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# Influences of Rate, Length, and Complexity on Speech Disfluency in a Single Speech Sample in Preschool Children Who Stutter

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## 1. Introduction

Perhaps the most distinguishing characteristic of stuttering is its variability. An adult might be very fluent one day, and very disfluent the next. A young child may seem to have completely stopped stuttering, only to have stuttering reappear a few weeks later. Variability within and between clients plays a role in therapy. A clinician who observes a child who is highly disfluent in sentences might start therapy at the level of single words. Another clinician might focus on rate reduction to help a child or adult gain control of fluency. At different stages of treatment, depending on symptoms and needs of the client, rate reduction and shorter, simpler utterances may be strategies used in the same individual.

Factors that influence the variability in stuttering have been the object of several investigations. Speech rate, grammatical complexity, and utterance length are three parameters that have received considerable attention. Generally, disfluencies tend to increase with increased grammatical complexity and length (Bernstein Ratner & Sih, 1987; Gaines, Runyan, & Meyers, 1991; Logan & Conture, 1995; Yaruss, 1999). The influence of speech rate on disfluencies has been inconclusive even though some studies showed possible relationships between disfluencies and a fast speech rate (Kelly & Conture, 1992; Logan & Conture, 1995; Meyers & Freeman, 1985; Vanryckeghem, Glessing, Brutten, & McAlindon, 1999; Ward, 1999; Yaruss 1997).

That complexity and length influence disfluencies provides evidence for the psycholinguistic theories of stuttering, which hold that disfluencies stem from difficulties in syntactic, phonological, or suprasegmental encoding (Bernstein Ratner, 1997; Perkins, Kent, & Curlee, 1991; Postma & Kolk, 1993). Increased length and complexity have been viewed as an increase

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***Educational objectives:*** The reader will learn about and be able to: (a) describe the influence of grammatical complexity and mean length of utterance on disfluent speech; (b) compare different procedures for assessing speech rate and determine why the effects of articulation rate have been inconclusive; (c) discuss procedures for comparing length, rate, and complexity across a single speech sample; and (d) explain why therapeutic methods that emphasize shorter utterance lengths, rather than only slower speech rates, are advisable in establishing fluency in preschool children who stutter.

in processing demands, and people who stutter are more vulnerable to such increases (Bosshardt, 2006). A fast speech rate could be another processing demand that results in increased disfluency. Studies of school-aged children have indicated that children who stutter may not have flexible rate control (Howell, Au-Yeung, & Pilgrim, 1999).

Grammatical complexity, speech rate, and utterance length, then, may play a role in the variability of stuttering. What is not clear is whether one parameter might have a greater influence on variability than another, and the role that the three parameters might play in variability in individual children. Determining whether one parameter has a greater influence than another might be helpful in designing effective therapy for particular children, as well as providing information about stuttering.

A recent investigation examined the variability of disfluencies in the conversational speech of 20 preschool children who stuttered (Sawyer & Yairi, 2006). Sawyer and Yairi measured stuttering-like disfluencies (SLD) in four consecutive 300-syllable sections of a single 1200-syllable speech sample for each child. SLD were those disfluencies more typical of stuttered speech, including part-word repetitions, single-syllable whole word repetitions, and disrhythmic phonation (blocks, prolongations, and broken words; Ambrose & Yairi, 1999). Results indicated that, in general, group means for SLD grew larger as the sample size increased, and specifically, there were significantly more SLD per 100 syllables in the fourth 300-syllable section than in the first.

Examining the factors of speech rate, grammatical complexity, and utterance length in this group of children would show how these variables vary for a given child in a single speech sample. If the children were more disfluent in one part of their speech sample, one might expect that they would have greater complexity, rate, and length in that part of the sample. Differences observed in the beginning versus the end of the sample might have meaningful clinical or theoretical implications. For example, the use of more complex syntax or longer utterances at the end of a long sample might provide evidence for psycholinguistic theories of stuttering. Moreover, from a clinical perspective, if the children had faster speech rate, longer utterances, or greater complexity at the end of a long speech sample, interventions which reduce rate, utterance length, and complexity might help children gain fluency. A closer examination of the parameters of utterance length, grammatical complexity, and speech rate in individual children would further inform clinicians and researchers about factors affecting disfluency in the preschool population.

### 1.1. The effects of utterance length and grammatical complexity on disfluent speech

Utterance length and grammatical complexity have been shown to influence disfluency in both children who stutter (see Zackheim & Conture, 2003, for a review) and normally fluent children (Gordon & Luper, 1989; Haynes & Hood, 1978; McLaughlin & Cullinan, 1989; Yaruss, Newman, & Flora, 1999).

Whereas length and complexity have been found to affect fluency, the level of influence is unclear. A mutual influence of complexity and length on stuttered speech has been observed in a few studies. Gaines, Runyan, and Meyers (1991) found that in the speech of 12 preschool children who stuttered, stuttered utterances were longer (measured in mean length of utterance, MLU) and more complex (measured using *Developmental Sentence Scoring*, DSS, Lee, 1974). In another study focusing on clustering, utterances with disfluency clusters were found to have significantly more syllables and clausal constituents than disfluent utterances without clusters (Logan & LaSalle, 1999).

