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Speech Disruptions in the Narratives of English-Speaking Children With Specific Language Impairment

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Abstract

Purpose—This study examined the types, frequencies, and distribution of speech disruptions in the spoken narratives of children with specific language impairment (SLI) and their age-matched (CA) and language-matched (LA) peers.

Method—Twenty 4th-grade children with SLI, 20 typically developing CA children, and 20 younger typically developing LA children were included in this study. Speech disruptions (i.e., silent pauses and vocal hesitations) occurring in the narratives of these children were analyzed.

Results—Children with SLI exhibited speech disruption rates that were higher than those of their age-matched peers but not higher than those of their language-matched peers. The difference in disruption rates between the SLI and CA groups was restricted to silent pauses of 500–1000 ms. Moreover, children with SLI produced more speech disruptions than their peers before phrases but not before sentences, clauses, or words.

Conclusions—These findings suggest that there is a relationship between language ability and speech disruptions. Higher disruption rates at phrase boundaries in children with SLI than in their age-matched peers reflect lexical and syntactic deficits in children with SLI.

Keywords

pause; narrative; specific language impairment (SLI); language production

The production of language involves three stages—namely, *conceptualization*, *formulation*, and *articulation*, with monitoring at each stage (Levelt, 1989). At the conceptualization stage, the speaker has a communicative intention and builds up a nonlinguistic representation of messages to convey the intention. At the formulation stage, the speaker first translates the preverbal message into linguistic structures by retrieving appropriate words from memory, assigning the syntactic roles (e.g., subject, object) to these words, and elaborating the syntactic structure (e.g., noun phrase, verb phrase) for them. Given the linguistic structure, an articulatory plan is then constructed. Finally, at the articulatory stage, the speaker executes the articulatory plan. Glitches may arise within any of the stages. For example, the speaker might encounter difficulty in retrieving a particular word or building up the syntactic structure while producing a sentence. When glitches occur, the steady process of language production is interrupted (Levelt, 1989; Rispoli, 2003). Eventually, the glitch surfaces as a dysfluency or a speech disruption in spoken discourse. Speech disruptions thus reflect the cognitive processes underlying language production (Goldman-Eisler, 1968).

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Types and Functions of Speech Disruptions

Speech disruptions occur in the steady flow of spontaneous discourse; these include silent pauses and vocal hesitations (Kowal, O'Connell, & Sabin, 1975). *Silent pauses* are the periods of time when no phonation is being made during spoken discourse. In research on speech disruptions, silent pauses typically refer to the silent intervals that are equal to or greater than 250ms (Goldman-Eisler, 1968). Silent intervals of fewer than 250 ms are considered to serve an articulatory rather than cognitive function in speech production and are not counted as silent pauses.

Vocal hesitations denote filled pauses, interjections, repetitions, or revisions occurring during spoken discourse (Dollaghan & Campbell, 1992; Kowal et al., 1975). *Filled pauses* refer to conventional but nonlexical one-syllable filler vocalizations (e.g., *um*, *uh*, *ah*), whereas *interjections* refer to conventional words or phrases that do not contribute information to an utterance (e.g., *I mean*, *well*, *like*, *you know*; Clark & Fox Tree, 2002). *Repetitions* denote repeated linguistic units (e.g., segment, syllable, or word) that do not signal emphatic meaning. *Part-word repetition* refers to repetition of segments (e.g., *he <u>p*</u> picked up the nest*) or syllables (e.g., *the bull was <u>al*</u> always there*) of a word. *Whole-word repetition* refers to the repetition of single monosyllabic (e.g., *<u>but</u> but she liked it*) or multisyllabic words (e.g., *the girl was <u>flying</u> flying her kite*). *Phrasal repetition* (e.g., *she is flying <u>a kite</u> a kite*) and *multi-word repetition* (e.g., *He <u>would go</u> would go home*) are both treated as whole-word repetitions. *Revisions* refer to "reliably recognizable modifications of a unit already produced by the speaker" (Dollaghan & Campbell, 1992, p. 62), which result in the alteration of lexical, morphological, syntactic, semantic, or phonological material (Rispoli, 2003), as exemplified in Example (1).

(1)

a. then (<u>the g*</u>) the boy drownened. [lexical change]

b. his mom picked up the basket and (<u>ru*</u>) ran into the house. [morphological change]

c. and the girl was flying (<u>her kite</u>) her new kite. [semantic change]

d. the oldest brother didn't know how to (sim) swim. [phonological change]

Finally, those linguistic units that do not have a reliably identifiable relationship to other units, such as *I will get <u>in</u> the money*, are categorized as *orphans*.

From a functional point of view, speech disruptions are the strategies that speakers adopt to solve the problems or breakdowns in sentence production (Clark & Fox Tree, 2002; Postma & Kolk, 1993). Breakdowns can be due to difficulty or errors of commission in forming concepts or in activating linguistic elements, such as syntactic frames (e.g., *<u>the + Noun</u>*) and lexical items (Rispoli, 2003). Processing difficulties during sentence production may result in the occurrence of silent pauses, filled pauses, interjections, or repetitions. The use of these speech disruptions would allow the speaker more time to deal with these difficulties. Silent pauses tend to occur when speakers encounter difficulties in forming concepts, activating syntactic frames, or retrieving the syntactic and semantic information (i.e., lemma) of lexical items (Levelt, 1989; Postma & Kolk, 1993). In online conversation, the speaker is not allowed to pause for too long because this would cause him to lose the floor (Clark, 2002). The speaker may thus use filled pauses (e.g., *um* and *uh*) or interjections to keep the floor when he predicts his own prolonged silences. The use of filled pauses and interjections may also buy more time for the speaker to deal with processing difficulties (Rispoli, 2003). Phrasal repetitions may involve difficulties in forming concepts or in activating syntactic frames, whereas word repetitions may result from difficulties in retrieving the lemma information of lexical items. Part-word repetitions, in contrast, are due to difficulties in retrieving the lexeme information (i.e., phonological forms) of lexical items. The speaker repeats the phrase, word(s), or phoneme

(s) to gain more time for sentence planning and to keep the integrity of the constituent (Clark, 2002; Maclay & Osgood, 1959). For instance, consider the utterance *(on the) on the farm*. In the beginning, the child retrieves the syntactic information of *farm* (i.e., noun) but not the semantic information. The phrase structure *on the +N* is also activated, and part of the phrase (e.g., *on the*) has been executed. The child may have to stop because he has not retrieved the semantic information of *farm*. He may use repetitions (e.g., *on the* *on the farm*) to buy more time to retrieve the semantic information of *farm*. In contrast to other types of speech disruptions, revisions result from errors of commission in forming incorrect concepts or in activating inaccurate linguistic elements. Revisions take place when speakers detect and attempt to repair planning errors. Interjections, like *I mean*, can be used to signal a repair (e.g., *the girl*, *I mean*, *the boy was worried*). In summary, speech disruptions may serve as processing strategies to buy time or repair errors, but they do reflect the occurrence of processing breakdowns in sentence production. Different types of processing breakdowns result in different surface forms of speech disruption.

Speech Disruptions in Typical Language Development

Research on speech disruptions in typically developing children has shown that the production of these disruptions is related to language development, specifically syntactic development. Kowal et al. (1975) examined speech disruptions in spoken narratives by children at seven age levels (i.e., from kindergarten to high school seniors). In general, younger age groups tended to produce more silent pauses and longer silent pause duration (measured by silent pause length per syllable) than older age groups. It was suggested that younger children needed more time for planning language production than older age groups.

