Published in final edited form as:
J Fluency Disord. 2009 September ; 34(3): 155–172. doi:10.1016/j.jfludis.2009.08.001.

Sentence Position and Syntactic Complexity of Stuttering in Early Childhood: A Longitudinal Study

Anthony P. Buhr and
Department of Hearing and Speech Sciences, Vanderbilt University, 8310 Bill Wilkerson Center, Nashville, TN 37232, 319-541-5610, Anthony.buhr@vanderbilt.edu

Patricia M. Zebrowski
Department of Speech Pathology Audiology, University of Iowa, 127C SHC, Iowa City, Iowa 52245, 319-335-8735, Tricia-zebrowksi@uiowa.edu

Abstract

The purpose of the present investigation was to assess longitudinal word- and sentence-level measures of stuttering in young children. Participants included 12 stuttering and non-stuttering children between 36 and 71 months of age at an initial who exhibited a range of stuttering rates. Parent-child spontaneous speech samples were obtained over a period of two years at six-month intervals. Each speech sample was transcribed, and both stuttering-like disfluencies (SLDs) and other disfluencies (ODs) were coded. Word and sentence-level measures of SLDs were used to assess linguistic characteristics of stuttering. Results of the word-level analysis indicated that stuttering was most likely to occur at the sentence-initial position, but that a tendency to stutter on function words was present only at the sentence-initial position. Results of the sentence-level analyses indicated that sentences containing ODs and those containing SLDs were both significantly longer and more complex than fluent sentences, but did not differ from each other. Word- and sentence-level measures also did not change across visits. Results were taken to suggest that both SLDs and ODs originate during the same stage of sentence planning.

Introduction

Linguistic characteristics of instances of stuttering have been examined at the *word*-level and at the *sentence*-level. Spencer Brown first observed that instances of stuttering tend to occur on words at the beginning of sentences (Brown, 1938) and on content words such as nouns and verbs (Brown, 1937). One explanation for these findings was that both content words and sentence-initial words hold greater communicative importance within a sentence (e.g., Brown, 1945; Eisenson & Horowitz, 1945; Quarrington, 1965; Trotter, 1956). It has also been argued that stuttering at the beginning of a sentence is related to greater indecision or uncertainty associated with formulating an idea or constructing a sentence (e.g., Soderberg, 1967; Taylor, 1966). Subsequent work has shown that children are more likely to stutter on function words such as pronouns and conjunctions (Au-Yeung, Howell, & Pilgrim, 1998; Bloodstein & Gantwerk, 1967; Bloodstein & Grossman, 1981; Silverman, 1974; Williams, Silverman, & Kools, 1969), and that this may be related to sentence position as well (e.g., Bloodstein & Gantwerk 1967; Bloodstein & Grossman, 1981).

The finding that the occurrence of instances of stuttering is predictable (i.e., beginning of a sentence) was consistent with psycholinguistic studies showing that other, more typical, disfluencies such as whole-word repetitions and pauses are also more likely to occur at the beginning of an utterance (e.g., Boomer, 1965; Goldman-Eisler, 1958; Holmes, 1988; Maclay & Osgood, 1959), for example, due to uncertainty associated with planning the sentence. Similarly, studies examining stuttering in childhood have suggested that instances of stuttering at the beginning of a sentence are related to aspects of sentence planning, such as integrating syntactic constituents (Bernstein, 1981; Wall, Starkweather, & Cairns, 1981) or motor initiation/execution (Bloodstein & Gantwerk, 1981; Logan & LaSalle, 1999).

Linguistic factors related to instances of stuttering have also been examined at the sentence-level. A number of studies have reported that utterances that are longer and/or more syntactically complex are more likely to be stuttered (Gains, Runyan, & Meyers, 1991; Logan & Conture, 1995; Logan & Conture, 1997; Logan & LaSalle, 1999; Sawyer, Chon, & Ambrose, 2008; Watkins, Yairi, & Ambrose, 1999; Weiss & Zebrowski, 1992; Yaruss, 1999; Zackheim & Conture, 2003). Studies have also found evidence of a relation between sentence complexity and other types of disfluency such as interjections and revisions (Bernstein Ratner and Costa Sih, 1987; Rispoli & Hadley, 2001; Silverman & Bernstein Ratner, 1997).

Findings from studies examining word- and sentence-level measures of disfluency therefore seem to demonstrate that both stuttered and other disfluencies 1) tend to be located at the beginning of an utterance, and 2) tend to occur in longer and syntactically complex utterances. These findings suggest that the occurrence of both stuttering and other types of disfluencies may be triggered by aspects of sentence planning, and that their manifestation in speech tends to occur at the beginning of a planning unit (i.e., a clause). Thus, stuttering and other types of disfluency may both be triggered by similar factors, and word- and sentence-level measures may each may tap into those factors.

Another way in which the relation between linguistic factors and instances of stuttering has been investigated is in terms of development. In a cross-sectional study using five different age groups ranging from early childhood to adulthood, Au-Yeung et al. (1998) reported that children stuttered on a significantly greater proportion of function words, but that older children, teenagers, and adults as a group were significantly more likely to stutter on content words. In particular, they found evidence of an exchange from stuttering on function words to stuttering on content words at around age nine. To further explore the relation between stuttering and word class, Au-Yeung et al. (1998) segmented utterances into phonological words. Sellkirk (1984) has described phonological words as units of speech consisting of a content word and any associated function words that modify the content word. For example, in the sentence *I looked after my nephew*, phonological words would be formed by *I looked after* and *my nephew*, since *I* and *after* both modify *looked*, and *my* modifies *nephew*. Au-Yeung et al. found that function words *preceding* content word heads within phonological words were more likely to be stuttered than function words that *followed* content word heads.

Howell and colleagues (e.g., Howell, 2004; Howell, Au-Yeung, & Sackin, 1999) have hypothesized that function words are stuttered as a delaying tactic for insufficiently planned content words that follow, and that the apparent word class exchange was the result of attempting to execute insufficiently planned content words rather than stuttering on the preceding function word. Au-Yeung et al. thus argued that function words are stuttered due to word *external* factors, whereas content words are stuttered due word *internal* factors.

Two points can be taken away from the work of Howell & colleagues. First, the tendency to stutter on initial function words within phonological words appears to be consistent with findings that stuttering tends to take place at the beginning of a sentence. In other words, speech disfluencies may emerge due to difficulties or inefficiencies associated with the planning of linguistic units, whether they are syntactic units or phonological word units. Consistent with this speculation, Au-Yeung et al. (1998) also found that stuttering rate on function words was significantly higher at the sentence-initial position than at other positions within a sentence. Thus, it does not appear to be function words per se that are related to stuttering, but rather their position within a linguistic unit.

Second, the inference that a word class exchange takes place around nine years of age suggests that such an exchange is not related to language development. While it may indeed be the case that a word class exchange involves a shifting strategy in dealing with stuttering, this shift appears to take place at a later age than what would be expected if it were to involve linguistic factors. As such, Au-Yeung et al. (1998) found evidence that the influence of utterance position on stuttering becomes less marked as children get older, consistent with previous findings (e.g., Williams et al., 1969). Thus, to the extent that disfluency patterns change over language development (Hall, Wagovich, & Bernstein Ratner, 2007; Rispoli & Hadley, 2001; Wijnen, 1990), the development of sentence planning may lead to instances of stuttering becoming more evenly distributed throughout an utterance, resulting in a relatively greater proportion of stuttering on content words. Whether a word class shift is related to language development can therefore be investigated by assessing word- and sentence-level measures of stuttering during a period of time when language is developing.

To summarize, while it has been speculated that stuttering on function words is related to stuttering at the beginning of an utterance (e.g., Bloodstein & Grossman, 1981; Wall et al., 1981), whether stuttering on function words is to some extent an artifact of stuttering at the beginning of an utterance has not been empirically assessed. Furthermore, while previous studies have interpreted word- and sentence-level measures of stuttering in terms of sentence planning (e.g., Bernstein, 1981; Logan & LaSalle, 1999), these measures do not appear to have been extensively examined in terms of a common underlying factor. Finally, word- and sentence-level measures of stuttering have not been examined longitudinally within the same study, and to the extent that each relate to linguistic planning, any change may be expected to occur during *language development*.

The purpose of the present investigation was therefore to assess word- and sentence-level measures of stuttering longitudinally. *First*, the relation between word class and sentence position were investigated. It was predicted that if the tendency to stutter on function words is due to their position in a sentence, then a tendency to stutter on function words would only be apparent at the sentence-initial position. *Second*, the relation between sentence position and sentence length and syntactic complexity was investigated. It was predicted that if each taps into similar aspects of sentence planning, then both would be related to speech disfluencies within the same set of sentences. *Third*, the relation between stuttering and language development was investigated. It was predicted that if linguistic factors do indeed contribute to stuttering, then word- and sentence-level measures of stuttering would change during early childhood, the time at which language is developing relatively rapidly.

Method

Participants

Participants consisted of 12 children who were between 3 and 5 years of age (36–71 months) at an initial visit (see Table 1). The onset of stuttering is generally observed to occur within this age range (Yairi & Ambrose, 2005). Each participant was part of a larger multi-site study directed by investigators at the University of Illinois (N. Ambrose, PI, E. Yairi, former PI). This multi-site study was intended to investigate developmental subgroups of early childhood stuttering and to identify predictive factors of persistence or recovery from stuttering. The focus of the present investigation, however, was to examine linguistic factors associated with instances of stuttering during speech, which have been observed to be present in the speech of all children, whether categorized as stuttering or non-stuttering (e.g., Au-Yeung et al., 1998;Silverman, 1974;Williams et al., 1969). Thus, although developmental trajectories were identified (i.e., persistence, recovery, and normally-fluent) for the purposes of the larger study, developmental subgroup classifications were not utilized in the present investigation.