The influence of length and grammatical complexity on disfluency appears to vary individually. In a study comparing conversational utterances in children who stuttered, group data indicated that stuttered utterances were significantly longer and more complex than fluent utterances (Yaruss, 1999). Analysis of individual speech data, however, revealed the effects of length and complexity were present for only a small number of children.

Some studies have found grammatical complexity to be a greater influence than length. A study employing a sentence imitation task revealed that grammatical complexity was a greater predictor of disfluency than length, measured in syllables (Bernstein Ratner & Sih, 1987). Grammatical complexity was the focus of another study which compared fluent and stuttered utterances in children who stutter, holding length constant (Logan & Conture, 1997). Stuttered utterances were found to have significantly more clausal constituents than the length-matched fluent utterances.

Other studies have found length to be more influential on fluency than grammatical complexity. In a study of the spontaneous speech of normally fluent children, Yaruss, Newman, and Flora (1999) found that utterances containing disfluencies were significantly longer and more grammatically complex than fluent utterances, and that for individual children, length was a better predictor of disfluency than complexity. Length was measured in words, syllables, morphemes, and clausal constituents. Length measured in clausal constituents was a greater predictor of disfluency than length measured in morphemes, pointing to a complex relationship between length and grammatical complexity.

In a study which examined parameters of length, complexity, and articulation rate, Logan and Conture (1995) found that stuttered utterances were significantly longer than perceptually fluent utterances. No significant differences were found in stuttered or perceptually fluent utterances in terms of speech rate or grammatical complexity. There appeared to be a combined influence of length and complexity on stuttering, revealed in a median split procedure. Utterances classified as being either “high” complexity and/or “high” length contained more stuttering than did those characterized as “low” in those categories.

Length relative to a child’s typical MLU appears to influence the production of fluent speech. A study which examined disfluencies as children talked above or below their mean length of utterance revealed that for children who stuttered, higher percentages of SLD occurred on utterances that were both longer and more grammatically complex (Zackheim & Conture, 2003). A similar influence of length and complexity was observed in disfluencies in the speech of normally fluent children. As for length, children who stuttered had more SLD on utterances that were longer than their typical MLU, but in regard to complexity, more SLD were found on non-complex utterances shorter than their typical MLU.

### 1.2. The measurement of articulation rate and its effects on disfluent speech

Past studies on the effects of speech rate on disfluency have been inconclusive, due in part to what was being compared. For example, some studies have examined speech rate differences in (a) children who stutter and normally fluent children, (b) perceptually fluent speech and disfluent speech in children who stutter, and (c) different groups of children who stutter.

The method of measurement and the metric used may account for some of the discrepancies in results in the various studies. The appendix provides an overview of the methods and results of previous studies which investigated speech rates of children who stutter and/or children who do not stutter. These investigations can be generally categorized by the participants and/or age ranges in the studies. As can be seen, many studies have measured articulation rate, measured in words, syllables and/or phones per second or minute. Some studies have measured overall speaking rate, which included all disfluencies, whereas others have measured articulation rate, in either syllables per second or minute. Measurements have been made using a stopwatch, video time codes, audio signals, or acoustic measures. Some studies have measured perceptually fluent speech, whereas others have measured rate in disfluent speech, removing disfluencies.

The influence of rate on stuttering has been addressed by comparing the articulation rates of children who stutter with those of normally fluent children. Some of the studies found no significant differences in articulation rate of children who stutter and their normally fluent peers (Chon, Ko, & Shin, 2004; Kelly, 1994; Kelly & Conture, 1992; Ryan, 1992, 2000), but others did find differences (Meyers & Freeman, 1985). Rate differences might be attributed to stuttering severity, as the participants in Meyers and Freeman's study stuttered at moderate to severe levels. What is measured may also make a difference. One longitudinal study examined speech rates in children whose stuttering would persist over time, in those whose stuttering would remit, and in normally fluent children (Hall, Amir, & Yairi, 1999). Looking at perceptually fluent utterances, Hall and colleagues found no significant differences in the three groups over time in terms of articulation rate measured in syllables per second. Measurement in phones per second, however, showed some significant differences. Those children who would recover had the slowest articulation rate near the onset of stuttering, whereas the normally fluent children had the fastest articulation rate.

Five studies, using different measurement techniques, found no significant differences in the articulation rate of children who stutter and normally fluent children. In two of the studies, articulation rate was measured in both words and syllables, with disfluencies removed from the disfluent utterances in both groups of children (Kelly, 1994; Kelly & Conture, 1992). The mean articulation rate for children who stutter was similar in both studies. Three other studies comparing children who stutter to normally fluent children showed no significant differences in either overall speaking rate or articulation rate (Chon, Ko, & Shin, 2004; Ryan, 1992, 2000).

Several studies of articulation rate have been conducted looking only at children who stutter. Yaruss and Conture (1996) measured articulation rates of children who stutter with normal and disordered phonological development and found the articulation rates of the two groups were not significantly different. Both groups of children showed relatively slower articulation rates in stuttered utterances, but the result was not significantly different.