Wijnen (1990) analyzed the frequency and distribution of speech disruptions in a typically developing Dutch child between the ages of 2;4 (years;months) and 2;11. The frequency of speech disruptions increased initially and then subsequently declined. In addition, speech disruptions were randomly distributed within sentences at the first half of the observation period but tended to concentrate at phrase boundaries or sentence boundaries at the second half. Wijnen concluded that the decrease of speech disruptions was related to the abundant use of a few syntactic frames (e.g., *Pronoun + Verb + X*) as grammar developed. The frequent use led to an increase of automaticity of these frames in sentence formulation and reduced the risk of disruptions (Wijnen). In addition, speech disruptions were concentrated at phrase and sentence boundaries because these were the locations where language planning took place, which reflected the emergence of a sentence formulation system in this child.

Colburn and Mysak (1982) examined the semantic–syntactic structures (e.g., locative + action, *wh*-question) of dysfluent utterances in longitudinal samples of 4 children from MLU Level I–IV. Novel semantic–syntactic structures that were just emerging provoked more dysfluencies than the structures that had recently emerged or were consistently used in the child's language sample. Colburn and Mysak concluded that novel structures tended to precipitate dysfluencies because these structures were not fully practiced and hence placed high linguistic stress in sentence formulation.

Rispoli and Hadley (2001) investigated the relationship between speech disruptions, sentence length, and complexity in children from 2;6 to 4;0 years. Their results indicated that dysfluent sentences tended to be longer and more complex than fluent ones. With the development of the child's grammar, the gap in complexity between the dysfluent and fluent sentences expanded even when length effect was partialed out. Rispoli and Hadley (2001) therefore argued that as grammatical development proceeded, speech disruptions tended to appear in more-complex sentences. When a higher level of sentence complexity emerged, the sentence production mechanism was slow and inefficient, triggering a high rate of speech disruptions.

With development, complex sentences became more automatic, triggering speech disruption less often. In a similar vein, Rispoli and Hadley (2005) conducted a longitudinal study to investigate the relationship between speech disruptions and the acquisition of tense and agreement markers (i.e., third person singular *–s*, past tense *–ed*, and copula *BE*). The results showed that the disruption rate in sentences with tense and agreement markers decreased as the child's productive level of these markers (Hadley & Short, 2005) increased. It was again argued that the decrease in disruptions in sentences with tense and agreement markers was related to the increase in automaticity of those markers.

In summary, evidence from typically developing children suggests that speech disruptions decrease with syntactic development. An increase in the automaticity of syntactic knowledge may reduce the risk of disruptions. Although not addressed in these studies, lexical development may also play a role in speech disruptions. Evidence from adult language production shows that some speech disruptions stem from problems in lexical retrieval (Levelt, 1989; Maclay & Osgood, 1959). The ability to retrieve lexical items is related to the depth of knowledge in the semantic lexicon (McGregor, Newman, Reilly, & Capone, 2002). As the degree of semantic knowledge becomes enriched, children are able to retrieve lexical items more easily and efficiently, and disruptions due to difficulty in lexical retrieval may decrease. We therefore make the assumption that the production of speech disruptions in developmental language is related to general language ability (i.e., strength of linguistic representations), including lexical and syntactic abilities.

Two questions arise here: How are sentences produced from a representation of linguistic and nonlinguistic knowledge, and how do weak linguistic representations result in disruptions in language production? To answer these questions, we need to consider how preverbal messages are grammatically encoded (Bock & Levelt, 1994; Levelt, 1989). When a speaker intends to express a message such as *The boy eats the cakes*, he first builds up a nonlinguistic representation of this message. The preverbal message is then translated into linguistic forms by grammatical encoding. At grammatical encoding, the speaker needs to retrieve lemmas from the lexicon, code specific information for these lemmas (e.g., definiteness for *boy*; person, number and tense for *eat*), and assign them syntactic functions (e.g., subject, main verb). The information of lemmas and their syntactic functions, in turn, guides the activation of syntactic frames or phrase structures for positioning these lemmas (Bock & Levelt, 1994). For instance, a syntactic frame with the definite article *the* is built up for the lemma *boy* and is located at the subject position in a sentence because the lemma *boy* is attached with a feature of definiteness and is assigned the syntactic function of subject. It should be noted that this model (Bock & Levelt, 1994; Levelt, 1989) permits incremental production—that is, a sentence can be processed in increments or fragments. As the lemmas and their syntactic functions that require particular syntactic frames become available, pieces of syntactic frames can be built up. These pieces are then integrated into a sentence according to constraints on possible unifications (Bock & Levelt, 1994). Because the production of a sentence may involve activating a variety of lemmas and syntactic frames, each activation could be an opportunity for glitches. A prediction that follows is that speakers with stronger linguistic representations (i.e., higher language ability) would encounter fewer glitches in activating lemmas and syntactic frames for sentence production and hence produce fewer speech disruptions than those with weaker linguistic representations.

Speech Disruptions in Atypical Language Development

Given that younger children are less fluent than older children, we might predict that children with atypical language development would also be less fluent than typically developing children. However, the relationship between speech disruptions and language impairment remains inconsistent across extant studies. Several studies have documented an association between language impairment and speech disruptions. Loban (1976) conducted a longitudinal study of children's language development and found a correlation between fluency and verbal ability. Children with strong language ability tended to produce fewer disruptions per narrative word than those with weak language ability. Dollaghan and Campbell (1992) examined speech disruptions in spontaneous speech of children and adolescents with and without traumatic brain injury (TBI), aged from 7;9 to 20;8. The silent pause rate (measured by number of tokens per 100 words) was significantly higher in the TBI group than in the control group. However, the rates of filled pauses, revisions, or repetitions did not differ between these two groups.

Evidence from children with specific language impairment (SLI) also supports a relationship between language impairment and speech disruptions. Nettelbladt and Hansson (1999) examined speech disruptions in the narratives of Swedish preschoolers with SLI, aged from 5;3 to 5;11. They found that children with SLI produced more speech disruptions than the controls, especially repetitions and silent pauses. Relative to the control group, the repetitions produced by the SLI group were significantly more often of part-word length. Similarly, Boscolo, Bernstein Ratner, and Rescorla (2002) found that 9-year-olds with a history of specific expressive language impairment (HSLI-E) were significantly more dysfluent than their peers. The HSLI-E group outnumbered the control group in stuttering-like dysfluencies (i.e., part-word repetition, prolongations, broken words, and tense pauses) but not in normal dysfluencies (e.g., whole-word repetitions, revisions).

Other researchers found that there was no reliable relationship between language impairment and speech disruptions. MacLachlan and Chapman (1988) examined the frequency and type of speech disruptions occurring in the conversation and narratives of children with language learning disabilities (LLD), aged from 9;10 to 11;1. Although the LLD group produced more speech disruptions in longer utterances than in shorter ones and more disruptions in narratives than in conversation, their disruptions per communication unit did not outnumber those of the aged-matched or MLU-matched controls. Lees, Anderson, and Martin (1999) examined the relationship between language ability and fluency in 5- to 6-year-old children with and without language impairment. They found that the language-impaired and control groups did not differ in numbers of speech disruptions (i.e., silent pause, interjection, repetition, revision, and dysrhythmic phonation) in either imitation or modeling tasks. It was argued that language ability was not related to the child's ability to speak fluently. Scott and Windsor (2000) investigated the general language performance of children with LLD at the mean age of 11;5. Although the LLD group produced more grammatical errors and fewer words per minute than the age-matched group in spoken narratives and expository discourse, no group differences were found in percent of T-units with vocal hesitations (i.e., revisions, repetitions, and filled pauses).