Participants were recruited from various sources, such as from speech-language pathologists at the Wendell Johnson Speech and Hearing Clinic at the University of Iowa, day-care centers, and newspaper advertisements. Parents of children who were classified as stuttering were provided information about stuttering development and received professional clinical opinion about the likelihood of recovery. Although the study was not intended to provide clinical services, parents were given the option of deciding whether their children would receive treatment for stuttering while participating in the study (see Yairi & Ambrose, 1999). While three participants had received some form of speech therapy prior to the initial visit, this was not assumed to have a significant influence on characteristics of instances of stuttering. For each of the 12 participants, parents signed an informed consent. The protocol of the study was approved by the Institutional Review Board at the University of Iowa.

Inclusion criteria—Of the children who took part in the larger study, the first twelve who met inclusion criteria were retrospectively chosen for the present study. First, participants had to score within normal limits in speech and language development as assessed by the Test of Early Language Development (TELD; Hresko, Reid, & Hammill, 1991), the Hodson Assessment of Phonologic Proficiency (HAPP; Hodson, 1986), the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997), and the Expressive Vocabulary Test (EVT; Williams, 1997). Second, participants had to remain in the study for all five visits for a two-year period of time, and complete parent-child conversational samples of speech at each visit. Participants were considered to be stuttering at any visit if they a) produced at least 3 stuttering-like disfluencies per 100 words, and b) were perceived by their parents to be stuttering (Yairi & Ambrose, 1992, 1999).

The study period consisted of five visits (Visits I, II, III, IV, and V) across two years with a six-month interval between visits. Two separate conversational speech samples were acquired on separate days at visits I, III, and V (Yairi & Ambrose, 1999). It has been argued that multiple samples provide a more representative sample of a child's speech (see Sawyer & Yairi, 2006, for more detailed discussion relating to variables involved with the collection of conversational speech samples). Only one sample of speech was acquired at visits II and IV as children only visited the Stuttering Research Lab at the University of Iowa once on these visits. While all children exhibited trajectories associated with specific developmental subtypes (e.g., persistent or recovered) during the study period, children were not followed longitudinally for a long enough period of time to be assigned to developmental subgroups. Thus, "persistent" and "recovered" subgroups were not used for the purposes of the present study.

Data Collection

Conversational samples—Parent-child conversational samples were obtained at each of the five visits of the study. Children were seated at a table with a parent, and provided a variety of materials (e.g., play-doh) to stimulate conversation. Parents were instructed to avoid questions that prompted one-word answers, but to ask open-ended questions about the immediate play or other topics related to home or school. If a study investigator thought that an insufficient amount of spontaneous speech was being produced, he or she intervened to stimulate more conversation. Audio/video samples of each conversation were recorded by placing a microphone on a table 18 inches away from the child's mouth. A lapel microphone was also clipped to the shirt of each child to compensate for noise from the table that obscured the audio signal. Video of each conversational sample was recorded with a SONY (DCR-VX2000 NTSC) Digital Handycam onto a JVC (SR-VS30) Mini DV recorder and a Panasonic (DMR-T2020) DVD recorder.

Parent-child conversations were recorded until approximately 1000 words had been acquired from the child. Samples of this length are thought to increase measurement reliability and validity (Yairi & Ambrose, 1999; Sawyer & Yairi, 2006). At Visits I, III, and V, two separate parent-child conversational samples were collected for transcription, and at Visits II and IV a single parent-child conversational speech sample was collected. A total of eight separate conversational samples were therefore collected for each participant across the five visits (I–V). For all conversational speech samples, every effort was made to get each child to produce at least 1000 words. Table 2 presents the raw numbers of utterances and words that were acquired from participants across all five visits in the study.

Data Analyses

Transcriptions—Parent-child conversational samples of speech were first transcribed by a Master's-level research assistant with Systematic Analysis of Language Transcription software (SALT; Miller and Chapman, 1993). For transcriptions used for reliability, the first author then made an independent transcription using SALT. For all other transcriptions, the first author used the first pass by the Master's-level student as a template from which to make necessary changes. To arrive at a transcription to be used for final data analysis, several SALT conventions were applied. First, utterances of a non-linguistic nature such as screams or cries were not transcribed. Second, unintelligible sequences of speech were marked with a single "x" for each unintelligible syllable. Third, abandoned and interrupted utterances were appropriately marked. Fourth, repeated segments of utterances such as revisions or phrase repetitions were placed within parentheses so as not to be included in the linguistic analysis.

Disfluency coding—Speech disfluencies were categorized according to stuttering-like disfluency (SLD) and other disfluency (OD), consistent with that described by Yairi and Ambrose (1999). An SLD was defined as a part-word repetition, a monosyllabic whole-word repetition, and a disrhythmic phonation (i.e., sound prolongation or block). An OD was defined as a revision, a multi-syllable word repetition, a phrase repetition, and an interjection (Yairi & Ambrose, 1999). For the purposes of reliability, a Master's-level research assistant made initial judgments of disfluency within the initial transcription. These judgments were compared with those made by the first author within the independent transcription. Overall rates for total disfluency (TD), stuttering-like disfluency (SLD), and other disfluency (OD) are presented in Figure 1.

Data reduction—Prior to conducting word-level analyses, sentence fragments and incomplete (i.e., abandoned or interrupted) utterances were first eliminated from each transcription. Second, utterances that did not contain both a subject and a verb were eliminated since utterances that contain both a subject and a predicate are thought to be more representative of a child's linguistic competence (Lee, 1974). Third, utterances that were unintelligible were eliminated from each transcription (Yairi & Ambrose, 1999). In essence, only complete sentences in which all words could be reliability identified were used for data analysis. This resulted in 7878 total sentences available for word-based analysis, or approximately 46.1% of the original set of raw utterances (see Table 2).

For sentence-level analysis, utterances containing both an SLD and an OD were separated from those containing at least one SLD and those containing at least one OD. This was done to avoid

NIH-PA Author Manuscript

NIH-PA Author Manuscript

the possibility that their occurrence in overt speech was not independent, as has been discussed in terms of disfluency clusters (LaSalle & Conture, 1995). Thus, SLDs and ODs were each analyzed at the sentence-level without the potential influence of the other. The separation of sentences containing both SLDs and ODs from the data set resulted in a total number of 7526 available for sentence-level analysis, or approximately 44.1% of the original set of raw utterances (see Table 2). Despite the large number of utterances eliminated during data reduction, the set of sentences remaining was sufficiently large to permit meaningful assessment.

Word-Level Measures

Word Class—Content words were defined as words with full lexical meaning such as nouns, main verbs, adjectives, and adverbs. Function words were defined as words without full lexical meaning such as auxiliary verbs, copula verb forms, articles, pronouns, conjunctions, and prepositions (Au-Yeung et al., 1998). Starter words, or words beginning sentences such as "hey," "yeah," "well," "okay," and "uhhuh," were not counted as either function or content words, and were therefore not used for linguistic or disfluency analysis. The number of total words and the number of function words were first counted within each sentence. These were then summed across all sentences within each participant's corpus of data. The number of stuttered words and the number of stuttered function words were also counted and summed within each participant's corpus of data. These totals were later pooled across all participants at each visit to calculate proportions to be used for statistical analysis.

Sentence Position—Initial position was defined simply as the first function or content word of a sentence, while non-initial position was defined as any other position. Thus, all sentences could contain only one sentence-initial word (either a function or a content word), and the number of sentence-initial words was equal to the total number of sentences used for data analysis. All sentence-initial stuttered words were also counted and summed within each participant's corpus of data. These totals were pooled across all participants at each visit to calculate proportions to be used for statistical analysis.

For sentences beginning with starter words or parentheses (i.e., revised or repeated speech), the following rules were used to determine the sentence-initial word. First, for utterances beginning with starters words (e.g., yeah, well), the subsequent function or content word was defined as the sentence-initial word. For example in the utterance, "*YEAH HE WANTS IT*", *HE* would be counted as the sentence-initial word. Furthermore, for any starter word that was stuttered, the instance of stuttering was attributed to the following function or content word. Thus, if a part-word repetition had occurred on the starter word *YEAH*, the SLD would be attributed to the following function word *HE*.

Second, for utterances beginning with parentheses (e.g., to indicate revised or repeated speech), the first function or content word after the parentheses was defined as the sentence-initial word. For example, in the following utterance containing a revision, "*(I DON'T KNOW) HE DOESN'T KNOW WHERE IT IS*", *HE* would be counted as the first word in the sentence. Furthermore, a stuttered word within parentheses was only used for disfluency analysis if that word was also present outside of the parentheses. For example, a part-word repetition that had occurred on the word *KNOW* inside of the parentheses would be coded as stuttered on the *KNOW* outside of the parentheses.

Sentence-Level Measures

Syntactic complexity—Syntactic complexity was assessed by Developmental Sentence Scoring (DSS; Lee, 1974). DSS is obtained by assigning points to particular morpho-syntactic forms. For example, uninflected main verbs (e.g., *eat*) receive 1 point, but the combination of a main verb and the modal verb (e.g., *would eat*) would receive 6 points. Points are summed across all sentences within a conversational sample and divided by the total number of sentences (see Lee, 1974, for description of scoring system). It is argued (e.g., Lee, 1974) that to obtain a valid measure of syntactic complexity, a conversational sample should consist of least 50 utterances, with each utterance containing a subject and a predicate (i.e., a sentence). Thus, all conversational samples analyzed in the present study consisted of at least 50 sentences, with each sentence containing both a subject and a predicate.