Howell and colleagues (1999) found that speech rate had an influence on disfluency when speech was segmented into tone units, segments distinguished by prosodic structure. Speech rates were categorized as fast, medium, and slow, and tone units with a fast speech rate showed higher stuttering rates than those of medium and slow speech rates. Furthermore, the percentage of stuttering was higher in longer tone units, and speech rates were positively correlated with the length of the tone units.

Two studies compared articulation rate in stuttered and fluent utterances in children who stutter. Logan and Conture (1995) found perceptually fluent utterances were spoken at a faster rate than stuttered utterances, but this difference was not significant. Using similar methods to calculate articulation rate in both stuttered and fluent utterances, Yaruss (1997) examined articulation rate in individual utterances to determine if a faster or slower articulation rate was related to the occurrence of stuttering. No significant relationship was found between articulation rate and stuttering.

### 1.3. The influences of rate, length, and grammatical complexity on disfluent speech

To date, few studies have looked at the combined influence of rate, length, and complexity on disfluent speech. In adults, longer utterances have been shown to involve more planning time (Amster & Starkweather, 1987; Peters & Hulstijn, 1987; van Lieshout, Starkweather, Hulstijn, & Peters, 1995). Planning time required for the construction of longer, more complex utterances might have a negative effect on fluency. Adults who stutter have been found to produce shorter utterances and more disfluency than those with normal fluency under dual-task processing conditions (Bosshardt, 2006). Bosshardt (2006) has proposed that vulnerability to increased cognitive processing loads precipitates stuttering. Such sensitivity may underlie deficits in speech motor control. Task demands of producing utterances that are long, grammatically complex, and spoken at a fast rate may create demands on children's fluency.

The potential influences of rate, length, and grammatical complexity are both clinically and theoretically important. Clinically, interest in investigating these parameters has partially arisen from advice to parents to simplify their speech to increase their children's fluency (see Bernstein Ratner, 2004, for a review), as well as from therapies which have focused on reducing speech rate, utterance length, and grammatical complexity in children's and/or parents' speech (Costello Ingham, 1999; Ingham, 1999; Ingham & Riley, 2000; Riley & Riley, 1984).

In addition to clinical interest in factors that may contribute to stuttering, issues of rate, length, and complexity are underscored in several theories of stuttering. For example, the Demands and Capacity model of stuttering (Adams, 1990; Starkweather, 1987; Starkweather & Gottwald, 1990) might hold that a fast rate of speech, long utterances, and complex grammatical structures would be "demands" that might cause a child to exceed his "capacity" for fluent speech. Two other theories of stuttering, the Covert Repair Hypothesis (Postma & Kolk, 1993), and the neuropsycholinguistic theory of stuttering (Perkins, Kent, & Curlee, 1991) put the focus of stuttering on linguistic factors, but also include speech rate as a precipitator of disfluency. Disfluency, according to the Covert Repair Hypothesis, is a result of the speakers' covert repair of a phonetic plan. Faster speaking rates play a role in creating errors in the speech plan. The neuropsycholinguistic theory asserts that stuttering is a result of a dyssynchrony in both linguistic and paralinguistic planning prior to speech, and that fast speaking rates can be a contributing factor.

The present study sought to determine influences of rate, utterance length, and grammatical complexity on stuttering-like disfluencies as children became more disfluent at the end of a long speech sample (Sawyer & Yairi, 2006). The purpose of the research was two-fold. The first was to answer the question of whether factors of (a) length, measured in mean length of utterance, (b) grammatical complexity, measured in number of clauses and clausal constituents per utterance, and (c) articulation rate, measured acoustically in numbers of syllables per second, contributed to a significantly larger number of disfluencies at the end of a long speech sample (syllables 901–1200) than at the beginning (syllables 1–300). The second was to explore the interaction of rate, length, and grammatical complexity in the two sections of speech of these children.

## 2. Method

### 2.1. Participants

Participants were children who stutter from the Sawyer and Yairi (2006) study described earlier. Only those with a minimum 10% increase in SLD from the first 300 syllable section to the final 300 syllable section of their speech sample were selected. Fourteen of the 20 participants met this criterion. There were 8 boys and 6 girls, ages 33–57 months (M = 40.9). They were regarded by their parents and two certified speech-language pathologists as exhibiting stuttering, displayed a minimum of three SLD per 100 syllables in a 1200-syllable speech sample, and had no neurological disorders or abnormalities.

Severity was assessed using a weighted measure that reflected the frequency and type of SLD as well as the extent or length of the disfluencies (Ambrose & Yairi, 1999). One advantage of the weighted scale is that it accounts for the considerable contribution of disrhythmic phonation and a large number of repetition units that contribute to the perception of severity (Costello & Ingham, 1984; Zebrowski & Conture, 1989). The weighted scale was calculated by adding together part- and single-syllable word repetitions per 100 syllables and multiplying by the mean number of repetition units. Next, the number of instances of disrhythmic phonation multiplied by a factor of 2 was added to the result derived from the previous calculation (see Ambrose & Yairi, 1999, p 899). A weighted measure of 4.0 – 9.99 characterized the level of disfluency as “mild,” and a rating of 10.0 – 29.99 characterized the disfluency level as “moderate,” and a rating of 30.0 or above characterized the disfluency level as “severe.” Based on the 1200-syllable speech sample, 6 of the children presented with mild stuttering (weighted SLD 4.12 to 5.50), 7 had moderate stuttering (weighted SLD 13.2 to 26.47), and 1 had severe stuttering (weighted SLD 34.62).