The inconsistent relationship between language impairment and speech disruptions across studies may result from methodological differences. First, the methods used to count rates of speech disruptions varied across studies. Studies that found a relationship between language ability and speech disruptions (e.g., Boscolo et al., 2002; Nettelbladt & Hansson, 1999) all adjusted the frequency of disruptions by the total number of words in the language sample. In contrast, the studies that found no relationship between language ability and speech disruptions (e.g., MacLachlan & Chapman, 1988) corrected the frequency of disruptions by other measures (e.g., by number of C-units). As Dollaghan and Campbell (1992) argued, disruption frequency corrected by the total number of words was more sensitive to language impairment than other methods. Second, the tasks were different across studies. Although most of the studies used spontaneous speech (e.g., conversations and/or narratives), Lees et al. (1999) adopted the controlled speech approach (i.e., imitation and modeling tasks) to examine speech disruptions. In controlled speech tasks, sentence planning is minimized for the child, which reduces the risks of glitches and hence disruption rates. Third, not all studies measured silent pauses (e.g., Scott & Windsor, 2000). Because silent pauses may reflect cognitive processes of language production (Goldman-Eisler, 1968), excluding silent pauses in the analysis might limit the opportunity to find a relationship between language impairment and speech disruptions. Even in the studies that counted silent pauses, most of them did not measure silent pauses that were shorter than 2000 ms (e.g., Dollaghan & Campbell, 1992). Because silent pauses greater than 250 ms may signal planning problems in language production, inspecting silent pauses between 250 and 2000 ms could provide additional insight into the difficulties that children with language impairment might encounter in language production.

Because the relationship between language impairment and speech disruptions remains unclear, the present study examined the types and frequencies of speech disruptions in the narratives of English-speaking children with SLI and their age-matched and language-matched peers. Previous studies have shown that children with SLI appear to have lexical deficits (Leonard & Deevy, 2004) and syntactic deficits (Leonard, 1998; Rice, Wexler, & Cleave, 1995). Language abilities in children with SLI are less well developed than those in their age-matched peers, which suggests that children with SLI would have weaker linguistic representations. Therefore, they may suffer more glitches in the process of language production than their age-matched peers. We predicted that children with SLI would produce more speech disruptions than their age-matched peers. There would not be differences in disruption rates between children with SLI and their language-matched peers because their levels of language ability were similar. Including language-matched peers in the design enabled us to examine whether language ability was related to speech disruptions. If we found that children with the same level of language ability produced similar rates of disruption in spoken narratives, this would be additional evidence of the relationship between language ability and speech disruptions. Moreover, we also predicted that children with SLI would outnumber their age-matched peers both in silent pauses and in vocal hesitations (Boscolo et al., 2002; Dollaghan & Campbell, 1992) because children with SLI may need more time to activate the linguistic elements for sentences and may suffer more activation breakdowns due to their weak linguistic representations.

Distributions of Speech Disruptions

In addition to types and frequencies, we examined the distribution of speech disruptions in terms of syntactic position (i.e., before sentences, clauses, phrases, or words). Literature on adult language production indicates that speech disruptions may occur before words (Goldman-Eisler, 1968), phrases (Maclay & Osgood, 1959), clauses (Boomer, 1965), and sentences (Goldman-Eisler, 1972). Hawkins (1971) examined the syntactic location of speech disruptions in conversations and narratives by typically developing children aged from 6;6 to 7;0. Children tended to produce disruptions at constituent boundaries, especially clause boundaries. Wijnen (1990) also found that speech disruptions concentrated at phrase and sentence boundaries as grammar developed. He argued that these boundaries attracted more disruptions because they were the locations where sentence planning occurred. Bloodstein and Grossman (1981) observed the location of speech disruptions in children with stuttering between the ages of 3;10 and 5;7. The disruptions tended to occur at the boundaries of syntactic units (e.g., clauses, phrases) but not within phrases. Bloodstein and Grossman concluded that early stuttering was mainly related to difficulties in either the formulation or the execution of syntactic units. Bernstein (1981) examined the syntactic location of disruptions in the conversations of 8 children with stuttering at the mean age of 6;3. Only full sentences with the structure *Noun Phrase + Auxiliary + Verb Phrase* were included for analysis. Children with and without stuttering tended to produce disruptions at phrase boundaries rather than within the phrases. The sentence-initial NP (i.e., sentence boundaries) attracted the most disruptions, compared with other phrase boundaries. Moreover, children with stuttering produced more disruptions than typically developing children immediately preceding verb phrases but not before other phrase boundaries or within constituents. It was suggested that there were syntactic constraints on the location of disruptions produced by children.

To the best of our knowledge, research on the syntactic location of speech disruptions in children with SLI remains sparse. Previous studies on children with stuttering and typically developing children have shown that speech disruptions mostly occurred at constituent boundaries but not within constituents. Children with SLI tended to have difficulty retrieving lexical items (Leonard & Deevy, 2004) and/or activating syntactic frames (Leonard et al., 2002) because of weak linguistic representations. Because lemma information guides the activation of syntactic frames in Levelt's language production model, difficulties in lexical retrieval would further increase the risks of glitches in activating syntactic frames, which would lead to the increase of speech disruptions between syntactic frames or constituents. Given that children with SLI have lexical and syntactic deficits, we predicted that they would produce more speech disruptions than their age-matched peers not only at constituent boundaries (i.e., before sentences, clauses, or phrases) but also within constituents (i.e., before words within phrases).

Summary of Research Questions and Predictions

In summary, the questions addressed in the present study were: Do children with SLI produce more speech disruptions than their peers? Do children with SLI out-number typically developing children in specific types of speech disruptions? Does the syntactic position matter in the production of speech disruptions? Given that children with SLI have weaker linguistic representations than their age-matched peers, we predicted that they would produce more speech disruptions than their peers between and within constituents. We also predicted that silent pauses and vocal hesitations would both be indicative of difficulty in sentence production in children with SLI. In analyzing the types, frequency, and distribution of speech disruptions, this study would uncover not only the relationship between language impairment and speech disruptions but also the syntactic units that children with SLI may have difficulty encoding.

Method

Participants

The participants in this study were 20 fourth-grade children with SLI (SLI group), 20 typically developing second-graders matched in language scores (LA group), and the same 20 typically developing children at fourth grade (CA group). These participants were part of the sample included in the longitudinal study of Fey, Catts, Proctor-Williams, Tomblin, and Zhang (2004), which examined oral and written story composition skills of children with language impairment. The participants in Fey et al. (2004) were originally identified in Tomblin et al. (1997). In the Tomblin et al. (1997) epidemiological study, 420 children with language disorders and 1,509 children with normal language status were identified at kindergarten. A cohort of these children participated in a longitudinal study in the second grade (n = 604) and fourth grade (n = 570) after their initial participation in kindergarten. The participants in the current study were identified as SLI or typically developing in the fourth grade, based on scores from standardized language tests and a nonverbal IQ test. In the fourth grade, a composite score of language ability was derived from the Recalling Sentences and Formulating Sentences subtests of the Clinical Evaluation of Language Fundamentals–Third Edition (CELF-3; Semel, Wiig, & Secord, 1995), the Expressive Vocabulary subtest of the Comprehensive Receptive and Expressive Vocabulary Test (CREVT; Wallace & Hammill, 1994), and the Peabody Picture Vocabulary Test–Revised (PPVT-R; Dunn & Dunn, 1981) for each child. A composite score of nonverbal IQ was also obtained from the Block Design and Picture Completion subtests of the Wechsler Preschool and Primary Scale of Intelligence–Revised (WPPSI-R; Wechsler, 1989) for each child in the second grade. Children were identified as SLI in the fourth grade if they fell more than 1.14 *SD* below the mean of the language composite score but ranked at or above –1 *SD* of the nonverbal IQ composite score.

