Children With SLI Use Argument Structure Cues to Learn Verbs

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Across two tasks, children's use of argument structure cues to learn verbs was tested. In Task 1, we examined children's use of cues to *interpret* novel verbs while viewing single action scenes. In Task 2, we examined the role of cues for novel verb *interpretation* and *retention* through a story viewing task. The participants were 20 6-year-olds who were diagnosed as specifically language impaired (SLI) and 40 normally developing children who served as either age-matched or language-matched controls.

Across tasks, the children with SLI demonstrated an ability to use cues to *interpret* verb meaning. For Task 1, scores of the children with SLI were not significantly different from those of either control group; for Task 2, their scores exceeded chance and were not found to be different from those obtained by the language-matched controls. When verb *retention* was examined, scores of the children with SLI were lower than those of both control groups, and they also did not exceed chance even after repeated exposure to the stimuli and additional testing. Patterns within the data ruled out inattention and an inability to follow the narrative as contributing to the children's low scores. Additionally, poor verb retention was not found to be related to a limitation in the perception and encoding of the cue content. Specific deficits with the storage and retrieval of grammatical information within the lexicon, general working memory/capacity limitations, or both are posited as plausible, but unconfirmed, explanations for the verb retention difficulties of the children with SLI.

KEY WORDS: specific language impairment, word acquisition, syntactic bootstrapping

Verbs provide an interesting problem for the language learner. Although verbs are central to the organization and use of language, their referents are frequently fast and fleeting. As such, children might be less able to use their observations of the physical properties of people, places, and objects to learn the meanings of verbs as compared to other word types. The theory of syntactic bootstrapping was developed, in part, to explain how children learn verbs in environments that lack clear perceptual referents. According to this theory, children make use of less observable cues, such as syntactic structure, to learn verbs. In a number of studies, normally developing children and adults have been shown to exploit structural cues when they encounter a novel verb. The focus of the current work was to examine whether children with SLI also make use of these cues to learn verbs. Below, the theory of syntactic bootstrapping is briefly outlined and a rationale for applying this approach to children with SLI is provided.

Syntactic Bootstrapping

Syntactic bootstrapping was initially proposed by Landau and Gleitman (1985; for review also see Gleitman & Landau, 1994; Tomasello

& Merriman, 1995). The basic claim of this theory is that children make use of correlations between syntax and semantics to constrain inferences about a novel verb's meaning. According to Gleitman (1990), cues within a sentence help children narrow down or "zoom in on" the particular action to which a novel verb refers. Consider the following modified example by Naigles (1990). A young child hears the word *kibbing* when presented a scene that involves two young girls. The first girl is lifting pudding to the second girl's mouth, and the second girl is eating it. How might a child interpret the word *kibbing*? According to syntactic bootstrapping, the aspectual marking on the verb directs the child's attention to the actions of the scene. For example, the child may deduce that *kibbing* means the act of feeding or eating. The meaning of *kibbing* can be specified further by the presence of additional sentence cues, such as verb argument structure. Argument structure refers to the number of sentence constituents required by a verb for well-formedness in a sentence. For example, whereas the verb *eating* may involve only one argument (e.g., *She* is eating), *feeding* necessitates at least two (e.g., *She* is feeding *her*). In theory, if *kibbing* is presented with one argument as in, "She is *kibbing*," the child's attention will be directed toward the act of eating. Alternatively, if *kibbing* is presented with two arguments as in, "She is *kibbing* her," the child will attend to the act of feeding.

Children's and adults' sensitivity to sentence cues has been documented in a number of studies. Important for the work here is the finding that normally developing children as young as 2 years old have been shown to be sensitive to argument structure features when a preferential looking paradigm is implemented (Hirsh-Pasek, Gleitman, Gleitman, Golinkoff, & Naigles, 1988; Naigles, 1990). Argument structure cues and the prepositions *to* and *from* also have been shown to influence and constrain the verb interpretations of normally developing 3-year-olds (Fisher, 1993; Fisher, Hall, Rakowitz, & Gleitman, 1994).

Children With SLI

Children with SLI are well suited for studying the role sentence cues play in verb acquisition because these children demonstrate reduced language ability in the absence of other disabilities. In addition, these children's acquisition and use of morphosyntax has been identified as particularly limited relative to other language areas (for review, see Leonard, 1998; Rice, 1996; Watkins & Rice, 1994). Finally, in the area of word acquisition, there is growing evidence that verbs are more difficult for these children to learn and use than other word types (Conti-Ramsden & Jones, 1997; Fletcher, 1992; Fletcher & Peters, 1984; Grela & Leonard, 1997; Kelly, 1997; Kelly & Rice, 1994; Loeb, Pye, Redmond, & Richardson, 1996; Loeb, Pye, Richardson, & Redmond, 1998; Oetting, Rice, & Swank, 1995; Rice & Bode, 1993; Rice, Oetting, Marquis, Bode, & Pae, 1994; Watkins, Kelly, Habers, & Hollis, 1995; Watkins, Rice, & Moltz, 1993). Methods used in these vocabulary studies have included incidental learning paradigms, analyses of spoken language, and experimental tasks of verb comprehension and production. Although not all statistical comparisons have been significant, on some level each of these studies has implicated weaknesses within the verb lexicon of children with SLI.

If verb acquisition is heavily dependent upon syntactic information, as the theory of syntactic bootstrapping suggests, it follows that the verb learning difficulties of children with SLI may be related to their limited use of the structural cues of language. Some work in support of this hypothesis has been completed. Van der Lely (1994) found that six children with SLI, aged 6 to 9 years, were less able than language-matched controls to act out novel verbs when their meanings were dependent upon the sentence cues of reversible transitive (e.g., the girl kalls the boy) and locative syntax (e.g., the car rits the train to the lorry). O'Hara and Johnston (1997) also asked children to act out novel verbs that were embedded in sentences involving either reversible transitive, locative, or coordinated transitive syntax (e.g., the bunny bims the farmer and the cow). Consistent with van der Lely's findings, O'Hara and Johnston's 6 children with SLI, 7 years of age, produced fewer correct responses than did their language-matched counterparts. Both of these findings suggest that children with SLI have trouble processing the structural features of language.