## 2.2. Procedures

**2.2.1. Data collection—**Data collection procedures, recording equipment, and disfluency analysis of the speech samples have been described in detail in Sawyer and Yairi (2006). Conversational speech samples were audio- and videotaped in a sound-treated booth. Each sample was a minimum of 1,200 syllables in length, elicited while the child was playing with Play-Doh and interacting with a parent and a clinician. Disfluencies and morphemes were identified and marked using the Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 1996) to facilitate the counting. Morphemes were marked using Brown’s (1973) guidelines.

The speech samples selected for analysis were the first 300 and the last 300 syllables of the 1,200-syllable speech sample. These sections were the ones in which there was a significant increase in the number of SLD per 100 syllables. The increase in SLD from Section A, the first 300 syllables, to Section B, the final 300 syllables, ranged from approximately 12.4% to over 250%.

**2.2.2. Utterance length and grammatical complexity—**An utterance was defined as a string of words that (a) communicated an idea, (b) was bounded by a simple intonational contour, and/or (c) was grammatically complete (Golinkoff & Ames, 1979; Meyers & Freeman, 1985; Walker, Archibald, Cherniak, & Fish 1992; Yaruss & Conture, 1995). Mean length of utterance, rather than number of syllables, was selected as a measure of length to facilitate comparison with previous studies (for example, Logan & Conture, 1995; Zackheim & Conture, 2003). For each of the 300 syllable sections, mean length of utterance was calculated in morphemes for each child, using the Systematic Analysis of Language Transcripts (SALT) software program (Miller & Chapman, 1996).

Grammatical complexity was measured by counting the number of clausal constituents per utterance, using procedures described by Blake, Quartaro, and Onorati (1993; see also Logan & Conture, 1997, Logan & LaSalle, 1999, Yaruss, 1999, and Yaruss, Newman, & Flora, 1999). Utterances that did not have a verb (e.g., “How about with this, too?”) or that were interrupted were excluded from analysis. The mean number of utterances analyzed for each child was 39.79 (SD = 8.01) for Section A, and 37.64 (SD = 11.67) for Section B. Utterances excluded from the analysis represented 32 percent of the total utterances in the combined Sections A and B.

Clausal constituents included subjects, verbs, objects, complements, vocatives, and adverbials, and if an utterance contained a subordinate clause, those components were counted, too. For example, the utterance “I want to play a game now” would contain six clausal constituents: the subject “I,” the verb “want,” the object “to play a game,” the adverb “now,” and the subordinate clause, which has a verb “to play” and an object, “a game.” For each child, the mean number of clausal constituents in each of the 300-syllable sections was calculated.

An additional measure of grammatical complexity was the number of clauses per utterance. Procedures used were similar to those described by Logan and Conture (1997). The same criteria for utterance selection with clausal constituents were used for utterance selection for clauses per utterance. A clause was defined as a group of words containing a subject and predicate (Crystal, 1979). An utterance could consist of multiple clauses, except in the case of “and,” whereby only two independent clauses conjoined by “and” were considered as one utterance. For each of the speech sections, the mean number of clauses per utterance was calculated for each child.

**2.2.3. Articulation rate—**Articulation rate was defined as the number of perceptually fluent syllables in each utterance divided by the duration (in seconds) of the utterance removing all instances of stuttering-like disfluencies, other disfluencies (interjection, revision/abandoned utterances, multisyllable/phrase repetition), and pauses greater than 250 milliseconds (ms) (Chon, Ko, & Shin, 2004; Hall, Amir, & Yairi, 1999; Miller, Grosjean, & Lomanto, 1984; Walker, Archibald, Cherniak, & Fish, 1992; Yaruss, 1997). The participants’ speech was captured and analyzed using the Computerized Speech Lab (CSL), model 4500 by Kay Elemetrics. The speech data, recorded in a sound-treated booth, were converted to wav file format for use with CSL. The first and the second authors captured all utterances, and the overall duration of each utterance and the duration of pauses within the utterance were measured. The sample utterance in Figure 1 illustrates how articulation rate was measured.

If the pause in an utterance was less than 250 ms, the pause could be included but if the pause was more than 250 ms, only 250 ms was included and the remainder was removed. Therefore, the articulation rate of the sample utterance was 3.5487 syllables per second (overall duration of perceptually fluent speech (2.53615 sec) ÷ number of syllables (9) = 3.5487 SPS). Simultalk, unintelligible talk, or utterances less than three consecutive words were excluded (Hall, Amir, & Yairi, 1999; Logan & Conture, 1995; Yaruss, 1997; Yaruss & Conture, 1995). The mean number of utterances analyzed for each child was 33.5 (SD = 4.03) for Section A, and 33.79 (SD = 7.44) for Section B, and overall, 942 utterances (508 perceptually fluent utterances, 328 utterances including stuttering-like disfluencies, and 106 utterances including other disfluencies) were analyzed for the articulation rate.