For each participant, DSS was computed by hand for 1) the set of sentences that contained at least one SLD, 2) the set of sentences that contained at least one OD, and 3) the set of sentence that did not contain either an SLD or an OD. DSS was also computed for sentences that contained both an SLD and an OD, but this set was not used for statistical analysis. Such sentences comprised approximately 2.1% of total sentences (see Table 2). It should be noted that sentences that included multiple or adjacent SLDs (i.e., a stutter-stutter cluster) were not treated differently from those that only contained one SLD. DSS measures for each participant were then used for statistical analysis.

Sentence Length—Sentence length was defined as the total number of function and content words within a sentence. Number of words was chosen as the measure of sentence length because length in morphemes is thought to be most relevant for children up to the age of four (Brown, 1973), after which utterance length in morphemes is thought to indicate context. Because children in the present study were typically older than four by the second visit (Visit II), it was decided that MLU would not be a reliable measure at later visits. Only words that could be identified as either a function or a content word were counted in the word total for a sentence. Thus, affirmatives and negatives such as “yes” and “no”, interjections such as “wow” and “oh”, and starter words such as “well” and “like” were not counted in the total number of words for a sentence. Contractions such as “can’t” and “didn’t” and early-developing infinitives such as “gotta” and “wanna” were counted as two words to preserve word class distinctions.

For each participant’s data set, the measure of mean words per sentence was determined by dividing the total number of words by the total number of sentences. For each participant, this measure was computed for 1) the set of sentences that contained at least one SLD, 2) the set of sentence that contained at leas one OD, and 3) the set of sentence that did not contain either an SLD or an OD. As mentioned earlier, sentences that included multiple or adjacent SLDs (i.e., a stutter-stutter cluster) were not treated differently from those that only contained one SLD. Mean number of words per sentence for each participant was then used for statistical analysis.

Statistical Analysis

Word-level analysis—The relation between word class and stuttering was analyzed by comparing the proportions of all words that were function words to the proportion of all stuttered words that were function words. These comparisons were made with binomial tests using the z approximation. Binomial testing was used because it enabled the direct comparison of observed proportions to expected proportions. Binomial tests were also used to compare the proportion all words that were sentence-initial to the proportion of all stuttered words that were sentence-initial. Analysis of variance was used to evaluate whether relations between stuttering and both word class and sentence position changed over time. For each participant, the proportion of all stuttered words that were function words and the proportion of all stuttered words that were sentence-initial were used as dependent variables for comparison across all five visits.

Sentence-level analysis—T-tests were used to compare sentences that contained an SLD, those that contained an OD, and those that were fluent for both sentence length and syntactic complexity. ANOVA was used to assess whether differences in length and complexity between fluent sentences and those containing SLDs and those containing ODs changed across visits. Post hoc tests with Bonferroni adjusted p-values set to 0.005 were employed to assess differences between any two of the ten pairs of visits.

It should be noted that although participants did not contribute an equal amount of data to the entire data set, this was not assumed to factor in to the parametric analysis (i.e., ANOVA) since means were used as the dependent variable. Unequal contribution of speech disfluencies was also not assumed to factor in to the pooling of data in word-level analyses since word-level measures of stuttering have been found to be consistent across children regardless of subgroup classification (Au-Yeung et al., 1998; Silverman, 1974; Williams et al., 1969). In other words, word-class measures are assumed to be indicative of how SLDs occur in overt speech rather than how individuals stutter.

Inter- and Intra-judge Reliability—Three of the 12 participants were randomly chosen for measurement reliability. Reliability was determined for disfluency measures for these participants at Visit I, which comprised two conversational samples each, or 25% of the total number of transcriptions at that visit. For inter-judge measurement reliability, SLD and OD frequency measures made by the research assistant were correlated to those made on the independent measures made by the first author, resulting in Pearson correlations of $r = 0.99$ for SLD frequency and $r = 0.91$ for OD frequency. For intra-judge reliability, the first author made an additional transcription for each of these three participants several months later. SLD and OD frequency measures obtained from these transcriptions were then correlated to those obtained from the first set of measures, resulting in Pearson correlations of $r = 0.95$ for SLD frequency and $r = 0.98$ for OD frequency.

Results

Word-Level Analysis

Word class—A binomial test using the *z* approximation was used to compare the proportion of all words that were function words (58%) to the proportion of all stuttered words that were function words (59%). Results showed that these proportions did not significantly differ, $p = 0.201$, indicating that while more function words were stuttered than content words, this was due to their relatively greater occurrence overall.

Sentence position—A binomial test using the *z* approximation was also used to compare the proportion of all words at the sentence-initial position (17%) to the proportion of all stuttered words at the sentence-initial position (51%) (see Figure 2). Results showed that these proportions were significantly different, $p = 0.001$, indicating that the occurrence of stuttering was highly related to the sentence-initial position (Table 3). Results also showed that the proportion of ODs occurring at the initial position of a sentence was well above 50% across all visits (Table 3). These results suggest that both SLDs and ODs were highly likely to occur at the initial position of a sentence.

Interaction between word class and sentence position—Separate binomial tests using the *z* approximation were used at both sentence-initial and non-initial positions to assess whether a tendency to stutter on function words is due to sentence position (Table 4). Results showed that at the sentence-initial position, the proportion of all stuttered words that were function words (84%) was significantly greater than the proportion of all words that were function words (77%), $p = 0.001$ (Figure 3), while at the non-initial position, the proportion of all stuttered words that were function words (34%) was significantly less than the proportion of all words that were function words (54%), p = 0.001. Thus, function words were more likely than expected to be stuttered at the sentence-initial position, while content words were more likely than expected to be stuttered at the non-initial position.

Longitudinal assessment—Two one-way ANOVAs with *visit* as the fixed factor were used to longitudinally assess word class and sentence position. Results showed no significant differences across visits for either the proportion of stuttered words that were function words, $F(4,55) = 0.993$, $p = 0.419$, or the proportion of stuttered words that were sentence-initial, $F(4,55) = 0.089$, $p = 0.986$. These results therefore showed that the tendencies to stutter on function words and at the sentence-initial position did not change across the age range of children in the present study.

Sentence-Level Measures

Of the 7526 sentences remaining across all visits after data reduction (see Table 2), 6125 (77.7%) were produced fluently. Of the 1755 (22.3%) total sentences that were not fluent, 696 contained at least one SLD, 707 contained at least one OD, and 352 contained both an SLD and an OD. As stated earlier, sentences containing both an SLD and an OD were separated to permit examination of an SLD without the potential influence of an OD and vice versa (LaSalle & Conture, 1995). Table 5 shows mean length and syntactic complexity of sentences containing at least one SLD (without the presence of OD), those containing at least one OD (without the presence of SLD), those containing both SLDs and ODs, and those produced fluently.

Sentence length and syntactic complexity—Paired t-tests were used to compare the length and syntactic complexity of sentences containing at least one OD and sentences containing at least one SLD relative to fluent sentences (see Figure 4 and Figure 5). As expected, results showed that sentences containing at least one OD were significantly longer, $t(59) = 8.479$, $p = 0.001$, and more complex, $t(59) = 5.793$, $p = 0.001$, than fluent sentences, and sentences containing at least one SLD were significantly longer, $t(59) = 7.944$, $p = 0.001$, and more complex, $t(59) = 4.660$, $p = 0.001$, than fluent sentences (see Figure 4). Paired t-tests were also used to compare the length and complexity of sentences containing at least one OD to those containing at least one SLD. Results showed that these sentences did not significantly differ with respect to either length, $t(59) = 0.185$, $p = 0.854$, or complexity, $t(59) = 1.077$, $p = 0.286$. Thus, the presence of stuttered and other speech disfluencies appears to be similarly related to sentence length and syntactic complexity for children in the present study.

Longitudinal assessment—One-way ANOVAs with *visit* as the fixed factor were used to longitudinally assess length and complexity of fluent sentences, sentences containing at least one OD, and sentences containing at least one SLD. Results showed that the syntactic complexity of fluent sentences changed across visits, $F(4,55) = 3.134$, $p = 0.022$ (see Table 5), but the length of fluent sentences did not, $F(4,55) = 2.019$, $p = 0.104$. Post hoc comparisons with the alpha value set to 0.005 did not show significant differences in syntactic complexity between any two pairs of visits. The length and syntactic complexity of sentences containing SLDs and those containing ODs also did not significantly change across visits. These results suggest that while evidence of syntactic development was present (Figure 5), the relation between syntactic complexity and both SLDs and ODs appeared to be stable across visits.

One-way ANOVAs with *visit* as the fixed factor were also used to longitudinally assess differences in the length and syntactic complexity of sentences containing at least one OD and those containing at least one SLD versus fluent sentences. For sentences containing at least one OD relative to fluent sentences, differences in length, $F(4,55) = 1.747$, $p = 0.153$, and syntactic complexity, $F(4,55) = 0.556$, $p = 0.695$, were not found to change across visits.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Similarly, for sentences containing at least one SLD relative to fluent sentences, differences in length, $F(4,55) = 2.453$, $p = 0.057$, and syntactic complexity, $F(4,55) = 0.323$, $p = 0.861$, were not found to change across visits. Thus, the relation between sentence complexity and disfluency was stable across visits.