In contrast to the above studies, evidence of intact syntactic bootstrapping skills by children with SLI comes from Hoff Ginsberg, Kelly, and Buhr (1996). They asked 16 five-year-olds with SLI and their age-matched and language-matched controls to act out familiar verbs that were embedded within grammatical (e.g., The lion *puts* the camel on the ramp) and agrammatical (e.g., The lion *falls* the camel) sentences. Responses to the agrammatical sentences were of particular interest, because with these, children had either to ignore the grammatical features of the sentences while acting out the meanings of the familiar verbs or to ignore the meanings of the verbs while acting out the grammatical features. Within this study, responses by the children with SLI, like those of the controls, were consistent with the grammatical features of the sentences, regardless of verb meaning.

The above studies seem to provide mixed findings. The differences can be reconciled, however, if careful attention is directed toward the error patterns made by the children and the different task demands of the

studies. For example, as pointed out by O'Hara and Johnston, 69% of the enactments made by their children with SLI depicted the appropriate amount of causative or locative movement. In addition, many of the children's errors were due to incorrect assignment or omission of the thematic roles (i.e., specific noun phrases) that were to accompany the actions. Within van der Lely's (1994) discussion, she also states that many of the errors made by her children with SLI involved incorrect thematic role assignments. The frequency of these types of errors across studies led O'Hara and Johnston to argue that syntactic bootstrapping was not the problem for children with SLI. Instead, they characterized the deficit as a working memory/processing capacity limitation. Findings by Hoff Ginsberg et al. (1996) are not inconsistent with O'Hara and Johnston's hypothesis. Compared to the other two studies, the task used by these authors placed fewer demands on the children's working memory abilities, because many of the targeted locative sentences included nonreversible and obvious thematic role assignments (e.g., *ramp* in "The giraffe goes the lion to the *ramp*"). Thus, it is possible that group differences were not found in this particular study because memory demands were minimal.

In the current work, our goal was to further examine children's use of sentence cues. As with previous studies, we were interested in cues related to transitivity (i.e., "The bear is feeding the monkey" vs. "The monkey is eating").[1] Rather than asking children to act out sentences, however, two different tasks were developed to examine, in a more direct manner, children's use of cues for verb learning. For Task 1, we borrowed methods from a syntactic bootstrapping task by Fisher et al. (1994). For this task, children heard a nonce verb embedded within a transitive or intransitive sentence while watching videotaped scenes of two characters completing a complex action (e.g., bear feeding monkey). Children demonstrated their ability to use the sentence cues to infer meaning by telling a puppet what the nonce verb meant (e.g., "it means eating" or "it means feeding"). Memory demands were minimal because the target scenes remained on the video screen while the children formed their interpretations. The children also were not required to name the thematic roles of the verbs.

In Task 2, children's use of cues was examined using methods from previous studies of Quick Incidental Learning (QUIL; Rice, 1990). Within this task, nonce verbs were embedded into either transitive or intransitive sentences, and these were presented within a videotaped story. Each time a nonce verb was presented, the children saw two action scenes. One depicted two puppets completing a transitive action (e.g., snake biting a bee) and the other depicted the same two puppets completing an intransitive action (e.g., snake and bee jumping). During one viewing of the videotaped story, the children demonstrated their use of the sentence cues by pointing to the action scenes that went with the novel verbs while the videotaped story played. Although the stimulus used in this task was more complex than the first, memory demands again were considered minimal during this viewing because the children did not have to remember the meanings of the verbs after they made their choices. During three other viewings of the videotaped story, the children's use of cues for novel verb retention was examined by asking them to point to pictures of the novel verbs at the end of the story or midway through viewing.[2] Three viewings and two testing schedules were included because we were concerned about floor effects. In previous studies of QUIL, action labels have been found to be more difficult for all children to learn than those referring to objects or attributes (Rice, Buhr, & Nemeth, 1990; Rice & Woodsmall, 1988). Moreover, when compared to controls, children with SLI have demonstrated lower gains for, and less retention of, verbs than for other word types (Oetting et al., 1995; Rice et al., 1992, 1994).

Two general research questions guided the work: (a) Can children with SLI use argument structure cues to *interpret* the meanings of novel verbs? and (b) Can children with SLI use argument structure cues to *retain* the meanings of novel verbs? Given that verb interpretation was examined in both tasks and the format and testing procedures of these tasks varied in a number of ways, we were also interested in whether findings for verb interpretation would differ across tasks. Finally, given that verb retention was examined across three different viewings of the videotaped story and two different testing schedules were employed, we wanted to examine whether the children's use of cues for verb retention would be influenced by these factors. We reasoned that if children with SLI are less efficient cue users, additional exposure to the novel verbs and cues may benefit the children with SLI more than the controls. We also reasoned that working memory deficits among these children may result in a group-by-testing-schedule interaction. That is, retention scores of the children with SLI may be more affected by the testing manipulations than those of the controls.

[1]As demonstrated by the examples, the argument structure cues we examined provided children semantic as well as grammatical information because agents and patients of the verbs were specified. We used specific noun phrases rather than pronouns (e.g., *He* is kibbing *him*) to be consistent with other studies and because children with SLI are known to have difficulty with pronoun case marking.

[2]In previous QUIL studies, vocabulary testing that takes place immediately following story viewing has been described as a probe of initial word comprehension, and the term *retention* has been used to refer to probes administered one to three days after viewing (see Rice et al., 1994). In the current work, we use the terms *interpretation* and *retention* to differentiate testing that occurs each time a child encounters a new word from testing that occurs at the end of, or midway through, viewing.

Method

Participants

The study involved 20 six-year-olds (14 African American, 6 White; 13 male) who were classified as SLI. Also included were 20 six-year-olds (12 African American, 8 White; 12 male) who were classified as normally developing age-matches (6N) and 20 four-year-olds (12 African American, 8 White; 12 male) who were classified as normally developing language-matches (4N). All of the children were recruited from a rural parish in southeastern Louisiana.