From the sample of Fey et al. (2004), we selected 20 fourth-grade children with SLI and 20 typically developing language-matched second graders based on their language ability scores (i.e., W ability scores of language; see Appendix). In this study, these W scores served as indices of the children's language ability at the time of the language sampling, as reflected by performance on our standardized language test measures (i.e., CELF-3, CREVT, and PPVT-R). *Ability*, in this sense, refers to the child's language performance or achievement level rather than the child's language learning potential. Thus, children with similar W ability scores are likely to have similar language performance. A comprise power analysis (Erdfelder, 1984) showed that 20 participants within each group would yield a power of .80 (d = 0.67, alpha/beta ratio = 1). Because the longitudinal sample of Fey et al. (2004) included the narratives of the same children in the second and fourth grades, this offered the opportunity to use the same participants as age-matched controls in the fourth grade and language-matched controls in the second grade, which would reduce variability in the design. Thus, the participants in the present study were composed of fourth-grade children with SLI and a comparison peer group observed twice when language matched and then when age matched. The inclusion of the CA group allowed us to compare speech disruptions in children with SLI with those of their age-matched peers and to determine the relationship between language impairment and speech disruptions. At the same time, the inclusion of the LA group provided us with additional evidence to verify the role of language ability in speech disruptions. Table 1 presents the group means and standard deviations for language composite scores, raw and standard scores of the standardized language tests (i.e., CELF-3, CREVT, and PPVT-R), nonverbal IQ, maternal education, and male/female ratio for the SLI and CA groups.

Task Administration

The spoken narratives used in the current study were from Fey et al. (2004). They were collected as part of a test battery administered during two 2-hr sessions in each child's second and fourth grades. The narrative generation task was embedded roughly in the middle of the first or second testing session, with order counter-balanced across participants. The narrative task and other tests were conducted by one of the four trained examiners in a specially designed van parked at the participant's home or school.

On the day of the narrative generation task, each participant was presented with four sets of colorful laminated pictures and was asked to pick two sets, one for spoken narratives and one for written narratives (Fey et al., 2004). Each picture set contained three pictures describing a conflict and a vague resolution. The first picture of each set included the characters and key elements of the setting. The second picture presented the main character involved in a situation, which may be interpreted as a problem or conflict. The last picture depicted the main character taking some action to solve the problem or conflict, but no explicit resolution was demonstrated (for details about the story materials, see http://www.ku.edu/%7Esplh/research/catts1.html).

Before the child described the pictures, the examiner placed one of two unselected sets of pictures on the table and pointed to and labeled the main character and key elements in the picture set. Then the examiner read a prewritten model story based on the pictures to the child. All four model stories were approximately equivalent in C-units, words, grammatical complexity, and basic episodic structure (Fey et al., 2004). Next, the examiner presented the participant with one of the child-selected pictures and asked him or her to identify all of the key elements in the story. If the child failed to give the anticipated description, the examiner identified the key elements and provided the full description for the child. This procedure was used to ensure that the participant had inspected the character and the basic elements of the picture set. Thus, if the child provided a weak spoken narrative, we could exclude the factor of failure to identify the story details with more certainty and attribute it to the factors of concern. After the completion of this procedure, the child was instructed to tell a story by using the three pictures within the set. The examiner was instructed not to prompt or intervene during the child's storytelling unless the child merely labeled story elements or stopped narration without using an identifiable ending statement (e.g., *the end*). In these situations, the examiner prompted the child by asking "Is this the end of the story?" All the narratives were audiotaped for further transcription and analysis.

Transcription

The participants' spoken narratives were transcribed according to the conventions of the Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 2000) by one of three graduate research assistants at the University of Kansas. These assistants were blind to the diagnosis of participants. The unit of segmentation was the C-unit (Loban, 1976). A *C-unit* is an independent clause plus all of its dependent clauses. Side comments unrelated to the story (e.g., *bring the pictures down lower*) were marked with special symbols and were excluded from analysis. Unlike Fey et al. (2004), we included the stereotypic closings (e.g., *the end*) in our analysis because they occurred during the process of narrative production.

Data Coding and Analysis

Measuring silent pauses—The spoken narrative samples were digitized by means of Multi-Speech Model 3700 (Kay Elemetrics Corporation, Lincoln Park, NJ) with a sampling rate of 10 kHz and were then analyzed using time-frequency analysis for 32-bit Windows software (TF-32; Milenkovic, 2000) in order to measure the length of silent pauses. Because silent pauses shorter than 250 ms may reflect breathing patterns instead of cognitive acts of planning (Goldman-Eisler, 1968), only silent pauses that were longer than 250 ms were measured and categorized as (a) 250–500 ms, (b) 500–1,000 ms, (c) 1,000–2,000 ms, or (d) over 2,000 ms (Yang, 1997). The token frequency within each category was tallied.

Identifying vocal hesitations—We combined the taxonomy of Dollaghan and Campbell (1992) and of Kowal et al. (1975) to identify the types of vocal hesitation. The taxonomy of vocal hesitations included six major categories: (a) filled pauses, (b) interjections, (c) whole-word repetition, (d) part-word repetition, (e) revision, and (f) orphans. The operational definition of each type of vocal hesitation appears in Table 2.

Computing background measures of narratives—To calculate the rate of speech disruptions, we computed the total number of words by subject. We also calculated the number of C-units and mean length of C-units in words and in morphemes by subject as background measures.

Computing rates of speech disruptions—To illuminate the types of speech disruptions characteristic of each group, we computed the rates by type of disruption: (a) *Speech disruption rates by specific type:* Number of each category of silent pauses or each type of vocal hesitations divided by total number of words. We adjusted the frequency of speech disruptions by the total number of words because Dollaghan and Campbell (1992) suggested that it was a measure that was sensitive to language impairment. (b) *Total silent pause rates:* Total number of silent pauses collapsing across durational categories divided by total number of words. (c) *Total vocal hesitation rates:* Total number of vocal hesitations collapsing across types divided by total number of words.

Computing disruption rates by syntactic positions—This study also examined the distribution of speech disruptions at different syntactic positions—namely, before sentences, before clauses, before phrases, and before words. In the present analysis, a sentence must contain at least a subject and a verb, including simple sentences and complex sentences (i.e., a main clause plus at least one embedded clause). Speech disruptions before sentences were those before simple sentences or those before a complex sentence. A clause in this study must also contain at least a subject and a verb. Speech disruptions before clauses can be those before an embedded clause that occurs after the main clause or those before a main clause that occurs after the embedded clause. In both cases, the clause location referred to a sentence-internal locus because clauses at the sentence boundary would be assigned to the sentence locus. A phrase must include a head (e.g., N, Adj., V, Prep.) and its modifier/adjunct or argument/complement, and a word is a bare head without any modifier/adjunct or argument/complement. Again, phrases were internal to sentences/clauses, and words were internal to phrases. The identification of syntactic positions of pauses is exemplified in Example (2).