Summary of Results

Word-level analyses indicated that 1) stuttering was most likely to occur at the sentence-initial position, but that 2) a function word effect was found only at the sentence-initial position, and that 3) the tendency to stutter at the sentence-initial position did not change across visits. Sentence-level analyses indicated that 1) sentences containing ODs and those containing SLDs were both significantly longer and more complex than fluent sentences, but that 2) these sentence types did not differ from each other, and 3) these results did change across visits.

Discussion

Discussion of the present findings will be divided into four subsections. First, results of word-level analyses are discussed in terms of how word class and sentence position may be explained by a common underlying factor. Second, results of sentence-level analyses are discussed in terms of how the occurrence of SLDs and ODs may both be related to similar aspects of sentence planning. Third, longitudinal analyses are discussed in terms of whether word- and sentence-level measures of stuttering are related to language development. Finally, linguistic and non-linguistic aspects of sentence planning and their potential roles in stuttering are discussed.

Word-Level Measures of Stuttering

Sentence position—In the present study, instances of stuttering tended to occur at the sentence-initial position, consistent with previous research using adults (Brown, 1945; Quarrington, 1965; Soderberg, 1967; Taylor, 1966; Wingate, 1979) and children (Au-Yeung et al., 1998; Bernstein, 1981; Bloodstein & Grossman, 1981; Logan & LaSalle, 1999; Wall et al., 1981). It has been previously suggested that childhood stuttering may be related to uncertainty or indecision associated with formulating an idea or constructing a sentence (Soderberg, 1967; Taylor, 1966), integrating syntactic constituents (Bernstein, 1981; Wall et al., 1981), or motor initiation/execution (Bloodstein & Gantwerk, 1981; Logan & LaSalle, 1999). Stuttering at the beginning of a sentence may provide additional time for aspects of sentence planning to be completed, as has been suggested to be the case with planning phonological words (Au-Yeung et al., 1998).

Word class—Although more function words were stuttered than content words overall, the proportion of function words that were stuttered was not significantly greater than the overall proportion of function words. This finding is contrary to previous studies showing that children tend to stutter on function words after taking into account their overall distribution (Au-Yeung et al., 1998; Bloodstein & Gantwerk, 1967; Bloodstein & Grossman, 1981; Silverman, 1974; Williams et al., 1969). One possible reason for why present findings differ is that sentence fragments were eliminated from each participant’s corpus of speech. For example, a corpus of speech consisting only of complete sentences would contain proportionally more non-initial words than a corpus of speech including sentence fragments. Considering that content words in the present study were more likely to be stuttered than function words at non-initial positions, using only complete sentences in the corpus of speech would have increased the influence of stuttering on content words. This may have offset the relative influence of stuttering on function words at the sentence-initial position. This speculation suggests that a tendency to stutter on function or content words may depend, to some extent, on the corpus of speech used for analysis.

Second, one might argue that a few participants may have stuttered significantly more on content words, thereby obscuring a tendency to stutter on function words by other participants. However, inspection of the data revealed that only six of the twelve participants stuttered on a greater proportion of function words than what they produced overall. This suggests that the absence of a tendency to stutter on function words was relatively common among the participants in the study. Thus, the failure to detect a tendency to stutter on function words overall is likely due to the elimination of sentence fragments.

Sentence position and word class—Results showed that function words at the beginning of a sentence were more likely to be stuttered than content words, a finding consistent with previous studies (e.g., Au-Yeung et al., 1998; Bernstein, 1981; Bloodstein & Grossman, 1981). However, in the present study, function words at the sentence-initial position were also more likely to be stuttered than their overall proportion at this position. There are a few reasons why this may have been the case. First, the combined effects of planning both clauses and phonological words may have increased overall demand on planning at the beginning of a sentence. This is in agreement with the notion that planning behaviors involves the integration of multiple sources of information (e.g., Glover, 2004). Another reason is that sentences that begin with function words (i.e., pronouns and conjunctions) may be associated with greater demand on sentence planning. For example, sentences beginning with articles (e.g., a, an, the), pronouns (e.g., I, what, which), or closed-class adverbs (e.g., why, when, where) may be associated with relatively more *new information* (i.e., higher propositionality). Consistent with this view, Weiss & Zebrowski (1992) found that assertive utterances were more likely to be stuttered than responsive utterances. Thus, propositionality may be an important factor leading to the occurrence of stuttering on function words at the sentence-initial position.

When eliminating the influence of sentence-initial position, children in the present investigation were more likely to stutter on content words, a phenomenon that is usually reported in older children and adults (Au-Yeung et al, 1998; Brown, 1945; Quarrington, 1965; Soderberg, 1967, Taylor, 1966). It is therefore possible that previous studies reporting that children tend to stutter on function words (e.g., Au-Yeung et al., 1998; Bloodstein & Gantwerk, 1967; Bloodstein & Grossman, 1981; Williams et. al., 1969) may not have fully accounted for sentence position. One possible reason for the tendency to stutter on content words after the first word of a sentence is that sentence non-initial phonological words may be more likely to begin with content words. As a result, greater planning demand on phonological words would be more likely to manifest on a content word. More research is needed to investigate phonological word types across utterance positions.

Sentence-Level Measures of Stuttering

Utterances containing ODs and SLDs—Results showed that sentences containing SLDs and those containing ODs were longer and more syntactically complex than fluent utterances, a finding that is consistent with previous studies (e.g., Logan & LaSalle, 1999; Rispoli & Hadley, 2001; Sawyer, Chon, & Ambrosek, 2008; Weiss & Zebrowski, 1992; Zackheim & Conture, 2003). However, this finding should not be taken to suggest that sentence length and syntactic complexity necessarily exert a *causal influence* on disfluency (Wall et al., 2007). Rather, each may reflect the relative amount of demand associated with sentence planning. For example, a relatively greater level of demand on sentence planning may lead to increased sentence length and syntactic complexity *as well as* an increased likelihood of disfluency.

It was also found that the length and complexity of sentences containing SLDs did not differ from those containing ODs. This suggests that factors that influence the emergence of ODs may be similar to those that lead to the emergence of SLDs. For example, Rispoli Hadley, & Holt (2008) have suggested that *incremental sentence production* may be related to ODs such as phrase repetitions and interjections, and *monitoring* may be related to revisions. Present findings suggest that SLDs may also be related to these factors. In other words, while aspects of incremental sentence production may trigger the occurrence of disfluencies in general, the ability to manage them may play a role in whether they will be stuttered. To the extent that disfluency is an inherent part of productive speech (e.g., O'Connell & Kowal, 2005), the ability to manage or regulate natural disfluencies may be a potentially important aspect of speech-language acquisition.

Longitudinal Change in Word-and Sentence-Level Measures of Stuttering

The finding that the tendencies to stutter on function words and at the sentence-initial position did not significantly differ across visits suggests that any word class exchange that may take place over childhood does not occur within the age range of children in the present study. This is consistent with previous findings that children stutter on function words until around nine years of age (Au-Yeung et al., 1998). To the extent that change from stuttering on function words to stuttering on content words is related to attempting to execute insufficiently planned content words, as has been suggested by Howell and colleagues (Howell, 2004; Howell et al., 1999), the precise factors that may instigate such change are unknown.

As with word-level measures of stuttering, sentence-level measures did not significantly change across visits. This suggests that those aspects of sentence planning that are related to syntactic complexity had a relatively stable influence on the occurrence of speech disfluencies. While findings did show evidence that syntactic complexity increased from the first to the fifth visits (Figure 5), this was not accompanied by a change in the relation between syntactic complexity and the occurrence of speech disfluencies. In other words, to the extent that language was developing for participants in the present study, this did not appear to influence the essential relationship between sentence planning and the occurrence of SLDs or ODs. Thus, longitudinal findings did not show evidence of a contribution of linguistic development to the occurrence of speech disfluencies in overt speech, at least for children of the age ranges in the present study.

Sentence Planning and Stuttering

Present findings suggest that both word- and sentence-level measures of stuttering tap into *sentence planning*. Specifically, utterances that pose a greater demand on sentence planning are more likely to be stuttered, and stuttering is more likely to occur at the beginning of a sentence. However, longitudinal analyses of word- and sentence-level measures of stuttering did not show evidence of a relation to language development. This begs the question whether those aspects of sentence planning that are related to stuttering are necessarily *linguistic* in nature. To this end, it is worth considering that evidence of linguistic and/or motor contributions to stuttering has often not been obtained from stuttered speech.

For example, several reaction time (RT) studies examining linguistic processes have reported that children who do and do not stutter may be different in terms of lexical retrieval (Anderson, 2008; Hartfield & Conture 2007; Pellowski & Conture, 2005), syntactic encoding (Anderson & Conture, 2004), and phonological encoding (Byrd, Conture, & Ohde, 2007; Melnick, Conture, & Ohde, 2003). Furthermore, kinematic studies reporting between-group differences in selected temporal measures within or across motor subsystems have often used fluent speech productions (e.g., Caruso, Abbs, & Gracco, 1988; Max, Caruso, & Gracco, 2003; McClean, Tasko, & Runyan, 2004). Finally, between-group differences in neural activity during fluent speech tasks have been interpreted in terms of language, motor, or timing aberrancies for individuals who stutter (e.g., De Nil, Kroll, Kapur, & Houle, 2000; Foundas et al., 2004; Fox et al., 2000; Giraud et al., 2008; Watkins, Smith, Davis, & Howell, 2008).