**2.2.4. Reliability—**All SLD and morphemes were identified and marked on the transcripts by a listener with several hundred hours of experience in both disfluency and language analysis. The first author re-listened to the two 300-syllable samples in their entirety and recounted/rechecked the marking of disfluencies and morphemes in the speech samples for all participants. The interjudge reliability for type and location of SLD in was .93, using the “percent occurrence agreement” formula described by Baird and Nelson-Gray (1999). Agreement was calculated for disfluent events, and the number of agreements of SLD occurrence was divided by the number of agreements plus disagreements. Interjudge comparisons for the marking of morphemes yielded a .98 agreement coefficient. Intrajudge agreement for the first author was derived after a period of 5 months on 20 percent of the speech samples. The values for the SLD and morphemes were .92, and .98, respectively.

Inter- and intrajudge measurements of reliability were also made for the number of clauses, clausal constituents, and articulatory speaking rate. Because these were ordinal scale measurements, reliability was calculated in terms of Pearson product-moment correlations. For each child, 20% of the utterances in both sections were randomly selected for re-analysis for rate, utterance length, and clausal constituents by the first two authors, who each analyzed approximately one half of the rate data. Approximately four months after analyzing the rate data, the first two authors re-analyzed the data for inter- and intra-rater reliability. The grammar and length data were analyzed by the first author, with the first author re-checking the data for intra-rater reliability approximately five months after analysis, and the second author providing inter-rater reliability. For clauses per utterance, Pearson product-moment correlations were .90 for both inter- and intrajudge reliability. The coefficients for clausal constituents per utterance were .91 for interjudge and .92 for intrajudge reliability. For articulation rate, the coefficients were .90 for interjudge and .96 for intrajudge reliability.

## 3. Results

### 3.1. Grammatical complexity and utterance length

Figure 2 shows the mean difference in Sections A and B in the number of clauses per utterance, clausal constituents, and mean length of utterance measured in morphemes. The mean number of clauses per utterance was very similar in Sections A and B, at 1.09 and 1.10, respectively. A one-way repeated measures analysis of variance revealed no significant differences, $F_{(1, 13)} = .044$, $p = .838$. There was a tendency for clausal constituents to increase in Section B, in which the mean number of clausal constituents per utterance was 4.00, as compared to Section A, at 3.63. This difference was not significant, however, as revealed by a one-way repeated measures ANOVA ($F_{(1, 13)} = 2.596$, $p = .131$). Mean length of utterance showed similar patterns of increase in Section B, with the group means for MLU at 4.30 in Section A and 5.14 in Section B. A one-way repeated measures ANOVA revealed this difference to be significant ($F_{(1, 30)} = 8.27$, $p = .013$, at alpha level = .05).

Although the increase in clausal constituents in Section B did not reach significance, clausal constituents were found to be significantly correlated with MLU. A Pearson's product-moment correlation analysis revealed a correlation of .814 ($p < .01$) between clausal constituents and MLU in Section A, and .89 ($p < .01$) in Section B.

The significant increase in MLU in Section B led to further analysis regarding MLU. Zackheim and Conture (2003) had found that children who stutter produced significantly more SLD when they talked "over" their "typical" MLU. To determine if MLU had a similar effect on SLD in the current study, a comparison of each child's MLU in Sections A and B with that child's MLU over the entire 1,200-syllable sample was made. Because this was a comparison of parts to the whole, the data were analyzed descriptively. Table 1 shows the individual and group data for the child's age, the predicted MLU for that age (from Miller, 1981), the MLU for the entire speech sample, and the MLU for Sections A and B.

Using the criterion of one standard deviation above the mean as being "above average," individual data showed 10 children to be above average in terms of the expected MLU for their age across the entire 1,200 speech sample, including Sections A and B. Participants 1, 4, 6, 7, 8, and 12 were two standard deviations above their expected MLU. Most of the children (11 out of 14) spoke "over" the MLU for the entire sample in Section B. Group means also showed a tendency for children to talk "over" their MLU for the entire speech sample in Section B, and to talk "under" their MLU in Section A.

### 3.2. Articulation rate

The mean articulation rate was 3.49 syllables per second in Section A (SD = 0.40) and 3.44 syllables per second in Section B (SD = 0.40), and the overall mean articulation rate including Sections A and B was 3.47 syllables per second (SD = 0.39). As seen in the box plots in Figure 3, the difference between the upper quartile and the lower quartile in the box plot of Section A suggested comparatively more variable articulation rate in Section A than in Section B. A one-way repeated measures ANOVA showed no significant differences in articulation rates between the two sections, $F_{(1, 13)} = 0.274$, $p = .610$.