Children were included in the SLI group if they were identified as primarily language-impaired and receiving services by a certified speech-language pathologist in the public schools. In addition, the classroom teachers verbally confirmed that these children's language skills were substantially below their classroom peers. Children were recruited for the 6N group if they were enrolled in the same classroom as a child with SLI, did not present a history of speech and language impairment, and presented average language abilities in comparison with their peers as documented by teacher report. Criteria for the 4N group was the same as for the 6N group except children were recruited from day-care centers (n = 5) and Head Start programs (n = 15) that were known to feed into the target kindergartens. With the exception of two triads, gender and race were matched across groups. Using the guidelines from Hollingshead (1975), the socioeconomic profiles of the three groups also were not found to be significantly different. The data for this comparison came from a voluntary questionnaire that asked for the highest level of education and occupation of the primary caregiver(s). Approximately 62% (SLI = 11, 6N = 10, 4N = 16) of the families in each group returned the form.

The test battery used to document the children's receptive and expressive language abilities included the Columbia Mental Maturity Scale (CMMS; Burgemeister, Blum, & Lorge, 1972), Peabody Picture Vocabulary Test–Revised (PPVT-R; Dunn & Dunn, 1981), subtests III–V of the Test of Language Development–Primary (TOLD; Newcomer & Hammill, 1988), and the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986). All of the children in the SLI group scored within or above one standard deviation of the mean on the CMMS but below one standard deviation of the mean on the PPVT-R. In addition, all but one child with SLI scored below one standard deviation of the mean on the syntax quotient (combined scores of subtests III–V) of the TOLD. All of the normally developing children, except for one 4N child who received a 79 on the TOLD, performed within normal limits on all standardized tests (see Table 1). In Table 2, similarities between the language skills of the SLI and 4N groups were confirmed through the use of raw scores from the PPVT-R and TOLD subtests.[3]

[3]The culturally diverse make-up of the target schools required us to select normally developing children who were individually matched to those in the SLI group on race, gender, and school. Given the constraints of these variables, participant matching on age and language ability were completed at the group rather than the individual level. Our strategy for language matching was to select children approximately two years younger than those in the SLI group and examine, post hoc, group differences in language status.

Table 1. Test scores of participants.

	SLI	6N	4N
Age in months	77.15 (7.51)	75.50 (5.75)	54.50 (4.38)
Hollingshead SES Index[a]	36 (range 22–63)	43 (range = 33–55)	35 (range = 17–58)
CMMS[b]	96.45 (6.16)	103.15 (7.33)	103.15 (7.06)
PPVT-R[c]	71.25 (9.98)	103.75 (11.41)	98.35 (6.88)
TOLD[d]			
Syntax Quotient	73.35 (6.63)	102.55 (10.42)	96.79 (9.39)
Subtest III	5.65 (2.13)	8.90 (2.07)	9.68 (2.14)
Subtest IV	5.70 (1.12)	12.45 (3.13)	9.36 (2.17)
Subtest V	6.20 (1.88)	10.30 (3.20)	9.42 (1.92)
GFTA[e]	67.50 (20.72)	95.10 (9.26)	83.45 (13.78)

[a]Hollingshead SES Index = Maximum total is 66. [b]CMMS = standard score from Columbia Mental Maturity Scale, mean = 100, SD = 15. [c]PPVT-R=standard score from Peabody Picture Vocabulary Test–Revised, mean = 100, SD = 15. [d]TOLD = standard score of syntactic quotient from Test of Language Development–Primary, mean = 100, SD = 15, standard scores for subtests, mean = 10; SD = 3; Subtest III = Grammatical Comprehension, Subtest IV = Sentence Repetition, Subtest V = Sentence Completion. [e]GFTA = percentile ranking of Goldman-Fristoe Test of Articulation. Unless noted, standard deviations are reported in parentheses.

Table 2. Raw scores on language tests: SLI and 4N groups.

	SLI	4N
Age		
M	77.15	54.50
SD	7.51	4.38
Range	66–92	45–61
PPVT-R Raw Score[a]		
M	49.30	49.65
SD	9.54	7.14
Range	25–63	34–61
TOLD III Raw Score[b]		
M	12.00	10.50
SD	5.25	3.97
Range	4–21	2–16
TOLD IV Raw Score[c]		
M	4.50	7.15
SD	1.96	4.82
Range	2–10	2–14
TOLD V Raw Score[d]		
M	6.05	5.45
SD	5.65	4.07
Range	1–18	0–16

[a]Peabody Picture Vocabulary Test–Revised.
[b]Grammatical Comprehension Subtest of Test of Language Development–Primary.
[c]Sentence Repetition Subtest of Test of Language Development–Primary.
[d]Sentence Completion Subtest of Test of Language Development–Primary.

Materials

Pretest

Twenty puppets or human characters were used as materials for the two tasks described below. A four-choice picture pointing pretest was created using photographs of each puppet or character. Directions were "Show me X." The pretest was included to assess the children's knowledge of the characters used in the study.

Syntactic Bootstrapping Task

Following Fisher et al. (1994), a videotape of 10 two-character action scenes was created. One character in each scene was completing a transitive action, and the other was completing a related intransitive action (see Table 3). For each scene, actions were completed by the characters for 18 s. The scenes then froze on screen for 10 s, then 10 s of a blue screen followed. While viewing the action scenes, nonce verbs and their accompanying syntax were presented in live voice to the children. Half of the verbs were presented with intransitive syntax ("Look, the monkey is *kibbing*"), and the others were presented with transitive syntax ("Look, the bear is *kibbing* the monkey"). Presentation was counterbalanced so that each word was heard equally often in each syntactic context. In addition, one of two pseudo-random orders was used to present the novel verbs and action scenes to the children.

Following the procedures of Fisher et al. (1994), a puppet named Sam was used to introduce the novel verbs to the children. The children were told to listen to Sam talk about the videotape, and when Sam used a funny word, they should tell the examiner what Sam meant. Binary choices (e.g., "Do you think *kibbing* means eating or feeding?") were offered following no responses and incomplete or ambiguous responses. Although the need for these was infrequent (i.e., less than 12% of items required them; SLI = 6%; 6N = 8%; 4N = 11%), they were included to circumvent any word retrieval difficulties of the children.