While such findings do demonstrate talker group differences in terms of various linguistic and/or motor processes, they do not link such processes to *specific instances of stuttering*. Furthermore, to the extent that linguistic and motor factors contribute to stuttering, one might expect stuttering frequency to be relatively stable over time. However, stuttering frequency has generally been observed to be highly variable (Bloodstein & Bernstein Ratner, 2008). This suggests that at least some factors that exert a causal influence on stuttering may be highly variable (Conture & Walden, 2009). In other words, "a varying effect may not be accounted for by reference to an unchanging cause" (Johnson & Associates, 1959, p. 5).

It is therefore difficult to rule out the possibility that linguistic and/or motor aspects of stuttering are not merely the overt manifestation of events that take place at prior stages of sentence planning. These events may only become observable downstream in the form of vocal tract movements, and may be most easily characterized in terms of the words or sentences in which they occur. For example, it has been posited that early in sentence planning speakers formulate *communicative intentions* (Levelt, 1989; Levelt, Meyer, & Roelofs, 1999), which involves the integration of multiple sources of information. One type of information is the relative degree of familiarity between a speaker and an audience, also referred to as *common ground* (Horton & Gerrig, 2005). Thus, formulating a communicative intention when there is relatively little common ground between a speaker and an audience may involve relatively greater demand on sentence planning, leading to a greater likelihood of stuttering occurring in overt speech.

One might therefore speculate that instances of stuttering originate where the formulation of communicative intentions meets the construction of the sentence itself. For example, increased demand on formulating a communicative intention, such as making decisions about *what to say* or *how to say it*, may delay downstream linguistic and/or motor processes, thereby creating natural opportunities for speech disfluencies to occur. Instances of stuttering may thus emerge in overt speech due to the effort required to manage naturally occurring disfluencies. As speculated above, managing naturally occurring disfluencies may be an important aspect of speech-language acquisition.

During social communication, a speaker must not only make decisions that accurately convey a communicative intention, but must make such decisions in an appropriate amount of time given the dynamic social interaction. These twin pressures would likely be most intense at the beginning of an utterance, and would most likely be experienced at the *initiation of speech*. Efforts to manage such communicative pressures may be more demanding for some speakers, potentially contributing to atypical speech-language development. In support of this notion, some evidence suggests that children who stutter may be more susceptible to conversational pressures (e.g., Savelkoul, Zebrowski, Feldstein, & Cole-Harding, 2007). Thus, demand on sentence planning may be greatest during dynamic social interaction, and may be particularly problematic for timing the initiation of speech (see Packman, Code, & Onslow, 2007, for discussion of syllable initiation in stuttering).

Limitations of Study

One limitation of the present study was that, although the acquisition of speech can take place over several years, the data used in the present study covered a range of only two years. Thus, developmental subgroups such as "persistent" and "recovered" (Yairi & Ambrose, 2005) were not addressed. Another limitation was that only 12 children participated in the present study. While it would have been ideal to use additional children, the longitudinal design encompassing five visits limited the number of participants for whom data could be collected and analyzed. A final limitation was that function and content words were not analyzed according to phonological word position. However, the present focus on sentence position permitted investigation of similarities between SLDs and ODs, particularly in terms of sentence planning.

Conclusion

Results of the present investigation were taken to support the notion that word-and sentence-level measures of stuttering may both tap into sentence planning. While both SLDs and ODs appear to originate at the same level of sentence planning, they may differ in terms of their manifestation in overt speech. It was suggested that although both SLDs and ODs may be most easily observed in linguistic terms, this does not entail that linguistic factors are causal contributors to stuttering. Rather, one aspect of sentence planning that may be involved in stuttering is formulating communicative intentions. In particular, the interface between intention formulation and linguistic aspects of sentence planning may present opportunities for speech disfluencies to occur, and efforts to manage such disfluency may be an important factor in stuttering, particularly for timing the initiation of speech. Finally, present findings point to the importance of situational contributors to stuttering. However, further research is needed to identify the types of situational contributors most relevant to dynamic social interaction as well as their potential impact on stuttering.

Acknowledgments

The authors would like to thank Dr. Carol Hubbard Seery at the University of Wisconsin-Milwaukee, Dr. Edward Conture at Vanderbilt University, and Dr. Peter Howell at University College London, for editorial comments on earlier versions of this manuscript. This research was partially supported by the National Institutes of Health, the National Institute On Deafness and Other Communications Disorders, grant # RO1-DC 05210, principal investigators: Ehud Yairi and Nicoline Ambrose. This research was also supported in part by grant # T32 HD07226 from the National Institute of Child Health and Human Development to Vanderbilt University. The author opinions expressed in this article do not necessarily reflect the position of the National Institutes of Health.

References

Anderson J. Age of acquisition and repetition priming effects on picture naming of children who do and do not stutter. Journal of Fluency Disorders 2008;33:135–155. [PubMed: 18617053]

Anderson J, Conture E. Sentence-structure priming in young children who do and do not stutter. Journal of Speech, Language, and Hearing Research 2004;47:552–571.

Au-Yeung J, Howell P, Pilgrim L. Phonological words and stuttering on function words. Journal of Speech and Hearing Research 1998;41:1019–1030.

Bernstein NE. Are there constraints on childhood disfluency. Journal of Fluency Disorders 1981;6:341–350.

Bernstein Ratner N, Sih CC. Effects of gradual increases in sentence length and complexity on children's disfluency. Journal of Speech and Hearing Disorders 1987;52:278–287. [PubMed: 3455450]

Bloodstein, O.; Bernstein Ratner, N. A Handbook on Stuttering. Clifton Park, NY: Thompson/Delmar; 2008.

Bloodstein O, Gantwerk BF. Grammatical function in relation to stuttering in young children. Journal of Speech and Hearing Research 1967;10:786–789. [PubMed: 5586944]

Bloodstein O, Grossman M. Early stuttering: Some aspects of their form and distribution. Journal of Speech and Hearing Research 1981;24:298–302. [PubMed: 7265947]

Boomer DS. Hesitations and grammatical encoding. Language and Speech 1965;8:148–158. [PubMed: 5832573]

Brown, R. A first language: The early stages. Cambridge, MA: Harvard University Press; 1973.

Brown SF. The influence of grammatical function on the incidence of stuttering. Journal of Speech Disorders 1937;2:207–215.

Brown SF. Stuttering with relation to word accent and word position. Journal of Abnormal and Social Psychology 1938;33:112–120.

Brown SF. The loci of stuttering in the speech sequence. Journal of Speech Disorders 1945;10:181–192.

Byrd C, Conture E, Ohde R. Phonological priming in young children who stutter: Holistic versus incremental processing. American Journal of Speech-Language Pathology 2007;16:43–58. [PubMed: 17329674]

Conture E, Walden T. Dual diathesis-stress model of stuttering. 2009Manuscript submitted for publication in a scholarly monograph

Caruso AJ, Abbs JH, Gracco VL. Kinematic analysis of multiple movement coordination during speech in stutterers. Brain 1988;111:439–455. [PubMed: 3378144]

De Nil LF, Kroll RM, Kapur S, Houle S. A positron emission tomography study of silent and oral single word reading in stuttering and nonstuttering adults. Journal of Speech, Language, and Hearing Research 2000;43:1038–1053.

Dunn, L.; Dunn, L. Peabody picture vocabulary test. Vol. 3rd ed.. Circle Pines, MN: American Guidance Service, Inc; 1997. PPVT-III

Eisenson J, Horowitz E. The influence of propositionality on stuttering. Journal of Speech Disorders 1945;10:193–197.

Foundas AL, Bollich AM, Feldman J, Corey DM, Hurley M, Lemen LC, Heilman KM. Aberrent auditory processing and atypical planum temporale in developmental stuttering. Neurology 2004;63:1640–1646. [PubMed: 15534249]

Fox PT, Ingham RJ, Ingham JC, Zamarripa F, Xiong J, Lancaster JL. Brain correlates of stuttering and syllable production. Brain 2000;123:1985–2004. [PubMed: 11004117]

Gaines ND, Runyan CM, Meyers SG. A comparison of young stutterers' fluent versus stuttered utterances on measures of length and complexity. Journal of Speech and Hearing Research 1991;34:47–42.

Giraud A, Neumann K, Bachoud-Levi A, von Gudenberg AW, Euler HA, Lanfermann H, Preeibisc C. Severity of disfluency correlates with basal ganglia activity in persistent developmental stuttering. Brain and Language 2008;104:190–199. [PubMed: 17531310]

Goldman-Eisler F. Speech production and predictability of words in context. Quarterly Journal of Experimental Psychology 1958;10:96–106.

Glover S. Separate visual representations in the planning and control of action. Behavioral and Brain Sciences 2004;27:3–78. [PubMed: 15481943]

Hall, N.; Wagovich, S.; Bernstein, R. Language considerations in treatment of childhood stuttering. In: Conture, E.; Curlee, R., editors. Stuttering and Related Fluency Disorders. NY, NY: Thieme Medical; 2007. p. 153-167.

Hartfield KN, Conture EG. Effects of perceptual and conceptual similarity in lexical priming of young children who stutter: Preliminary findings. Journal of Fluency Disorders 2007;31:303–324. [PubMed: 17010422]

Hodson, BW. The assessment of phonological processes – revised. Austin, TX: PRO-ED; 1986.

Holmes VM. Hesitations and sentence planning. Language and Cognitive Processes 1988;3:323–361.

Horton WS, Gerrig RJ. Conversational common ground and memory processes in language production. Discourse Processes 2005;40:1–35.