### 3.3 Interactions of rate, length, and complexity

To determine interactions between rate, utterance length, and grammatical complexity across the two speech samples, a median split procedure (Logan & Conture, 1995; Yaruss, 1997) was used to categorize utterances as either “high” or “low” in each of the three parameters. Because the difference in the number of clauses per utterance in Sections A and B was very small (mean difference of .01), grammatical complexity was measured in terms of the number of clausal constituents. Comparisons were across three different contrasts using the “high” and “low” criteria: complexity and rate, complexity and length, and length and rate. As was the case in the Logan and Conture (1995) study, the contrasts were paired, rather than making comparisons across three (rate, length, complexity). The reason for this was that all children had utterances which could be classified across two contrasts (for example, “high” rate and “low” length), but many did not have utterances which could be classified across three (for example, “high” rate, “high” complexity, and “low” length). The paired contrasts were analyzed using paired *t*-tests with a Bonferroni correction of .0125 to account for Type I error (overall alpha = .05).

**3.3.1. Grammatical complexity and rate—**Figure 4 shows the mean number of utterances in Sections A and B classified as either “high” or “low” in grammatical complexity, measured by the number of clausal constituents per utterance, and in articulation rate. Four paired *t*-tests indicated no significant differences in the two sections in any of the categories. There were more utterances in Section A than B that were in the “low” complexity / “high” rate category, but these differences were not significant ($t = .829$; $p = .414$). In addition, there was another trend for more utterances with “high” complexity / “low” rate to occur in Section B than A, but this difference was not significant ($t = -1.06$; $p = .297$).

**3.3.2. Grammatical complexity and utterance length—**Figure 5 shows the contrast between Sections A and B in the mean number of utterances of “high” or “low” grammatical complexity, measured in the number of clausal constituents, and utterance length, measured in morphemes. The two sections were similar in the number of utterances across all four categories, with no significant differences noted in four paired *t*-tests. There were trends noted for “low” length / “low” complexity and “high” length / “high” complexity, with Section A having more utterances in the former and B having more utterances in the latter category, but these differences were not significant ($t = 1.44$; $p = .160$, and $t = -1.85$; $p = .075$, respectively).

**3.3.3. Utterance length and rate—**The mean number of utterances in Sections A and B classified as either “high” or “low” in utterance length, measured in morphemes, and articulation rate are found in Figure 6. Four paired *t*-tests revealed no significant differences between the two sections. The mean number of utterances that were classified as “high” length / “low” rate tended to be larger in Section B than A, but this difference was not significant ($t = -2.38$; $p = .025$). There was also a non-significant trend for more utterances of “low” length / “high” rate to occur in Section A than B ($t = 1.07$; $p = .295$).

## 4. Discussion

The focus of the current study was to determine whether articulation rate, grammatical complexity, and/or utterance length might have influenced a significant increase in disfluencies at the end of a 1,200-syllable speech sample. To this end, the mean articulation rate, clauses per utterance, clausal constituents per utterance, and length of utterance in morphemes were calculated in the first and final 300 syllables of the sample. Relations among the parameters of articulation rate, clausal constituents, and MLU were determined through a median split procedure. Although the focus of this study was on influences observed in a speech sample, rather than directly on fluent or disfluent speech, the findings strengthen some of those of past investigations regarding influences of rate, length, and complexity on disfluency.

### 4.1. Utterance length and grammatical complexity

One of the significant findings of the current study was that mean length of utterance, measured in morphemes, was greater in Section B, which had significantly more SLD than Section A. Of course, a longer MLU in Section B does not imply a direct causal relationship to SLD, but it does point to influences beyond sample length as a factor in these children's disfluencies. In addition, it adds to the body of research implicating utterance length as a factor in disfluent speech (Gaines et al., 1991; Logan & Conture, 1995; Weiss & Zebrowski, 1992; Yaruss, 1999). The findings regarding MLU in Sections A and B relative to MLU in the longer speech sample are consistent with those of Zackheim and Conture (2003), who found that children who stuttered produced more SLD on utterances that were above their MLU. Zackheim and Conture's (2003) study was specifically designed to address the effects of MLU on disfluency, and the children selected had MLU described as typical for their age. The present study compared sections of speech to a longer speech sample, which of course, did not necessarily represent the children's typical MLU. In addition, the children in the current study were somewhat precocious in regard to MLU. Despite the differences in purpose and design of the two studies, both point to the influence of MLU on speech disfluency. In the current study, almost 80 percent of the children were talking over their MLU in the final section of speech, which may have contributed to the increased number of disfluencies in that section as compared to the first.

In the present study, length (measured by MLU), rather than grammatical complexity, was a more important difference in the two speech sections. This finding is consistent with Logan and Conture (1995) and Yaruss (1999), but not with that of Gaines and colleagues (1991), who found mutual influences of grammatical complexity and length. Bernstein Ratner and Sih (1987) found grammatical complexity to be of greater influence to stuttered speech, but their study was a sentence imitation task, rather than a study of spontaneous speech. The current study measured complexity in terms of the number of clausal constituents and clauses per utterance, which are more accurate measures of syntactic complexity than overall grammatical complexity. DSS, which systematically quantifies and analyzes children's syntax, is probably a more appropriate measure of grammatical complexity, but could not be used in the present study because it requires a corpus of 50 utterances, each with a subject and verb, or an imperative structure.