Responses were coded as one of three types: (a) Transitive, (b) Intransitive, and (c) Other. Excluding

Table 3. Action scenes.

chase/run	A crab chases Garfield as Garfield runs away.
pat/cough	A bear pats a girl's back as she coughs (for this scene, a human played the role of the girl).
cover/sleep	Big Bird covers Ernie with a blanket while Ernie sleeps.
pet/hiss	A girl pets and lifts a cat as the cat meows and hisses (for this scene, a human played the role of the girl and a live cat was used).
bite/fly	A snake bites a bumble bee as the bee flies away.
pull/slide	Minnie Mouse pulls the tail of a mouse as the mouse slides down a slide.
feed/eat	A bear feeds a monkey with a spoon as the monkey eats.
tickle/laugh	A Mardi Gras jester tickles a second Mardi Gras jester with a large feather while the second Mardi Gras jester laughs (for this scene, two humans wore Mardi Gras masks and costumes to play the roles of the jesters).
push/fall	A chipmunk pushes a lion while the lion falls off of a box.
pinch/cry	One bear pinches another bear on the toe while the second bear cries.

run/chase, the following criteria were used for scoring. Transitive responses were those that described or paraphrased the action of the puppet or human who acted upon the other (e.g., bear feeding monkey, girl petting cat, Minnie pulling the mouse). Responses, other than periphrastic causatives (i.e., "He is trying to make him X"), also had to include a verb that could be produced in a transitive sentence (i.e., "She is Xing her"); and when a subject or object noun phrase was produced, it had to specify the correct referent. Intransitive responses were those that described or paraphrased the action of the puppet or human who was not applying external force to the other (e.g., cat meowing, monkey eating, lion falling). These responses had to include a verb that could be produced in an intransitive sentence (e.g., "He is Xing"), and when a noun phrase was produced it also had to specify the correct referent. Answers coded as Other included responses describing both actions (e.g., "He is feeding him and he is eating") or the entire event (e.g., "They're playing"), responses including a verb in isolation that didn't clearly refer to a particular character or action (e.g., "Being good"), responses such as "I don't know," and repetitions of the nonce words.

Coding for *run/chase* varied slightly from the above criteria because children used the verb *run* in a variety of ways. The response "He's running after him" was coded as Transitive, the response "He's running away from him" was coded as Intransitive, and the response "Run" was coded as Other because we did not know if the child was referring to one or more of the characters. In addition to these exceptions, a small number of responses were coded even though they did not meet all of the criteria listed above. These included responses that clearly indicated the action of one puppet over the other regardless of the syntactic properties of the verb the child chose to produce. For example, "Wiping his eyes" was coded as Intransitive for the verb pair *pinch/cry*. Although *wipe* is a transitive verb, this response described the action of the the bear who was crying.

Reliability of the coding was assessed by having a graduate student independently code 20% of the responses. For the SLI group, agreement between coders was 93%; for the normally developing groups, agreement was 97%.

QUIL task

As in previous QUIL studies, a videotaped story that had novel verbs embedded into the narrative was used as stimuli. In order to examine cue use by the children, however, a number of modifications were made. For example, the novel verbs were presented in sentences involving either transitive cr intransitive syntax, and every time a novel verb was presented, the children saw two action scenes—a transitive action (e.g., bear feeding monkey) and an intransitive action (e.g., bear and monkey eating). Thus, the word learning task examined here was whether the children could use the syntax presented in the story to figure out and remember which actions depicted by the puppets went with each novel verb.

Eight of the 10 actions used in the bootstrapping task were included in the story task; *pat/cough* and *pet/meow* had to be excluded because we could not accurately depict a puppet coughing nor a human meowing. Also, when creating two scenes for each verb, two actions pairs had to be altered slightly to depict a clear intransitive activity—*chase/run* became *chase/roll* (i.e., both puppets rolled to and away from each other), and *bite/fly* became *bite/jump* (i.e., the snake and bee jumped up and down because a snake cannot fly). The nonce words used in this task were different from those used earlier—four words involved two syllables, two involved three syllables, and two involved four syllables (see Table 4).

The videotaped story was about a clown named Buster. The story begins by having Buster wake up on his birthday. He is sad because he doesn't have any friends to help him celebrate his big day. Throughout the story, Buster encounters pairs of puppets who are completing target actions. Initially he is surprised to find these puppets, but then he becomes angry that puppets are bothering him. At the end of the story, Buster takes a nap because he is very tired from finding so many puppets in his room. When he wakes, he finds that the puppets have planned a big surprise party for his birthday. The story ends by having Buster blow out the candles on his cake.

Throughout the story, nonce verbs and pairs of action scenes were introduced to the children by having Buster look into or under a variety of containers (e.g., his shoe, his hair, his cereal box). After the introduction of a container, the two action scenes played for approximately 7 s. The two scenes were presented on the video at the same time using a color-quad editing system. One scene appeared in the upper right quadrant of the video screen and one appeared in the lower left; the other two quadrants were black. Following the presentation of each

Table 4. Phonological probe.

Target items	Phonologically similar items	Phonologically dissimilar items
plurding	plaking	froithing
kanifering	konatering	yoding
zorking	zoshing	hooling
doopelating	dipomaking	sorning
menooking	moziking	weking
blicking	blofing	jading
tumpering	toosering	leaming
ruping	rooging	glotting

pair of actions and a nonce verb, the focus of the video went back to Buster, and the story line continued (see Appendix for an excerpt of the story).

Two versions of the videotape were created. On the first version, half of the novel verbs were presented with transitive syntax and the other half were with intransitive syntax; the order in which the verbs were presented was randomly determined. The second version of the story was identical to the first, except the argument structure cues of the verbs were reversed. For each version, each novel verb and its argument structure cues were presented three times while the actions played on the screen. Although argument structure cues for each verb remained constant, the narrative format of the task required us to make minor changes to the surface characteristics of the sentences when we repeated them (again, see Appendix).

Finally, to examine the children's retention of the novel verbs, a picture comprehension test and a phonological recognition test were created. As in previous QUIL studies, the picture test was created to examine the children's retention of the novel verb meanings. Following the format of the PPVT-R, children were shown four pictures for each nonce verb. They included a picture of the target characters completing the target action (e.g., bear feeding monkey); a picture of the target characters completing the related, but incorrect, action (e.g., bear and monkey eating); a picture of a different set of puppets completing an action that came from the story (e.g., chipmunk pushing lion); and a picture of the container in which the target puppets were discovered (e.g., cereal box). The test direction for each item was "Show me Xing."