Howell P. Assessment of some contemporary theories of stuttering that apply to spontaneous speech. Contemporary Issues in Communication Science and Disorders 2004;31:122–139. [PubMed: 18259590]

Howell P, Au-Yeung J, Sackin S. Exchange of stuttering from function words to content words with age. Journal of Speech, Language, and Hearing Research 1999;42:345–354.

Hresko, W.; Reid, D.; Hammill, D. Test of early language development (TELD). Austin, TX: PRO-ED; 1991.

Johnson, W. Associates. The onset of stuttering. Minneapolis: University of Minnesota Press; 1959.

LaSalle LR, Conture EG. Disfluency clusters of children who stutter: Relation of stutterings to self-repairs. Journal of Speech and Hearing Research 1995;38:965–977. [PubMed: 8558887]

Lee. Developmental sentence analysis. Evanston, IL: Northwestern University Press; 1974.

Levelt, WJM. Speaking: From intention to articulation. Cambridge, MA: The MIT Press; 1989.

Levelt WJM, Roelofs A, Meyers A. A theory of lexical access in speech production. Behavioral and Brain Sciences 1999;22:1–38. [PubMed: 11301520]

Logan KJ, Conture E. Length, grammatical complexity, and rate differences in stuttered and fluent conversational utterances of children who stutter. Journal of Fluency Disorders 1995;20:35–61.

Logan KJ, Conture E. Selected temporal, grammatical, and phonological characteristics of conversational utterances produced by children who stutter. Journal of Speech, Language, and Hearing Research 1997;40:107–120.

Logan KJ, LaSalle LR. Grammatical characteristics of children's conversational utterances than contain disfluency clusters. Journal of Speech, Language, & Hearing Research 1999;42:80–91.

Maclay H, Osgood CE. Hesitation phenomena in spontaneous English speech. Word 1959;15:19–44.

Max L, Caruso AJ, Gracco VL. Kinematic analyses of speech, orofacial nonspeech, and finger movements in stuttering and nonstuttering individuals. Journal of Speech and Hearing Research 2003;46:215–232.

McClean MD, Tasko SM, Runyan CM. Orofacial movements associated with fluent speech in person who stutter. Journal of Speech, Language, and Hearing Research 2004;47:294–303.

Melnick K, Conture E, Ohde R. Phonological priming in picture-naming of young children who stutter. Journal of Speech Language Hearing Research 2003;46:1428–1443.

Miller, JF.; Chapman, RS. Systematic Analysis of Language Transcripts. Madison, WI: University of Wisconsin; 1993.

O'Connell DC, Kowal S. Uh and um revisited: Are they interjections for signaling delay? Journal of Psycholinguistic Research 2005;34:555–576. [PubMed: 16341914]

Packman A, Code C, Onslow M. On the cause of stuttering: Integrating theory with brain and behavioral research. Journal of Neurolinguistics 2007;20:353–362.

Pellowski M, Conture E. Lexical priming in picture naming of young children who do and do not stutter. Journal of Speech, Language and Hearing Research 2005;48:278–294.

Quarrington B. Stuttering as a function of the information value and sentence position of words. Journal of Abnormal Psychology 1965;30:221–224. [PubMed: 14297663]

Rispoli M, Hadley P. The leading edge: The significance of sentence disruptions in the development of grammar. Journal of Speech, Language, and Hearing Research 2001;44:1131–1143.

Rispoli M, Hadley P, Holt J. Stalls and revisions: A developmental perspective on sentence production. Journal Speech, Language, and Hearing Research 2008;51:953–966.

Savelkoul EM, Zebrowski PM, Feldstein S, Cole-Harding S. Coordinated interpersonal timing in the conversations of children who stutter and their mothers and fathers. Journal of Fluency Disorders 32:1–32. [PubMed: 17267028]

Sawyer J, Chon H, Ambrose NG. Influence of rate, length, and complexity on speech disfluency in a single-speech sample in preschool children who stutter. Journal of Fluency Disorders 2008;33:220–240. [PubMed: 18762063]

Sawyer J, Yairi E. The effect of sample size on the assessment of stuttering severity. American Journal of Speech-Language Pathology 2006;15:36–44. [PubMed: 16533091]

Selkirk, E. Phonology and Syntax: The Relation Between Sound and Structure. Cambridge, MA: MIT Press; 1984.

Silverman E. Word position and grammatical function in relation to preschoolers' speech disfluency. Perceptual and Motor Skills 1974;39:267–272.

Silverman SW, Bernstein Ratner N. Syntactic complexity, fluency, and accuracy of sentence imitation in adolescents. Journal of Speech, Language, and Hearing Disorders 1997;40:95–106.

Soderberg GA. Linguistic factors in stuttering. Journal of Speech and Hearing Research 1967;10:801–810. [PubMed: 5586947]

Taylor IK. The properties of stuttered words. Journal of Verbal Learning and Verbal Behavior 1966;5:112–118.

Trotter WD. Relationship between severity of stuttering and word conspicuousness. Journal of Speech Disorders 1956;21:198–201.

Wall M, Starkweather CW, Cairns HS. Syntactic influences on stuttering in young child stutterers. Journal of Fluency Disorders 1981;6:283–298.

Watkins K, Smith S, Davis S, Howell P. Structural and functional abnormalities of motor system in developmental stuttering. Brain 2008;131:50–59. [PubMed: 17928317]

Watkins RV, Yairi E, Ambrose NG. Early childhood stuttering III: Initial status of expressive language abilities. Journal of Speech, Language, and Hearing Research 1999;42:1125–1135.

Weiss AL, Zebrowski PM. Disfluencies in the conversations of young children who stutter: Some questions about answers. Journal of Speech and Hearing Research 1992;35:1230–1238. [PubMed: 1494268]

Wijnen F. The development of sentence planning. Journal of Child Language 1990;17:651–675. [PubMed: 2269702]

Williams, K. Expressive vocabulary test (EVT). Circle Pines, MN: American Guidance Service, Inc.; 1997.

Williams DE, Silverman FH, Kools JA. Disfluency behavior of elementary-school stutterers and non-stutterers: Loci of instances of disfluency. Journal of Speech and Hearing Research 1969;12:308–318. [PubMed: 5808857]

Wingate ME. The first three words. Journal of Speech and Hearing Research 1979;22:604–612. [PubMed: 502517]

Yairi E, Ambrose NC. Onset of stuttering in preschool children: Selected factors. Journal of Speech and Hearing Research 1992;35:782–788. [PubMed: 1405533]

Yairi E, Ambrose NC. Early childhood stuttering I: Persistency and recovery rates. Journal of Speech, Language, and Hearing Research 1999;42:1097–1112.

Yairi, E.; Ambrose, NC. Early childhood stuttering: For clinicians by clinicians. Austin, TX: Pro-Ed, Inc; 2005.

Yaruss JS. Utterance length, syntactic complexity, and childhood stuttering. Journal of Speech, Language, and Hearing Research 1999;42:329–344.

Zackheim C, Conture E. Childhood stuttering and speech disfluencies in relation to children's mean length of utterance: A preliminary study. Journal of Fluency Disorders 2003;28:115–142. [PubMed: 12809748]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

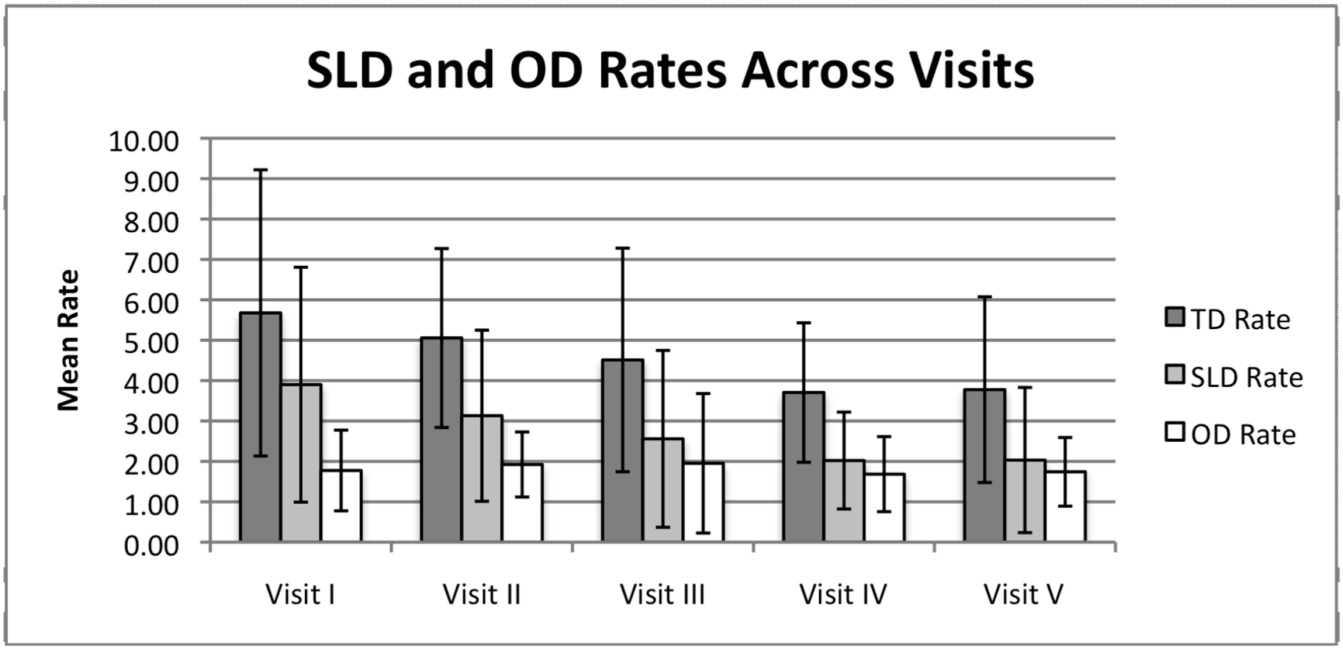

Figure 1.
Total disfluency (TD), stuttering-like disfluency (SLD), and other disfluency (OD) rates across all five visits.