(2) ([SP1]) When the baby ([SP2]) horse (um [FP]) grew up, ([SP3]) there was probably no more apples on their side.

The C-unit in Example (2) contains four speech disruptions, where SP refers to silent pauses and FP refers to filled pauses. By definition, SP_1 is located before a sentence, SP_2 is situated before a word (i.e., *horse*), FP is located before a phrase (i.e., verb phrase, *grew up*), and SP_3 is situated before a clause. We computed the speech disruption rate before each syntactic position by dividing the total number of disruptions before each syntactic position by the total number of possible contexts for each syntactic position in each narrative.

Reliability

The transcripts used in the present study were originally from Fey et al. (2004). The reliability of transcription and C-unit segmentation reported were uniformly high (*rs* > .97; Fey et al., 2004, p. 1307). To check the measurement and coding reliability in the present study, we randomly sampled 20% of the narratives from each group ($n = 12$). The first author conducted the measurement and coding for all samples, and the third author did the same thing for the 12 samples. The point-to-point reliability was 90.85% for identifying the presence of silent pauses, 90.49% for identifying the types of vocal hesitations, and 94.98% for identifying the syntactic position of each disruption. The measurement of silent pause duration was also uniformly high, Pearson correlation: $r = .942$, $p < .01$; paired *t* test: $t(306) = -0.643$, $p = .521$.

Statistical Methods

We performed mixed analyses of variance (ANOVAs) to examine between-group differences of disruption rates by type. We tested the SLI group against the CA group and against the LA group separately because we were not interested in the difference between the CA and LA groups and because the CA and the LA groups were the same children. Given that two separate mixed ANOVAs were performed in each analysis, alpha was set at $p = .025$ (i.e., .05/2). Alpha for all follow-up tests was set at $p = .05$. We also conducted preplanned univariate ANOVAs to explore between-group differences of disruption rates by syntactic positions. Again, the SLI group was tested against the CA group and against the LA group separately. Alpha for all preplanned tests was set at $p = .05$. Univariate ANOVAs were also computed to examine the group differences in background measures of narratives.

Results

Background Measures of Narratives

Table 3 summarizes the background measures of spoken narratives in this study. Univariate ANOVAs showed that the SLI group produced a lower number of words than the CA group, $F(1, 38) = 7.221$, $p = .011$, $\eta_p^2 = .160$, but not a lower number of words than the LA group, $F(1, 38) = 0.071$, $p = .792$, $\eta_p^2 = .002$. However, there were no significant group differences in number of C-units, $Fs(1, 38) < 3.751$, $ps > .060$; in mean length of utterance in words, *F*s(1,

38) < 2.478, *p*s > .124; or in mean length of utterance in morphemes, *F*s(1, 38) < 2.543, *p*s > .119.

Speech Disruption Rates by Type

Table 4 presents silent pause rates by group and duration category, and Table 5 presents vocal hesitation rates by group and specific type. We first examined the group differences in speech disruption rates by collapsing specific duration categories and types into two general disruption types: total silent pauses and total vocal hesitations. Two 2 (groups: SLI vs. CA or LA) × 2 (disruption types) mixed ANOVAs were performed. In the comparisons between the SLI and the CA groups, there was a main effect of group, $F(1, 38) = 8.197$, $p = .007$, $\eta_p^2 = .177$, where the SLI group produced higher disruption rates than the CA group. There was also a main effect of disruption type, $F(1, 38) = 331.396$, $p = .000$, $\eta_p^2 = .897$, where total silent pause rates were higher than total vocal hesitation rates. The main effects were qualified by a Group × Disruption Type interaction effect, $F(1, 38) = 7.749$, $p = .008$, $\eta_p^2 = .169$. Follow-up univariate ANOVAs showed that the SLI group outnumbered the CA group in total silent pause rates, $F(1, 38) = 9.642$, $p = .004$, $\eta_p^2 = .202$, but not in total vocal hesitation rates, $F(1, 38) = 1.195$, $p = .281$, $\eta_p^2 = .030$. In the comparison between the SLI and the LA groups, there was a main effect of disruption type, $F(1, 38) = 329.627$, $p = .000$, $\eta_p^2 = .897$, due to higher rates in total silent pauses than in total vocal hesitations. There was no main effect of group, $F(1, 38) = 0.800$, $p = .377$, $\eta_p^2 = .021$, or Group × Disruption Type interaction effect, $F(1, 38) = 0.328$, $p = .570$, $\eta_p^2 = .009$. Thus, the SLI and the LA groups did not differ significantly in disruption rates.

A 2 (groups: SLI vs. CA) × 4 (duration categories) mixed ANOVA was then conducted to examine whether the SLI and the CA groups differed in specific duration categories of silent pauses. There was a main effect of group, $F(1, 38) = 310.354$, $p = .003$, $\eta_p^2 = .214$, and a main effect of duration category, $F(3, 114) = 45.293$, $p = .000$, $\eta_p^2 = .544$. The main effect of duration category was due to higher rates in the category of 500–1,000 ms than in the categories of 250–500 ms and 1,000–2,000 ms, followed by the category of over 2,000 ms (*p*s < .05) The main effects were qualified by a Group × Duration Category interaction effect, $F(3, 114) = 4.484$, $p = .000$, $\eta_p^2 = .106$. Follow-up univariate ANOVAs revealed that the SLI group produced higher silent pause rates than the CA group in the duration category of 500–1,000 ms, $F(1, 38) = 15.148$, $p = .000$, $\eta_p^2 = .285$, but not in other categories, all *F*s(1, 38) < 3.981, *p*s > .05.

Although there was no difference in total vocal hesitation rates between the SLI and the CA group, it was possible that these two groups may differ in specific types of vocal hesitations. These differences may have been obscured because we combined all the specific types of vocal hesitations at the global test. To examine this possibility, we conducted univariate ANOVAs to compare the SLI and the CA groups by specific type of vocal hesitations. The results showed that the SLI and the CA groups did not differ significantly in rates of any specific type of vocal hesitations, all *F*s(1, 38) < 2.533, *p*s > .120.

Speech Disruption Rates by Syntactic Position

Table 6 displays speech disruption rates by group and syntactic position. Preplanned univariate ANOVAs were conducted to examine group differences in disruption rates by syntactic position. In the comparisons between the SLI and CA groups, univariate ANOVAs revealed that the SLI group produced more speech disruptions than the CA group before phrases, $F(1, 38) = 11.622$, $p = .002$, $\eta_p^2 = .234$, but not before sentences, clauses, or words, all *F*s(1, 38) <1.195, *p*s > .05. In the comparisons between the SLI and LA groups, univariate ANOVAs showed that the SLI group did not produce more speech disruptions than the LA group before any of the syntactic positions, all *F*s(1, 38) < 1.340, *p*s > .05.

Discussion

This study examined the types, frequencies, and distribution of speech disruptions in the narratives of 20 fourth-grade children with SLI and their age-matched and language-matched peers. Three questions were addressed: (a) Do children with SLI produce more speech disruptions than their peers? (b) Do children with SLI outnumber typically developing children in specific types of speech disruptions? and (c) Does the syntactic position matter in the production of speech disruptions? We predicted that the SLI group would produce higher silent pause rates and vocal hesitation rates than the CA group and that the SLI group would produce more disruptions than the CA group not only at constituent boundaries (i.e., before sentences, clauses, and phrases) but also within constituents (i.e., before words). As predicted, children with SLI produced more speech disruptions than their age-matched peers but not their language-matched peers. Analyses by speech disruption types indicated that the SLI group outnumbered the CA group in silent pauses of 500–1,000 ms but not in vocal hesitations, which partially supported our predictions. In addition, the SLI group produced higher disruption rates before phrases than the CA group, which supports our predictions. However, contrary to our prediction, these two groups did not differ in disruption rates before sentences, clauses, or words.