The phonological probe was created to learn more about the children's retention of the phonological content of the novel verbs. Following procedures used by Ellis Weismer and Hesketh (1996), the phonological probe included 24 items: eight targets, eight nonce words that were phonologically similar to the targets, and eight nonce words that were phonologically dissimilar. All items were presented with the present progressive inflection. The word roots of the phonologically similar items were created by altering one or two consonants and vowels of each target; syllable structure and stress patterns of these items matched the targets. The phonologically dissimilar items were two syllables in length, and their word roots included consonant-vowel combinations that did not appear in the targets (see Table 4). Items were presented every 5 s in a fixed random order through the audio track of a videotape. A blue screen was displayed on the video track of the tape; immediately preceding and during the presentation of each nonce word, a white blinking square appeared in the upper left corner of the blue screen. Children were asked to listen to the words on the videotape and to push a buzzer when they heard a word that came from the story.

Procedures

Children were seen individually in a quiet room in their school or day-care center for six 20-min sessions. Standardized testing was completed on Days 1–3. The syntactic bootstrapping task was completed on Day 4. For this task, children first completed the pretest to document their knowledge of the puppets. All children passed the pretest with 100% accuracy. Next, children were introduced to and allowed to play with Sam the puppet, and then they viewed the videotape of the 10 action scenes. For some children in the SLI and 4N groups ($n < 5$) an action scene was repeated if attention wavered or an outside interruption occurred.

The QUIL task involved four viewings of the story, and these were completed on Days 5 and 6. On Day 5, the children watched the videotaped story two times. For Viewing 1, the children's *retention* of the novel verb meanings was assessed by having them watch the entire story and then complete the picture comprehension test. For Viewing 2, the children's *interpretation*, but not retention, of the novel verbs was assessed by having the children point to the action scenes while the story unfolded. During this viewing children pointed to the actual scenes on the video monitor. On Day 6, the children watched the videotaped story a third and fourth time, and verb retention was assessed both times. For Viewing 3, testing for the first half of the items occurred midway through the story, and testing for the second half occurred when the story ended. Viewing 4 was exactly like Viewing 1; children watched the entire video and completed the picture comprehension test afterwards. At the end of Days 5 and 6, children completed the phonological probe. Thus, each child completed the phonological task twice.

Results

Preliminary Analyses

Initially, analyses reported below were run with gender, race, and order included as between-group variables. For the controls, girls outperformed boys during Viewing 4 of the QUIL task. Main effects and interactions for all results pertaining to the SLI group were not significant. Visual inspection of the means also confirmed the absence of any consistent trends; therefore, the data were collapsed on these variables.

Task 1: Syntactic Bootstrapping

Frequency distributions of the children's responses are listed in Table 5. Proportions of Intransitive and Transitive responses, with responses coded as Other excluded, are presented in Table 6. If the cues influenced

Table 5. Frequency distribution of responses.

	Intransitive	Transitive	Other	Total
SLI	67	128	5	200
4N	59	117	24	200
6N	72	121	7	200

Table 6. Syntactic bootstrapping task: Percentage of responses by syntax condition.

	Intransitive	Transitive	Difference
One Argument			
SLI	59	41	18
4N	69	31	38
6N	73	27	46
Two Arguments			
SLI	10	90	80
4N	7	93	86
6N	3	97	94

the verb interpretations of the children, one would expect two distinct patterns of results. First, a greater proportion of intransitive responses should occur with verbs presented with one argument as compared to those presented with two. Second, the opposite pattern should occur for transitive responses. A greater proportion of these should occur with verbs presented with two arguments as compared to one. In Table 6, cells which should contain the highest proportions of responses are shaded.

Responses by the children with SLI were consistent with the predictions. Verbs presented with one argument as compared to two led to a higher proportion of intransitive responses, $t(19) = 6.71$, $p < .001$. In addition, these children produced a higher proportion of transitive responses with verbs presented with two arguments as compared to those presented with one, $t(19) = 6.32$, $p < .001$. A second analysis involving two one-way ANOVAs compared the SLI group's data to those of the normal controls. For the first analysis, the dependent variable was the proportion of intransitive responses, and for the second it was the proportion of transitive responses. Neither analysis indicated significant differences between the groups.

A third analysis was completed to examine whether one type of cue (1 vs. 2 arguments) facilitated the verb interpretations of the children more than the other. To complete this analysis, difference scores between the two types of responses as a function of argument structure cue were calculated. Given that only one type of response was correct for each argument structure, the cue with the greatest difference between the two response types reflects the highest number of correct verb interpretations made by the children. As demonstrated in Table 6, difference scores of the children with SLI were highest for verbs presented with two arguments as compared to one, $t(19) = 4.81$, $p < .001$. Similar findings were obtained for the controls: 4N, $t(19) = 3.63$, $p = .002$; and 6N, $t(19) = 5.40$, $p < .001$. Again, group differences were not significant.

Task 2: QUIL

Recall that the children viewed the videotaped story four times. Verb interpretation was assessed during Viewing 2, and verb retention was examined during Viewings 1, 3, and 4. For ease of presentation, the interpretation scores are considered first and separate from the retention scores.

Viewing 2: Verb Interpretation

Means (and standard deviations) for the interpretation probe were: SLI, 4.90 (1.21); 4N, 5.45 (1.57); 6N, 6.75 (1.16). The maximum number was 8. Initially, a one-way analysis of variance with Tukey follow-up procedures ($p < .05$) was completed to examine whether the groups differed in their use of the cues for verb interpretation. These analyses indicated a significant difference between the groups, $F(2, 59) = 10.24$, $p < .001$, with the scores of the 6N group higher than those of the SLI and 4N groups. The difference between the scores of the SLI and 4N group was not significant. Secondly, the children's scores were tested against chance. Chance was calculated as 4 because the children were asked to point to one of two videotaped actions while the story played (i.e., 8 items with 2 choices each). For this comparison, the scores of the children with SLI, like those of the controls, were significantly above chance, SLI, $t(19) = 3.33$, $p = .004$; 4N, $t(19) = 4.13$, $p < .001$; 6N, $t(19) = 10.56$, $p < .001$.