The use of clauses as a measure of grammatical complexity did not differentiate the two sections as well as clausal constituents did. For most of the children, the number of clauses per utterance was just over one. At least one previous study used the number of clauses per utterance as a measure of grammatical complexity in utterances with disfluency clusters. Logan and LaSalle (1999) found that the number of clauses per utterance was significantly larger in utterances which contained disfluency clusters than in perceptually fluent utterances. For the preschool children in the current study, the number of clauses was not a fine enough parameter to differentiate the two speech sections.

Whether length or complexity is more relevant to stuttering may not be the right question to ask, as the relationship between the two parameters is far from clear. Certainly, longer utterances have a greater probability to be stuttered than shorter ones simply because there are more opportunities (i.e., more words and syllables) for stuttering to occur. Length has been referred to as a "macrovariable" in that it encompasses grammatical complexity, and linguistic, phonological, and prosodic planning (Logan & Conture, 1995, p. 56). MLU has also been called a measure of linguistic maturity (Zackheim & Conture, 2003). Indeed, it is difficult to separate the effects of length and complexity, as utterances that are more grammatically complex are also those that tend to be longer (see also Bernstein Ratner and Sih, 1987, and Yaruss, 1999). In fact, Yaruss and colleagues (1999) treated clausal constituents as a measure of length, and found that length measured in clausal constituents was more influential on disfluencies in normally fluent children than length measured in morphemes. This finding was not supported by the current study, which found length in morphemes to be more influential in Section B than clausal constituents. Although the children significantly increased their MLU in Section B, there was not a parallel significant increase of clausal constituents. It was beyond the scope of the study to determine what exactly the children were adding as they increased their MLU, but one child in particular was adding adjectives as he talked about different models of cars (for example, a “Ford Mustang G-80 convertible”) in Section B. Adding modifiers did not increase the number of clausal constituents, but did, of course, increase MLU. Furthermore, clausal constituents were highly correlated with MLU, pointing to a close relationship between the two parameters.

### 4.2 Articulation rate

The results for articulation rate in the present study were not easy to compare to previous studies because of different methodologies such as measurement devices, types of analysis, measurements of pauses, or inclusion of disfluencies. For example, Hall and colleagues (1999) studied articulation rate of children who stuttered, measured in syllables per second using acoustic analysis. Because they did not include disfluent utterances, however, it is difficult to compare that study with the present study.

One of the factors hypothesized to influence the increase in SLD in Section B was articulation rate. The articulation rate in Section A was relatively faster than in Section B, but the two sections were not significantly different. Even though speech rate might be related to the occurrence of SLD (Howell, et al., 1999; Logan & Conture, 1995; Yaruss & Conture, 1996), the results here did not support that articulation rate influenced the increase of SLD. Whether children manipulate their speech rate as a response to disfluencies or to process longer and/or grammatically complex utterances remains unclear, as Kelly and Conture (1992) also concluded.

The present study showed the trend that articulation rate in Section B was relatively more stable than in Section A, even though Section B included more SLD. Whereas specific information regarding underlying motoric processes cannot be inferred from surface analyses of disfluent speech (Kent, 1996; Kleinow & Smith, 2000; van Lieshout, Hulstijn, & Peters, 2004), the theory of coordination dynamics could provide one explanation for the variability in the two speech samples. Control of motor systems, according to this theory, is achieved through coupling, for example, between articulators (Kelso, 1995). The coupling is not hard-wired; for example, in speech, if the movement of an articulator is restricted, the system finds another way to achieve its goal (Kelso, Saltzman, & Tuller, 1986). Skilled movements, such as speech, require both stability and flexibility to meet the needs of rapidly changing demands of speed and accuracy on individual movements. One way coordination is stabilized is through recruiting degrees of freedom (Buchanan & Kelso, 1999). The variability in rate in Section A might be evidence of flexibility in the system. Van Lieshout and colleagues (2004) have suggested that strategies involved in faster speaking rates in people who stutter may act as a facilitator for movement control. The slightly faster rates of Section A may be an example of the speakers’ recruiting additional degrees of freedom to stabilize motor coordination in an effort to produce fluent speech. The slower rate in Section B might be evidence of the speakers’ attempts to gain stability in the face of the linguistic demands of an increase in MLU.

### 4.3. Interactions of rate, length, and complexity

The median split procedure comparing two parameters across the speech sections in three 2 × 2 tabulations revealed no significant differences between the two sections. The current study showed trends for utterances that were high length/low rate and high length/high complexity to appear in greater frequency in Section B. These trends were consistent with significant differences in fluent and disfluent utterances in the Logan and Conture (1995) study. These trends are not surprising, for all have high length in common, which was a significant difference in the current study. All trends that characterized Section A in this study have low length in common: Section A had more utterances of low length/low rate, low length/high rate, and low length/low complexity. This finding was consistent with the Logan and Conture study, which found that these parameters characterized more fluent than disfluent utterances to a significant extent. The current study showed a trend for more utterances in Section A than B to have low length/high complexity, a trend which was not consistent with Logan and Conture. Utterance length, in the current study, appeared to be a robust difference between the two sections.