Speech Disruption Is Related to Language Ability

The present study confirmed the relationship between language ability and speech disruptions. In this study, language ability was represented by performance on the independent tests of language (i.e., CELF-3, CREVT, and PPVT-R). Children with lower language ability (i.e., children with SLI) produced higher disruption rates than those with higher language ability (i.e., the CA group). When the levels of language ability were matched, children with and without SLI (i.e., the LA group) exhibited similar rates of speech disruptions. These findings were consistent with the extant literature on the relationship between language impairment and speech disruptions (Boscolo et al., 2002; Dollaghan & Campbell, 1992; Netttelbladt & Hansson, 1999). In these studies, children with atypical language development tended to produce more speech disruptions than children with typical language development in spoken discourse. Our finding also indirectly supported the studies on typical language development that children become more fluent as their language abilities enhance (Kowal et al., 1975; Wijnen, 1990).

The relationship between language ability and speech disruptions can be interpreted via a representation account (MacDonald & Christiansen, 2002). In the representation account, representation of and processing of linguistic knowledge (i.e., lexical and syntactic knowledge) are interdependent and operate on the same neural substrate or network. As children get older, their representation of linguistic knowledge becomes stronger because they hear more input from the environment and/or use the linguistic knowledge more often (Abbot-Smith & Tomasello, 2006). Improving the strength of representation will enhance the network’s capacity for activation and enables the knowledge to be processed more efficiently. Children with typical development will be able to activate the lexical items and syntactic frames during sentence production more efficiently and produce fewer disruptions as they get older. Because of lexical (McGregor et al., 2002) and syntactic deficits (Leonard, 1998; Rice et al., 1995), children with SLI may have weaker linguistic representations and hence lower capacity for activation of these representations than their age-matched peers. Children with SLI are thus at higher risk of glitches when activating lexical items and syntactic frames for sentence formulation and produce more disruptions than their age-matched peers in spoken discourse. On the other hand, children with SLI produced similar disruption rates as younger typically developing children with comparable level of language ability. This finding further confirms the prediction of the representation account. Children with comparable level of language ability would have similar strengths of linguistic representations and capacity for activation and would produce similar speech disruption rates.

An important question concerns why some researchers failed to find differences in speech disruption rates between children with and without language impairment (Lees et al., 1999; MacLachlan & Chapman, 1988; Scott & Windsor, 2000). There are two possible reasons. First, these studies did not investigate silent pauses shorter than 2,000 ms. MacLachlan and Chapman (1988) and Scott and Windsor (2000) examined vocal hesitations but not silent pauses in their studies. Lees et al. (1999) investigated silent pauses but they did not specify the cutoff point of silent pauses. In these data, 16 children produced only 20 silent pauses in total. This low number would have been very unlikely if they had measured silent pauses shorter than 2,000 ms. As our results indicate, silent pauses of 500–1,000 ms but not vocal hesitations differentiate children with SLI from their age-matched peers. Without conducting a detailed analysis of silent pauses, these studies may have limited their opportunity to find a relationship between language impairment and the production of speech disruptions. Second, these studies did not correct the token frequency of speech disruptions by the total number of words. For instance, Scott and Windsor (2002) documented fluency rates by percentage of T-units with disruptions. One potential drawback of this computation is that the number of disruptions per T-unit may be different in children with and without LLD. Each T-unit, on average, may contain more disruptions in the LLD group than in the control group, although the percentage of T-units with disruptions may be similar across groups. In this situation, the LLD group is actually more dysfluent than the control group but the measure—percentage of T-units with disruptions—does not reveal this difference.

Children With SLI Outnumbered the Age-Matched Peers in Silent Pause Rates but not in Vocal Hesitation Rates

In this study, the SLI group outnumbered the CA group in total silent pause rates. Contrary to our prediction, the SLI and the CA groups did not differ significantly in total vocal hesitation rates or in rates of any specific type of vocal hesitations (i.e., filled pauses, interjections, whole-word and part-word repetitions, and revisions). Nevertheless, these findings were consistent with the studies in children with atypical language development. Dollaghan and Campbell (1992) found that children and adolescents with TBI outnumbered their age-matched peers in silent pauses but not in vocal hesitations. Boscolo et al. (2002) indicated that children with and without HSLI-E differed in stuttering-like dysfluencies (part-word repetition, prolongations, broken words, and tense pauses) but not in normal dysfluencies (i.e., filled pauses, interjections, phrase and whole-word repetitions, and revisions). The current and previous studies reveal that silent pauses, instead of vocal hesitations (or normal dysfluencies), differentiate children with language impairment and the age-matched controls. The only inconsistency is that Boscolo et al. (2002) found that children with SLI produced higher part-word repetition rates than their age-matched peers—we did not find that to be the case. These issues are discussed in the paragraphs that follow.

The reason why children with SLI outnumbered their age-matched peers in silent pauses but not in vocal hesitations may be because they have more difficulty activating linguistic elements (e.g., syntactic frames, lexical items) during narrative production, but they do not make more errors of commission in activating incorrect linguistic elements than their age-matched peers. Because of the weak representation of linguistic knowledge, children with SLI may encounter more difficulty in activating the linguistic elements for sentence formulation as compared with their age-matched peers. They may need more time to activate these elements, so they might use speech disruptions that would buy time for them more often than the age-matched controls (Kowal et al., 1975). Despite slowdowns, children with SLI may not commit more errors than their age-matched peers in activating erroneous linguistic elements, at least in narrative production. If this is the case, we should expect to see that the SLI group would outnumber the CA group in the rates of silent pauses, filled pauses, interjections, and repetitions but not in the rate of revisions. The current results did show that children with SLI produced higher silent pause rates but similar revision rates as compared with their age-matched peers. However, if children with SLI needed more time to activate linguistic elements, why did they not produce higher rates of filled pauses, interjections, or repetitions than their age-matched peers? The similar rates of filled pauses and interjections between the SLI and the CA groups may be due to the current task we used (i.e., narratives). Although they also buy time for speakers during the course of sentence production, filled pauses and interjections tend to be used to keep the floor in discourse (Clark & Fox Tree, 2002; Maclay & Osgood, 1959). Due to the lack of conversation partners in the narrative task, children with SLI may not have to use filled pauses and interjections to maintain the floor. In addition, children with SLI may not need to use interjections to signal revisions as often because they did not commit more errors in retrieving linguistic elements than their age-matched peers.

The lack of differences in whole-word repetitions rates between the SLI and the CA group may result from strategy preferences. Whole-word repetitions, similar to silent pauses, buy time for the speaker to activate syntactic frames and/or lemma information of lexical items (Postma & Kolk, 1993; Rispoli, 2003) when he or she encounters difficulty in activating these elements. It is possible that children with SLI, similar to the age-matched controls, did not prefer repetitions as a strategy when they encountered difficulty in activating linguistic elements during sentence production, which is supported by the low rates of whole-word repetitions in both groups. They might prefer silent pauses to repetitions in this situation. In addition, the SLI group did not produce higher rates of part-word repetitions than the CA group. Contrary to whole-word repetitions, part-word repetitions reflect difficulties in activating phonological forms (i.e., lexemes) of lexical items (Postma & Kolk, 1993). The current sample of children with SLI might not have had more difficulty in activating phonological forms of lexical items than their age-matched peers and therefore did not produce more part-word repetitions (see the paragraphs that follow).