Viewings 1, 3, 4: Verb Retention

An omnibus ANOVA involving three levels of viewing and three levels of group indicated significant main effects for both variables and a significant interaction, $F(3, 171) = 47.82$, $p < .001$; $F(2, 57) = 24.65$, $p < .001$; $F(6, 171) = 3.16$, $p = .006$, respectively. For each viewing, a one-way analysis of variance was completed. Because each of these was significant, Viewing 1, $F(2, 59) = 7.749$, $p = .001$; Viewing 3, $F(2, 59) = 21.91$, $p < .001$; Viewing 4, $F(2, 59) = 16.99$, $p < .001$, Tukey follow-up procedures were completed. For all three viewings, the scores of the 6N and 4N group were higher than those of the SLI group. For Viewings 3 and 4, scores of the 6N group also were higher than those of the 4N group. Another significant component of the interaction was the amount of change, or lack of change, that occurred across viewings for the three groups. For the normal controls,

Table 7. Retention scores from QUIL task.[a]

	Viewing 1	Viewing 3	Viewing 4
SLI	2.40 (1.35)	2.25 (1.25)	2.40 (1.27)
4N	3.40 (1.47)	4.30 (1.78)	4.20 (1.85)
6N	4.10 (1.29)	5.65 (1.81)	5.35 (1.81)

[a] Maximum score is eight; standard deviations reported in parentheses.

retention scores from Day 2 (i.e., Viewings 3 and 4 combined) were significantly greater than those from Day 1 (i.e., Viewing 1), 4N, $t(19) = 2.77$, $p = .012$; 6N, $t(19) = 3.19$, $p = .005$.[4] Differences between retention scores were not significant for the children with SLI.

Secondly, independent t tests were completed to examine whether the retention scores of the children exceeded chance. For retention, chance was calculated as 2 because the comprehension test included eight items, and each was tested with four pictures. For each of the viewings, the scores of the children with SLI did not exceed chance, but those of the 4N and 6N groups did. Viewing 1: 4N, $t(19) = 4.27$, $p < .001$; 6N, $t(19) = 7.26$, $p < .001$. Viewing 3: 4N, $t(19) = 4.27$, $p < .001$; 6N, $t(19) = 7.26$, $p < .001$. Viewing 4: 4N, $t(19) = 4.27$, $p < .001$; 6N, $t(19) = 7.26$, $p < .001$.

The final analysis involved an item analysis to examine whether the children found verbs presented with two arguments easier to interpret and retain than those presented with one. For this analysis, data from all four viewings were considered. Although scores for items presented with two arguments were generally higher than those presented with one argument, differences between items were not significant for any of the groups. For the children with SLI, the greatest difference between the two types of cues was .55. For the 4N and 6N groups, the greatest difference was .95 and .35, respectively.

[4] Scores for Viewings 3 and 4 were combined here for ease of presentation. For all three groups, scores from Viewings 3 and 4 were not significantly different from each other.

Phonological Probe of QUIL

One SLI and two 4N participants were unable to complete the task, so their data were excluded from the analysis. Group means for the remaining children are presented in Figure 1. It can be seen that the children with SLI, like the controls, identified more targets than either the phonologically similar and dissimilar items. In addition, phonologically similar items were identified more often than the dissimilar ones. To examine these data statistically, A′ statistics were calculated. Given that there were two types of nontargets, phonologically similar and dissimilar, two A′ scores were calculated for each day of testing. This resulted in four A′ values for each group (see Table 8). For each A′ value, hits were the number of identified targets, and false alarms were the number of identified nontargets (Grier, 1971; Redmond, 1997). Perfect discrimination of targets from nontargets yields an A′ value of 1.00, identification of both targets and nontargets yields an A′ of .50, and a tendency to not identify either type of item can yield A′ values of less than .50 (for further discussion, see Rice, Wexler, & Redmond, 1999).

A mixed ANOVA involving group (SLI vs. 6N vs. 4N), day (1 vs. 2), and nontarget type (phonologically similar vs. dissimilar) with A′ as the dependent variable indicated a significant effect for group, $F(2, 54) = 4.48$, $p = .016$. Also observed was a main effect for day, $F(1, 54) = 8.64$, $p = .005$, but this was qualified by a significant two-way interaction between day and nontarget type, $F(1, 54) = 5.03$, $p = .029$. Averaged across primes, Tukey comparisons indicated that A′ values for the 6N group were higher than those of the SLI and 4N

Figure 1. Number of items identified on phonological probe.

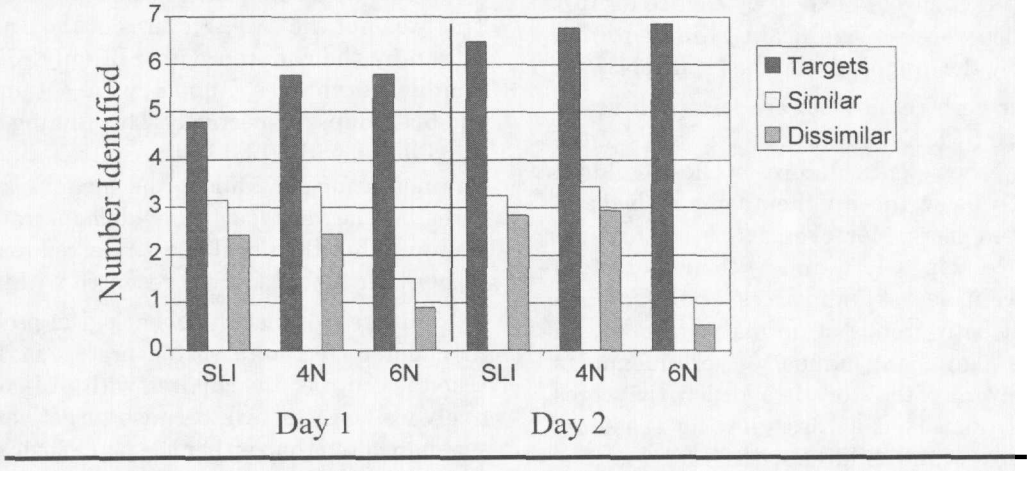

Table 8. A′ values for phonology probe.