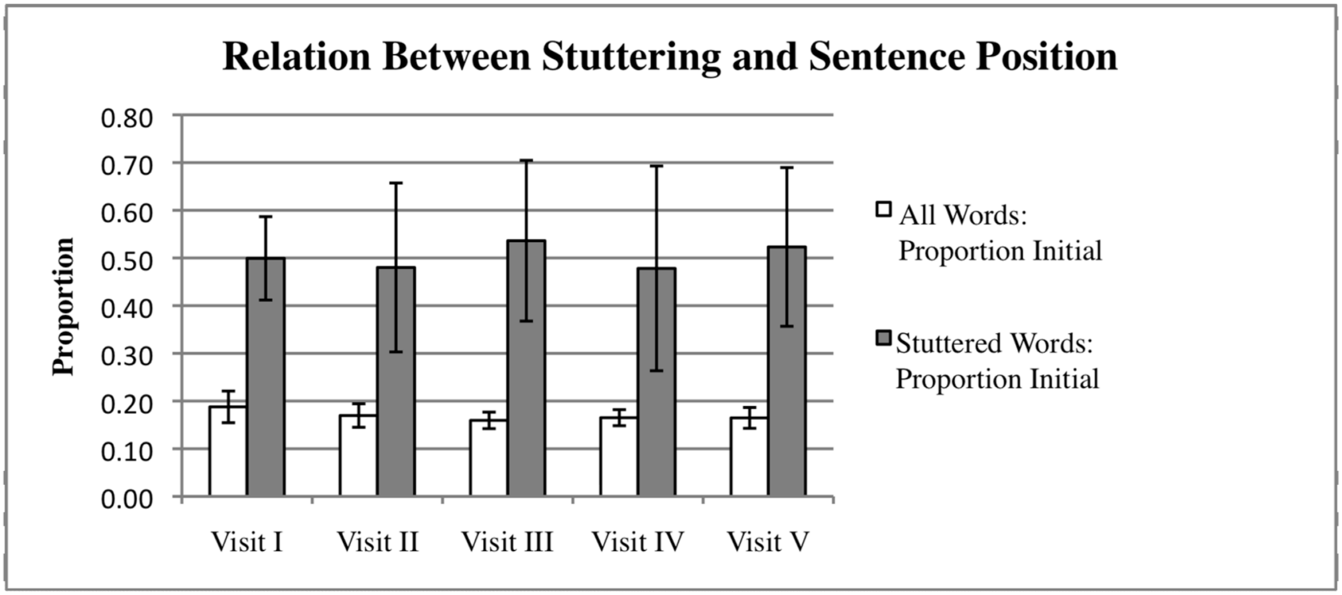

Figure 2.
Proportion of all words that were sentence-initial, and proportion of stuttered words that were sentence-initial.

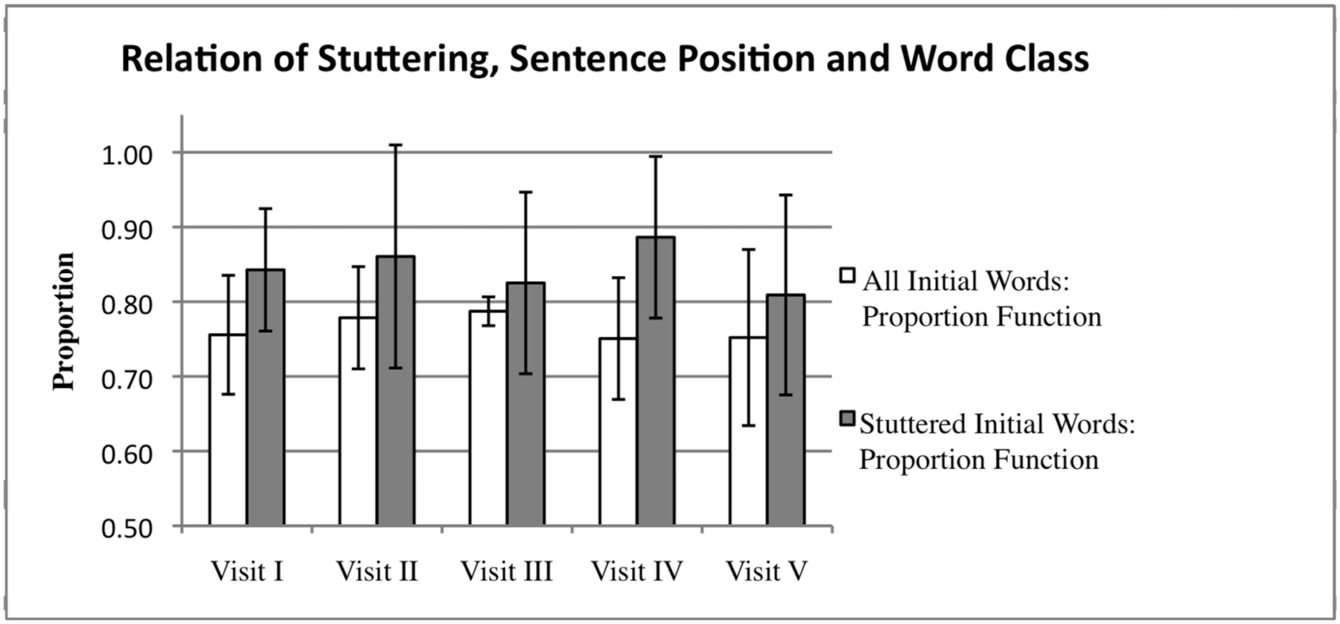

Figure 3.
Proportion of all sentence-initial words that were function words, and proportion of stuttered sentence-initial words that were function words.

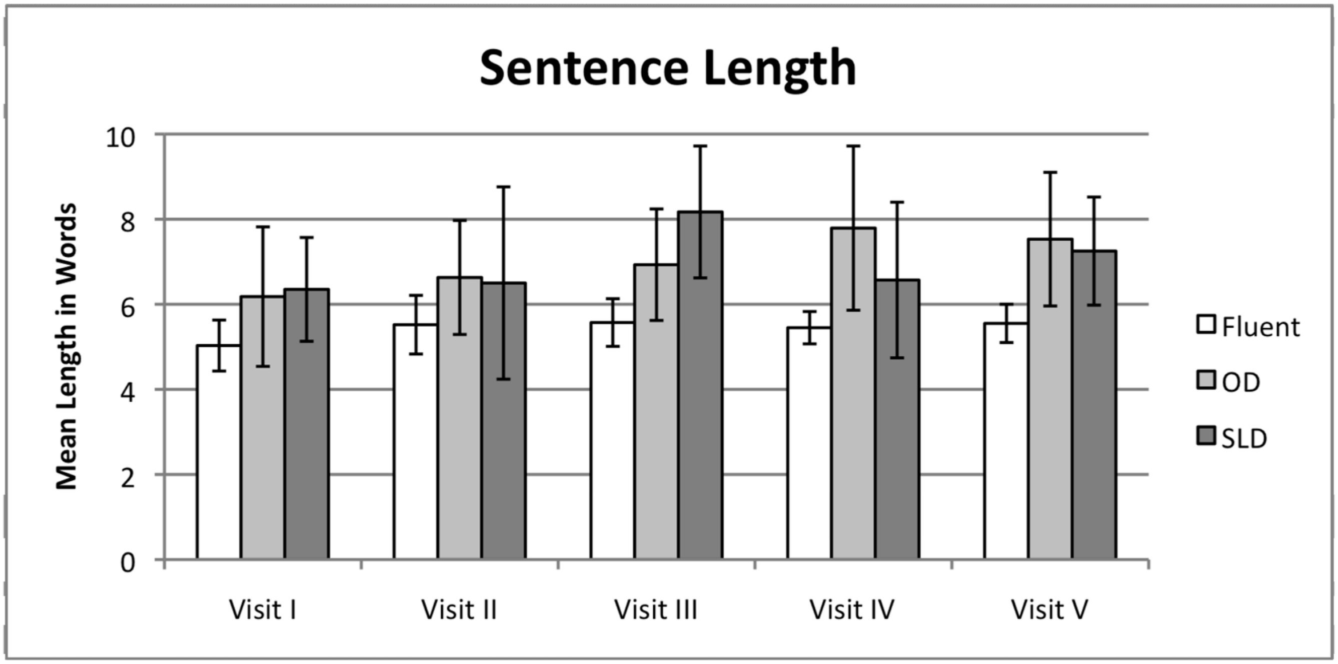

Figure 4.
Mean sentence length in words of fluent sentences and those containing SLDs and those containing ODs.