In the current study, we did not find differences in part-word repetition rates between the SLI and CA groups. Inconsistent with our finding, Boscolo et al. (2002) found that children with HSLI-E produced higher rates of total stuttering-like dysfluencies (i.e., the sum of part-word repetitions, prolongations, blocks, and broken words) than the controls. However, Boscolo et al. (2002) did not compare group differences by specific type of stuttering-like dysfluencies. It is not clear whether there would be group differences in part-word repetition rates because the average rate was low in each group (i.e., 0.3% for the SLI group; 0.1% for the CA group), with a wide range of individual rates (0–1.2%). Even if there were group differences in part-word repetition rates, the inconsistency between our study and that of Boscolo et al. (2002) may result from differences in samples. The sample from Boscolo et al. (2002) consisted of clinically referred children, whereas our groups comprised children from a large-scale epistemological study. Studies based on clinical samples tend to oversample children with co-occurring conditions (Fey et al., 2004). For instance, Zhang and Tomblin (2000) found that children with language impairment recruited from clinical samples were more likely to have speech sound disorders than those recruited from a broader population of children. The HSLI-E group in the Boscolo et al. (2002) study may have exhibited more speech sound disorders than the SLI group in our study. Part-word repetitions and other stuttering-like dysfluencies are related to difficulties in activating phonological forms of words (Postma & Kolk, 1993). Therefore, the HSLI-E group in Boscolo et al. (2002) may have been vulnerable to difficulties in retrieving phonological forms of lexical items during sentence production due to their co-occurring speech sound disorders. This vulnerability may have led to higher rates of part-word repetitions and other stuttering-like dysfluencies in the HSLI-E than in the control groups. This argument is further supported by Hall (1999), which indicated that children with both SLI and phonological impairment tended to produce more stuttering-like dysfluencies than those with SLI only. Taken together, the current and previous studies suggest that children with co-occurring language impairment and speech sound disorders may produce more stuttering-like dysfluencies than their age-matched peers, whereas children exhibiting only language impairment may not.

This study also found that children with SLI produced higher silent pause rates than their age-matched peers in the duration category of 500–1,000 ms but not in other categories. Across groups, the rate of the duration category of 500–1,000 ms was the highest among the four duration categories, whereas that of the category of over 2,000 ms was the lowest. In the language production model, a sentence can be processed in fragments or increments (Levelt, 1989). It is possible that the duration of 500–1,000 ms approximates the time needed for processing an increment for a fourth grader. Due to difficulties in activating lexical items and syntactic frames, children with SLI may need silent pauses of 500–1,000 ms more often than their age-matched peers. However, this does not mean that children will always have to pause between increments. Because the increments of a sentence are processed in parallel and are organized into a sentence under unification constraints (Bock & Levelt, 1994), a sentence can be produced fluently without any intervening silent pauses between increments. Silent pauses, which reflect processing time for sentence planning, would only occur when there are processing breakdowns.

Children With SLI Produced More Disruptions Before Phrases Than the Age-Matched Group

Children with SLI produced more speech disruptions than their age-matched peers before phrases but not before sentences, clauses, or words. These results partially support our prediction that children with SLI would produce more disruptions than their peers between and within constituents. The difference between the SLI and CA groups in disruption rates at phrase boundaries, nevertheless, seems to reflect the lexical and syntactic deficits in children with SLI. Building up the internal structure of a phrase requires the activation of lemma information of lexical items, which guides the activation of syntactic frames. Because of lexical and syntactic deficits (i.e., weak linguistic representations), children with SLI may encounter more glitches than their age-matched peers in activating lexical items and syntactic frames to build up phrases. The SLI group thus produced higher disruption rates than the CA group at phrase boundaries. It seems that disruption rates at phrase boundaries are a more sensitive measure, tapping the lexical and syntactic deficits in children with SLI, as compared with those at sentence, clause, or word boundaries in narratives.

Clinical and Experimental Implications

The current findings have two implications for clinicians and researchers who are interested in speech disruptions in special populations. First, the measurement of silent pauses shorter than 2,000 ms should be incorporated into language sample analyses. Traditional transcription conventions (e.g., Miller & Chapman, 2000) focus only on silent pauses that are equal or greater than 2,000 ms. Our results showed that silent pauses of 500 ms to 1,000 ms, rather than those greater than 2,000 ms, distinguished fourth-grade children with SLI from their age-matched peers. Second, the results from current and previous studies (Boscolo et al., 2002; Dollaghan & Campbell, 1990) showed that token frequency of disruptions divided by the total number of words is a measure that is sensitive to language impairment. Future studies examining speech disruption rates in special populations may need to take the total number of words into consideration (cf. Rispoli, 2003).

Issues for Future Research

This study did not include the disruption type, prolongation, in the analysis. *Prolongation* involves the lengthening of word segments or syllables and is determined perceptually relative to the speech tempo of the preceding syllables (Liu, 1998). We did not include prolongation in the analysis because we could not reliably identify the prolongation of syllables, especially phrase-final syllables. Prolongation, however, tends to signal the process of retrieving words or phrases (Liu, 1998). Children with SLI appear to have lexical retrieval difficulties. Excluding prolongation in this study may have limited the opportunity to capture the details of these difficulties in children with SLI. Therefore, we suggest that future studies include prolongation in the analysis and examine its relation to lexical retrieval deficits.

This study demonstrates that silent pauses are sensitive to the underlying deficits of children with SLI. The difference between fourth-grade children with SLI and their age-matched peers is restricted to silent pauses of 500–1,000 ms. There might, however, be developmental differences in this pattern. For instance, younger children with SLI may differ from their age-matched peers in silent pauses of 1,000–2,000 ms. This finding might also vary by using different tasks (e.g., conversation, expository discourse). In addition, we did not find that children with and without SLI differed in the use of filled pauses or interjections probably because of the limitation of narrative tasks. Future research should address potential developmental changes in speech disruptions and should include different tasks to verify these issues.

Conclusion

Speech disruptions reflect the cognitive processes underlying language production. This study examined the types, frequencies, and distribution of speech disruptions in the narratives of fourth-grade children with SLI and their age-matched and language-matched peers. Children with SLI produced speech disruptions more often than their age-matched peers but not their language-matched peers, suggesting a relationship between language ability and speech disruption. The difference between children with SLI and their age-matched peers was confined to silent pauses of 500–1,000 ms. Children with SLI did not produce more disruptions across the board in the production of narratives; rather, they outnumbered their peers in disruptions before phrases but not before sentences, clauses, or words. Taken together, these findings suggest that speech disruptions at phrase boundaries produced by children with SLI reflect their underlying lexical and syntactic immaturity.