	SLI		6N		4N	
Day 1						
Targets vs. Similar Items	.68	(.27)	.87	(.21)	.67	(.23)
Targets vs. Dissimilar Items	.77	(.24)	.94	(.12)	.75	(.25)
Day 2						
Targets vs. Similar Items	.75	(.18)	.84	(.44)	.75	(.17)
Targets vs. Dissimilar Items	.76	(.18)	.91	(.20)	.76	(.17)

groups. Follow-up analysis of the two-way interaction indicated that on Day 1, but not on Day 2, all three groups discriminated targets from phonologically different nontargets better than they were able to discriminate targets from phonologically similar nontargets, $t(56) = 3.41$, $p = .001$.

Discussion

Across two tasks, children's use of argument structure cues to interpret and retain the meanings of novel verbs was examined. In Task 1, the children with SLI demonstrated an ability to use cues to interpret novel verbs. In fact, for this task, response patterns of these children were identical to those of normal age-matched and language-matched controls. Verbs presented with one argument as compared to two led to a greater proportion of intransitive responses than transitive, and verbs presented with two arguments led to a greater proportion of transitive responses than intransitive. In addition, proportions of transitive and intransitive responses as a function of argument structure did not differ between the groups, and for all children verb interpretation scores were highest when transitive cues as opposed to intransitive cues accompanied the verbs. Findings from Task 2 also indicated that the children with SLI were able to make use of the cues for verb interpretation. Not only were the scores of these children greater than what one would expect by chance for this task, but they also were not significantly different from those obtained by the language-matched controls.

Findings for verb retention were less positive for the children with SLI. Even after four viewings of the videotaped story, the retention scores of these children were significantly below those of their age-matched and language-matched peers. Moreover, across all three retention probes (Viewings 1, 3, and 4) their scores did not exceed chance. This last finding is especially troublesome given that both groups of normal controls were able to retain a significant number of verb meanings after only one viewing of the story. In addition, the scores of the controls increased across viewing sessions, whereas the scores of the children with SLI did not.

Identifying the Source of the Children's Poor Retention Scores

Why did the children with SLI perform so poorly on the retention probes? In this section, we consider four possible explanations for the children's low scores. These include (a) poor attentional skills during viewing and testing, (b) an inability to follow the narrative structure of the story, (c) a specific deficit in the processing of cue content, and (d) a general limitation in working memory or processing capacity.

Four pieces of data seem to speak against inattention and an inability to follow the narrative as contributing factors. First, our informal documentation indicated that while viewing the story, children from all three groups frequently and spontaneously told the examiners which pairs of characters were to be found next and in what container Buster would find them. Children with SLI, like the controls, also were observed reciting various sections of the narrative and mimicking Buster's movements by stamping their feet and shaking their fists.

Second, recall that during the story viewing task, retention of each verb's meaning was tested by having the children point to one of four pictures. One picture was of the target container and the other three were of puppets completing actions. If the children had been guessing when completing the picture test, responses would have been distributed evenly across the four foils. This was not the case. Pictures of the containers were chosen by the children with SLI only 8% of the time. Similar percentages, 7 and 4, were obtained by the 4N and 6N groups, respectively. This finding suggests that the children with SLI, like the controls, had learned and retained something about the meanings of the novel verbs. At the very least, they demonstrated an understanding that the novel verbs referred to action scenes rather than object scenes presented within the story.

Third, recall that the phonological probe also tested the children's recognition of the target items from the story. Like the controls, the children with SLI performed relatively well on this task because target verbs were chosen more often than either the phonologically similar or

dissimilar items. Finally, recall that the verb interpretation scores of the children with SLI during the story viewing task exceeded chance, and their scores were not found to be significantly different from those of their language-matched peers. These findings, taken together, seem highly improbable if the children with SLI were not following the narrative nor understanding the testing procedures.

If inattention and an inability to follow the narrative cannot account for the children's low retention scores, can a specific deficit in cue use be implicated? The high verb interpretation scores of the SLI group suggest that perception and encoding of cues is not the source of these children's problems. Our findings for verb interpretation not only replicated across tasks but also are consistent with previous work by Hoff Ginsberg et al. (1996). That is, when tasks and testing procedures do not require children to remember specific details about the thematic roles of verbs, children with SLI can demonstrate intact syntactic bootstrapping ability. Adequate perception and encoding of cue content does not necessarily indicate that other aspects of cue use are unimpaired, however. Perhaps the children with SLI presented other types of linguistic deficiencies. For example, it is possible that the low retention scores of these children were tied to specific limitations in the storage and retrieval of argument structure content within the lexicon.

When designing the picture comprehension test we had hoped that an error analysis of the children's responses would be useful for thinking about cue storage and retrieval issues. Recall that in addition to the pictures of the containers, one incorrect foil was of the target puppets completing the related, but incorrect, action, and the other was of a different pair of puppets from the story. The comprehension test was constructed in this manner so that the children's inability to retain the cue content of the verbs could be examined if retention scores were low. Specifically, we reasoned that a deficit in the ability to retain cue content in the presence of good associative learning skills should have resulted in a significantly greater number of errors involving pictures of the correct characters as compared to the incorrect ones. For example, children should have been able to remember that a picture of the bee and snake, as opposed to a picture of a chipmunk and lion, went with the novel verb *ruping* even if they couldn't remember which picture of the bee and snake (i.e., snake biting bee vs. snake and bee jumping) was correct.

Unfortunately, this predicted pattern of results was not obtained for any of the groups. Across viewing sessions, when children with SLI made an error on the retention probe that did not involve a picture of a container, they chose the correct puppets 47% of the time and the incorrect puppets 53% of the time. Like percentages for the 4N group were 58% and 42%, and for the 6N group, 53% and 47%. For all three groups, these differences reflect chance performance. Thus, none of the groups was able to remember mappings between the puppets and the verbs when the specific argument structure cues were forgotten. Although the reason for this result is unclear, what is important for the study of SLI is the finding that all three groups demonstrated the same pattern of error. Given this, it is difficult to conclude that storage and retrieval of cue content is a problem specific to children with SLI.