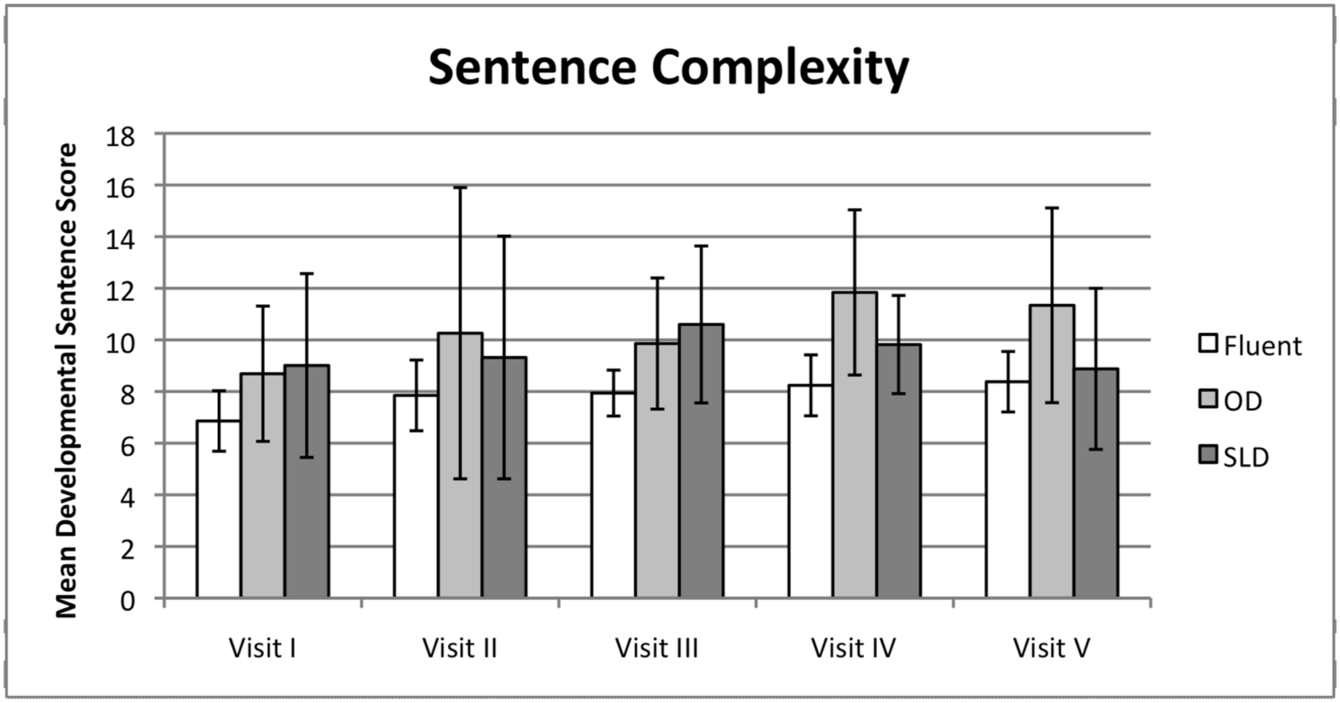

Figure 5.
Mean sentence complexity of fluent sentences and those containing SLDs and those containing ODs.

Table 1

Descriptive Statistics for All Participants at Initial Visit

ParticipantGender	Age	TELD	PPVT	EVT	SLD rate	OD rate
P1M	52	122	112	111	2.30	1.79
P2M	42	92	115	111	4.60	2.46
P3M	42	126	123	103	10.22	4.32
P4F	58	116	123	126	4.32	1.48
P5M	70	93	98	104	5.70	0.95
P6M	44	89	100	110	5.05	1.81
P7M	42	106	107	113	7.05	1.70
P8F	41	137	129	137	4.14	1.06
P9F	55	126	136	126	0.41	0.41
P10M	44	101	132	126	1.34	2.09
P11M	30	142	112	125	1.73	2.70
P12F	61	128	114	113	0.43	1.63
Means-	48.4	115	117	117	3.94	1.87

Note: TELD = Test of Early Language Development; PPVT = Peabody Picture Vocabulary Test; EVT = Expressive Vocabulary Test: DSS = Developmental Sentence Score; Length = mean words per sentence.

Table 2

Data Reduction Resulting in Number of Utterances Used for Word- and Sentence-Based Analysis Across Visits

		Excluded Speech			Analyzed Speech	
Visit	**Utterances Elicited**	**Utterance Fragments**	**Incomplete Utterances**	**Utterances SLD+OD**	**Word-Analysis Set**	**Sentence-Analysis Set**
I	4477	2550 *(57.0)*	333 *(7.4)*	92 *(2.1)*	1594 *(35.6)*	1502 *(33.5)*
II	2280	1046 *(45.9)*	166 *(7.3)*	62 *(2.7)*	1068 *(46.8)*	1006 *(44.1)*
III	3638	1559 *(42.8)*	327 *(9.0)*	79 *(2.2)*	1752 *(48.2)*	1673 *(46.0)*
IV	2803	1192 *(42.6)*	231 *(8.2)*	48 *(1.7)*	1380 *(49.2)*	1332 *(47.5)*
V	3879	1518 *(39.1)*	277 *(7.2)*	71 *(1.8)*	2084 *(53.7)*	2013 *(51.9)*
Overall	17077	7865 *(46.1)*	1334 *(7.8)*	352 *(2.0)*	7878 *(46.1)*	7526 *(44.1)*

Note: (%) = Percent total number of elicited utterances; Utterance fragments = utterances without both subject and verb; Incomplete = unintelligible, abandoned or interrupted utterance; Utterances SLD+OD = sentences containing both SLD and OD

Table 3

Numbers of Words and Proportions of SLDs and ODs Occurring at Initial Position of a Sentence Across Visits

Visit	Words	InitialProp.	SLDs (%)	InitialProp.	ODs (%)	InitialProp.
I	8562	15940.19	334 (*3.94*)	1670.50	152 (*1.76*)	1190.78
II	6291	10680.17	197 (*3.12*)	1210.61	121 (*1.92*)	880.73
III	10,750	17520.16	275 (*2.56*)	1420.52	210 (*1.95*)	1490.71
IV	8015	13800.17	162 (*2.02*)	750.46	135 (*1.68*)	960.71
V	12,395	20840.17	252 (*2.03*)	1350.54	216 (*1.74*)	1380.64
Overall	46,013	78780.17	1220 (2.65)	6170.51	834 (*1.81*)	5900.71

Note: Data at each visit based on conversational samples from 12 children.

Table 4

Total Numbers and Proportions of Function Words Stuttered According to Sentence Position Across Visits

Visit		Initial Position Total	Initial Position Function	Initial Position Prop.	Non-Initial Position Total	Non-Initial Position Function	Non-Initial Position Prop.
I	Total	1594	1215	0.76	6968	3811	0.55
	Stuttered	167	141	0.84	167	45	0.27
	Prop.	0.11	0.12	-	0.02	0.01	-
II	Total	1068	838	0.79	5223	2855	0.54
	Stuttered	98	83	0.85	98	38	0.39
	Prop.	0.09	0.10	-	0.02	0.01	-
III	Total	1752	1396	0.80	8998	4910	0.55
	Stuttered	142	116	0.82	133	53	0.40
	Prop.	0.08	0.08	-	0.02	0.01	-
IV	Total	1380	1052	0.76	6635	3579	0.54
	Stuttered	75	65	0.87	88	27	0.31
	Prop.	0.05	0.06	-	0.01	0.01	-
V	Total	2084	1597	0.77	10,311	5599	0.54
	Stuttered	135	110	0.82	117	44	0.38
	Prop.	0.07	0.07	-	0.01	0.01	-
Overall	Total	7878	6098	0.77	38,135	20,754	0.54
	Stuttered	617	515	0.84	603	207	0.34
	Prop.	0.08	0.08	-	0.02	0.01	-

Note: Data at each visit based on conversational samples from 12 children.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 5

Utterance Length and Complexity for Sentence Type Across Visits

Visit	Sentence Type	Sentences Total (%)M	Length SD	Complexity MSD
I				
	Fluent	1194 (*74.9*)5.03	0.60	6.861.17
	with OD	131 (*8.2*)6.18	1.64	8.692.62
	with SLD	177 (*11.1*)6.35	1.22	9.013.56
	OD & SLD	92 (*5.8*)7.28	1.43	9.652.67
II				
	Fluent	736 (*73.0*)5.52	0.69	7.851.37
	with OD	104 (*10.3*)6.63	1.34	10.265.64
	with SLD	106 (*10.5*)6.50	2.26	9.324.70
	OD & SLD	62 (*6.2*)8.37	2.12	11.333.81
III				
	Fluent	1349 (*76.9*)5.57	0.56	7.940.89
	with OD	172 (*9.8*)6.93	1.31	9.862.54
	with SLD	155 (*8.8*)8.17	1.55	10.603.04
	OD & SLD	79 (*4.5*)8.83	1.61	11.553.81
IV				
	Fluent	1118 (*80.9*)5.45	0.38	8.241.18
	with OD	113 (*8.2*)7.79	1.93	11.843.20
	with SLD	102 (*7.4*)6.57	1.83	9.821.90
	OD and SLD	48 (*3.5*)8.31	1.47	9.992.34
V				
	Fluent	1669 (*80.1*)5.55	0.45	8.381.17
	with OD	187 (*9.0*)7.53	1.57	11.343.77
	with SLD	156 (*7.5*)7.25	1.27	8.883.12
	OD & SLD	71 (*3.4*)8.26	2.04	12.293.55
Overall				
	Fluent	6125 (*77.7*)5.42	0.56	7.731.25
	with OD	707 (*9.0*)7.01	1.63	10.403.77
	with SLD	696 (*8.8*)6.97	1.75	10.053.31
	OD & SLD	352 (*4.5*)8.21	1.73	10.922.92

Note: Data based on conversational samples from 12 children; OD = contains at least one other disflency; SLD = contains at least one stuttering-like disfluency; Length = mean words per utterance; Complexity = Developmental Sentence Score.