Unrelated:	Treasure

Online measurement of sentential comprehension:

- Participants completed an experimental task modeled after Kamide, Altmann and Haywood (2003).
- In this task, (see Figure 1) participants hear simple, five-word sentences containing an Agent, Action and Object as they view images containing four objects.
- Eye movements were simultaneously recorded.
- The task is to select the image that corresponds to the sentential object.

Participants

- 12 adolescents with a documented history of SLI
- 14 age- IQ-matched typically developing controls (TD)

Demographics:

Table 1. Standardized measures for adolescents with SLI and TD controls

	SLI			TD			
	Mean	SD	Range	Mean	SD	Range	
Age in months	198.0	26.4	157-241	193.9	22.6	157-246	$p = .71$
Leiter-Nonverbal IQ	106.4	14.1	82-127	113.2	9.1	100-127	$p = .15$
CELF-4 Formulated Sents.	7.3	3.4	2-11	13.2	1.1	10-15	$p < .00$
CELF-4 Recalling Sents.	3	2	1-6	11.8	1.2	8-14	$p < .00$
CASL Nonliteral Lang.	74.9	10.5	52-92	102.8	9.5	81-118	$p < .00$
CASL Meaning from Context	76.6	12.5	60-93	110.7	13.4	88-129	$p < .00$
CREVT Expressive	84	8.9	73-102	105.1	8.7	90-115	$p < .00$
CREVT Receptive	85.5	11.5	66-101	107.1	10.5	80-118	$p < .00$

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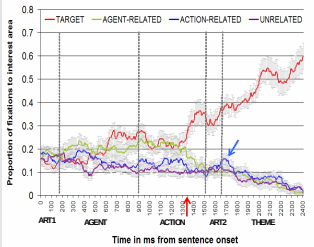
SLI group



Age-matched Group

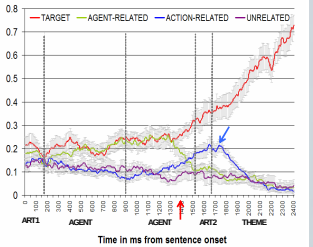


Figure 2. Proportion of time looking to each interest area averaged over each 10ms bin for participants in both groups. Target diverges from other objects at similar times for both groups: 1340ms for SLI and 1380ms for TD groups.

Gaze-Maps

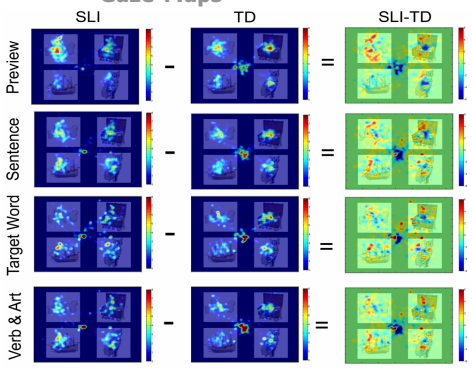


Figure 3. Group and differential fixation maps across several timewindows.

Areas of dark red in the subtraction image indicate regions where SLI group fixated significantly more than TD, and areas of dark blue indicate areas where TD group spent more time in fixation.

Results & Conclusions

1. Both SLI and TD groups rapidly integrated the agent and action to anticipate the sentence final object by directing their gaze to the target (Figure 2). The two groups did not significantly differ in the speed with which they anticipated the final object (see red arrows).
2. The TD group temporarily considered objects that were consistent with the verb, even if not consistent with the agent (see blue arrows, where looks to the Action-related object temporarily increase). This strategy replicates previous findings with younger children and college adults, and may reflect the ability to entertain parallel interpretations of a sentence as it unfolds.
3. The SLI group did not appear to consider such locally-plausible options. This suggests that they may either be unable to maintain multiple competing interpretations or may rely on potentially non-linguistic event-level information to a greater extent than their typically developing peers.
4. There were differences in the overall pattern of gaze fixations, both prior to sentence onset and subsequently while sentences were processed.
5. Children with SLI fixated less on the central regions of each image, and had more diffuse patterns of gaze overall.
6. These differences in patterns of gaze fixation may reflect difficulties by the SLI group in semantic integration of processing during this task.