We also had hoped that results from the phonological probe would help specify the nature of these children's verb retention difficulties. By design, the phonological probe and picture probe assessed different aspects of verb retention. Although it is interesting that the SLI and 4N groups were found to differ on the picture probe but not on the phonological probe, we are hesitant to make too much out of this finding. In addition to testing different verb content, the two retention probes we created were very different from each other. Whereas the picture probe required the children to identify a correct picture from an array of four previously viewed scenes, the phonological probe required them to identify previously heard words from a list of words that had never been encountered. In hindsight, these testing differences may have resulted in the phonological probe's being easier for children to complete than the picture probe. Given this, the phonological data, although useful for ruling out inattention and other task-related factors, should probably not be used to argue for a specific deficit in cue storage or retrieval among these children.

If a specific deficit in cue storage and retrieval cannot be implicated, perhaps a general limitation in working memory or processing capacity can be tied to the children's low retention scores. Recall that one of the reasons multiple viewing sessions and two testing schedules were included within the current work was to determine whether memory limitations or processing deficits could be identified. Unfortunately, it was the normally developing children and not those with SLI who benefited from the viewing and testing manipulations. Indeed, retention scores of both control groups were significantly higher after Viewings 3 and 4 compared to those from Viewing 1. And, although not significant, retention scores for the controls were higher when testing for half of the verbs occurred midway through the story (i.e., Viewing 3) than when testing for all verbs occurred at the end (i.e., Viewing 4).

Another place where processing limitations could have surfaced was on the two verb interpretation probes. Recall that of the two tasks, the second was

more complicated than the first. Story line constraints required the target sentences in the second task to be longer, more complex, and more varied than those used in the first. In addition, within Task 1, a single action scene was presented for each verb, and each scene was displayed for 28 s. In Task 2, two separate scenes appeared each time a nonce verb was presented, and these scenes were displayed for 7 s only. Given these complexity differences, it would not have been surprising if group comparisons would have differed on the two verb interpretation probes. Indeed, a group-by-task interaction is exactly what our data showed because the groups were found to differ on the second task only. Unfortunately, it was the 6N group and not the SLI or 4N group who were affected by the task differences. Recall that on Task 2, the 6N group outperformed the SLI and 4N groups, but the difference between the latter two groups was not significant. This pattern of findings as well as those observed for the verb retention probes make it difficult to implicate processing limitations as the source of children's verb retention difficulties.

Contributions and Future Directions

The results of this study contribute to our understanding of children's acquisition of verbs in at least three ways. First, the low retention scores of the children with SLI replicate previous work by Rice et al. (1992, 1994) and Oetting et al. (1995) by documenting the extreme difficulty these children have with verb acquisition, especially when exposure to novel items is brief and within an incidental learning context. Second, patterns within the data are useful for ruling out inattention and an inability to follow narrative structure as possible explanations for the children's lexical limitations. Third, our results provide direct evidence for the claim that children's verb retention difficulties are not tied to deficits in the perception and encoding of sentence cue content. This finding supports Hoff Ginsberg et al. (1996) and O'Hara and Johnston's (1997) claim that syntactic bootstrapping processes are intact in children with SLI.

We began our study by asking whether children with SLI use cues to learn verbs. Findings reported here make it clear that the answer to this question is yes with qualifications. Although children with SLI were just as able as language-matched controls to use cues for novel verb interpretation, they were unable to use this same information to retain verb meaning. Specific deficits in the storage and retrieval of grammatical information within the lexicon and/or general limitations in working memory or processing capacity remain plausible, but unconfirmed, explanations for the children's verb retention difficulties. Promising areas for future research include further study of the effects input manipulations and testing modifications have on word acquisition processes. Although modifications examined here were not found to benefit the children with SLI, they did facilitate word learning among the normal controls. And in previous work by Rice et al. (1994), increased exposure to novel items along with manipulations of word type and narrative saliency have resulted in substantial word gains by children with SLI. These findings indicate that there is much more to be learned about the ways in which language-specific and processing-general factors facilitate and impede children's acquisition of words.

The results also highlight the need for future work to experiment with a wide range of recognition and discrimination probes when assessing children's storage and retrieval of words. In the current work, we were able to use the picture comprehension test and phonological recognition task to examine different aspects of verb representation. The development and exploration of additional types of probes that range in complexity and format should help us learn more about the early and partial maps children create for newly encountered words. These types of tasks also should help explicate the elusive, yet profound, nature of children's vocabulary deficits.

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Appendix. Story excerpt from Buster's Birthday.

Audio Presentation	Video Presentation
This is a story about Buster the Clown.	Scene of Buster's bedroom. Buster is lying on his bed snoring.
Buster is excited. Today is his birthday.	Buster wakes up, walks over to his calender and points to the day marked his birthday.
"But wait," says Buster, "I don't have any friends to help me celebrate my big day."	Buster changes his expression and posture to indicate sadness.
Buster decides to get ready for his birthday all by himself.	Buster walks over to his bed and sits down. He picks up one shoe and puts it on.
"Something is in my shoe? Minnie and a mouse are in my shoe! Minnie and the mouse are plurding. Minnie and the mouse are plurding. Why are Minnie and the mouse plurding in my shoe?"	Buster picks up the other shoe and looks inside. He looks surprised. Two actions involving Minnie Mouse and a small mouse are presented. In one, both puppets are sliding down toy slides. In the other, Minnie is pulling the mouse by his tail across the table.
"This is strange. I must be dreaming," thinks Buster.	Buster looks confused while holding his shoe. He makes gestures indicating that he must be crazy in the head. Buster shrugs his shoulders, puts on his shoe, walks over to his kitchen table, sits down, and looks in a mirror.
Buster needs to brush his hair. "What a mess!" says Buster.	Buster touches his hair and makes a grimace. While brushing, he feels something in his hair and looks surprised and disgusted.
"Oh no," says Buster. "Something is in my hair. There are two Mardi Gras girls in my hair! One girl is kanifering the other girl. One girl is kanifering the other girl. Why is that girl kanifering the other girl in my hair?"	Actions involving two Mardi Gras girls are presented. In one, both girls are laughing. In the other, one girl is tickling the other girl with a long feather. The second girl laughs every time she gets tickled.
"This is turning out to be a very strange birthday."	Buster shakes his head and looks befuddled.