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Appendix

W ability scores of language

W-ability scores of language were computed using a Rasch model of item response theory (IRT). Within IRT, the probability of an item being passed in a test is a function of ability level of the examinee and the difficulty of the item as well as its discrimination and probability of guessing. In our Rasch IRT model, guessing was set as a constant and, thus, difficulty and discrimination were the key item variables. Therefore, if one knows from empirical work (administering the test to examinees) what the probability is for an item, then one can solve for either item difficulty and discrimination holding examinees constant or examinee ability holding items constant. This process is termed item *calibration* (Mislevy & Bock, 1998). For this purpose, it was necessary to select items from the test battery used with the children in the larger group of children from which the participants in study were sampled so that these items could be calibrated with regard to their difficulty. Therefore, 80 items were drawn from the PPVT-R (Dunn & Dunn, 1981), the Expressive subtest of the CREVT (Wallace & Hammill, 1994), and Concepts and Directions, Sentence Structure, Word Structures, and Recalling Sentences subtests of the CELF-3 (Semel, Wiig, & Secord, 1995). These items were selected because their overall pass rates were between 10% and 90%, and thus the items were within an appropriate range of difficulty for children between second and fourth grades. As noted previously, computation of item difficulty and discrimination is straightforward if all items are taken by the set examinees, where ability remains constant within examinee. However, some of the selected items in second and fourth grade were only taken by examinees at one grade level. Even though the same children were administered the items at each grade level, the ability level of these children had changed. Therefore, it was important to have some items that were administered at both second and fourth grades. Twenty-three of the 80 items were administered across grade levels. These items served as anchors (Vale, 1986), providing a means of measuring the change in the examinee's ability across time while holding the item difficulty constant. This process is referred to as *test equating*, and the methods are described by Mislevy and Bock (1998) in the documentation for BILOG. In this way, all items from second and fourth grade could be calibrated with regard to their difficulty.

We performed the IRT analysis using BILOG. Within the anchor set, the difficulty of the test items was invariant and, therefore, for these items the mean and standard deviation of their difficulty level were held constant across the grade levels. This was achieved by adjusting the location and scale parameters for the IRT model. Thus, the performance level increase on the same set of items from one grade level to the next could be totally attributed to the ability increase in examinees. After the average increase in the ability and the standard deviation change from one grade level to the next were determined (i.e., location and scale parameters were correctly specified), the IRT modeling procedure automatically estimated the difficulty and discrimination power for all items. Once these parameters were obtained, BILOG provided estimates of language ability that had a mean of 0 and standard deviation of 1.

Table 1

Background measures of participants.

Measure	SLI (*n* = 20) *M* (*SD*)	ND (*n* = 20) *M* (*SD*)
Language Composite (4th grade)	78.75 (10.34)	117.09 (12.65)
CELF-3 (4th grade): Raw score[a]	53.20 (14.12)	91.60 (11.91)
CELF-3 (4th grade): Standard score	6.30 (2.52)[b]/ 6.20 (3.96)[c]	12.20 (2.48)/12.35 (2.62)[bc]
CELF-3 (2nd grade): Raw score[d]	—	114.10 (12.78)
CELF-3 (2nd grade): Standard score	—	12.25 (2.82)/12.48 (2.98)[be]
	—	12.10 (2.71)/13.00 (2.75)[fg]
CREVT (4th grade): Raw score	8.40 (3.57)	16.80 (3.44)
CREVT (4th grade): Standard score	82.05 (11.66)	112.95 (16.51)
CREVT (2nd grade): Raw score	—	13.45 (2.67)
CREVT (2nd grade): Standard score	—	113.10 (13.17)
PPVT-R (4th grade): Raw score	92.00 (10.21)	121.60 (12.98)
PPVT-R (4th grade): Standard score	83.45 (12.57)	116.25 (17.45)
PPVT-R (2nd grade): Raw score	—	107.05 (10.25)
PPVT-R (2nd grade): Standard score	—	117.60 (14.78)
Nonverbal IQ	99.10 (8.67)	112.65 (12.77)
Maternal education	13.25 (1.92)	14.95 (1.99)
Age in 4th grade	9.95 (0.50)	9.97 (0.52)
Age in 2nd grade	—	8.13 (0.39)
Male/female ratio	1.88	1.00
% White	98	98
% Black	2	0
% Hispanic	0	2

Note. CELF = Clinical Evaluation of Language Fundamentals; CREVT = Comprehensive Receptive and Expressive Vocabulary Test; PPVT-R = Peabody Picture Vocabulary Test–Revised.

[a]Scores are based on the Recalling Sentences and Formulating Sentences subtests.

[b]Standard scores of the Recalling Sentences subtest.

[c]Standard scores of the Formulating Sentences subtest.

[d]Scores are based on the Recalling Sentences, Sentence Structure, Concepts and Directions, and Word Structure subtests.

[e]Standard scores of the Sentence Structure subtest.

[f]Standard scores of the Concepts and Directions subtest.

[g]Standard scores of the Word Structure subtest.

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Table 2

Operational definitions of vocal hesitations.

Type	Operational definition	Example
Filled pause	Nonlexical one-syllable filler syllables	*(Um) his colt named Blackie.*
Interjection	Conventional words or phrases that do not contribute information to an utterance	*(Well) the horses never got to get any apples.*
Part-word repetition	The repetition of phonemes or syllables of a word	*The girl wanted to (fl*) fly her yellow kite.*
Whole-word repetition	1. The repetition of whole monosyllabic or multisyllabic words without emphatic meaning	*(We) we are safe now.*
	2. The repetition of whole phrases or multi-words without emphatic meaning	*But then (the boy) the boy drowned. (The boy was) the boy was nervous about the birds.*
Revision	Recognizable modifications of an already-produced unit, which result in alternation of lexical, syntactic, semantic or phonological materials	*There was (a f*) a brown fence separated.*
Orphan	Linguistic units that do not have a reliably identifiable relationship to other units	*I will get (in) the money.*

Table 3

Background measures of narratives.

Group	Total no. of words		No. of C-units		MLCU-W		MLCU-M	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
SLI	102.75	33.99	12.50	4.36	8.57	1.20	9.47	1.31
CA	145.35	62.21	16.15	7.21	9.39	1.98	10.41	2.31
LA	106.10	44.97	12.05	5.68	9.15	1.42	10.17	1.66

Note. MLCU-W = mean length of C-units in words; MLCU-M = mean length of C-units in morphemes. SLI = specific language impairment; CA = age-matched peers; LA = language-matched peers.

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Table 4

Silent pause rates by group and duration category.

Group	250–500 ms		500–1000 ms		1000–2000 ms		>2000 ms[a]		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
SLI	0.07[b]	0.03	0.11[c]	0.05	0.07	0.04	0.03	0.02	0.27	0.09
CA	0.07	0.02	0.07[c]	0.02	0.05	0.03	0.01	0.01	0.20	0.05
LA	0.08	0.03	0.09	0.04	0.06	0.03	0.02	0.03	0.25	0.08

[a] *Note*. Silent pauses that are longer than 2000 ms.

[b] The unit of measure is the number of silent pauses per word.

[c] A significant between-groups difference, $p < .05$.

Table 5

Vocal hesitation rates by group and type.

Group	Filled pause		Interjection		WW-repetitions		PW-repetitions		Revision		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
SLI	0.01[a]	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.03	0.02	0.05	0.03
CA	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.04	0.04
LA	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.03	0.02	0.05	0.02

Note. WW = whole-word; PW = part-word.

[a]The unit of measure is the number of tokens per word.

Table 6

Speech disruption rates by group and syntactic position.

Group	Sentence		Clause		Phrases		Word	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
SLI	0.76[a]	0.22	0.47	0.35	0.27[b]	0.10	0.11	0.12
CA	0.72	0.24	0.27	0.29	0.17[b]	0.08	0.08	0.07
LA	0.85	0.25	0.43	0.36	0.21	0.08	0.09	0.09

[a] *Note*. The unit of measure is the number of tokens per possible context.

[b] A significant between-groups difference, $p < .05$.