### 4.4. Theoretical and clinical implications

The data in this study add support to a growing body of literature that suggests a linguistic influence on disfluent speech. Here, disfluency seems to have been affected more by length, measured in MLU, than rate or grammatical complexity. The MLU in Section B for most children was longer than that of their entire sample, in fact. This might suggest that the amount of speech, rather than its complexity, may be a factor in increasing disfluency. The data on length seem to support the Demands and Capacity (DCM) model of stuttering (Adams, 1990; Starkweather, 1987; Starkweather & Gottwald, 1990) in this regard, and support past studies that point to utterance length as a contributor to disfluency (Melnick & Conture, 2000; Logan & Conture, 1995; Yaruss, 1999; Zackheim & Conture, 2003). According to the DCM, a child has a particular set of capacities for producing fluent speech, and demands that serve to limit fluency either internally and/or externally (Adams, 1990; Starkweather, 1987; Starkweather & Gottwald, 1990). Production of utterances that are longer than the typical or expected MLU could be one example of an internal demand on fluency. The DCM would predict that both complexity and length are independently sufficient to be associated with greater disfluency, which helps explain the data in this study. The DCM would also predict that production of both longer and more complex utterances should elicit the most disfluency, but the current study does not validate this assumption.

A model relating to task demands that may partially explain the data presented here has been proposed by Bosshardt (2006). In a series of investigations, Bosshardt and colleagues have found that adults who stutter produce either shorter and less grammatically complex utterances or more disfluency under dual task conditions, in which attention is divided (e.g., Bosshardt, 2002; Bosshardt, Ballmer, & de Nil, 2002). These investigations point to differences in cognitive processing in people who stutter and normally fluent speakers. Bosshardt (2006) has suggested that people who stutter are vulnerable to increased processing loads, perhaps due to an overlap in functioning in speech-motor and speech planning areas of the brain. Looking at the data from the current study from the viewpoint of Bosshardt's model, it could be said that the longer utterances in section B required more cognitive resources to generate than the shorter utterances in Section A, with more disfluencies resulting. Conceivably, the trend for slower speech rates in Section B could also mean longer processing and planning time with longer utterances as a result of more cognitive processing. The data reported here do not fully support Bosshardt's theory, however, as the theory would also predict that Section B, with more disfluencies would also have more grammatically complex utterances than Section A.

Finally, a psycholinguistic theory of stuttering, the Covert Repair Hypothesis (CRH), may provide some explanation for the results found here. This hypothesis purports that disfluencies are created as a byproduct of covert repair that occurs while the speaker is monitoring the phonetic plan, and presumably, longer or more complex utterances would require more monitoring than shorter, simpler ones (Kolk & Postma, 1997). The increase in monitoring could lead to more disfluency in longer utterances, which is consistent with the results from the current study. The trends for a relatively slower rate found in Section B, however, is not consistent with the CRH, as the hypothesis would predict that slower speech rates facilitate fluency, because they allow more processing time.

Clinically, in regard to rate, several preschool therapies include a requirement that the child's and/or parents' speech rates be reduced (e.g., Conture, 1990; Gottwald & Starkweather, 1995; Gregory, 2003; Shapiro, 1999; Yaruss, Coleman, & Hammer, 2006). A slower speech rate by parents has been shown to improve children's fluency (Guitar & Marchinkoski, 2001), but there has not been a strong link between the child's speech rate and disfluencies (Kelly, 1994; Logan & Conture, 1995; Ryan, 2000; Yaruss, 1997). In the present study, the relationship of rate and disfluencies remains unclear. At the end of the speech sample, there was a trend for a slower articulation rate. Perhaps the children were slowing down as a result of the disfluencies produced or in an effort to gain stability to process longer utterances. More research is needed to determine the relationship between rate, utterance length, and disfluency, perhaps by using an experimental design which includes normally fluent children where length is manipulated and rate is measured across different utterance lengths.

That utterance length appeared to be a factor in disfluent speech gives support to preschool therapies that begin with shorter utterances and progress to longer ones (e.g., Costello Ingham, 1999; Ryan, 1986). Therapies that take into account the child's MLU may effectively reduce planning demands and thus, stuttering.

### 4.5. Caveats and future research directions

One limitation to the present study was the number of utterances analyzed. By design, the samples were limited to 300 syllables, and this meant that some utterances were too short to be analyzed for rate and/or grammatical complexity. A larger corpus of data may have revealed differences in rate and/or grammar. The small sample size in each section did not permit analysis by DSS, which may have been a better indicator of grammatical complexity than clauses or clausal constituents. One might expect, too, that as utterance length increased, clausal constituents would have increased as well. A longer speech sample might have revealed trends in this direction. To determine the relation between MLU and clausal constituents, further study as to what elements the children were adding in Section B is warranted.

One consideration is the high variability of disfluency from Section A to B. Some children increased disfluencies by 12 percent, while others increased by 250 percent. This is a large range, especially considering the sample size of 300 syllables. An examination of individual differences might reveal greater effects of rate, length, and complexity for some children than others. Further study using larger groups of children at different levels of severity would enable comparisons of such effects.

A closer examination of speech rate might also be useful, especially considering that studies of speech rate have provided significant clinical implications (Guitar, 2006; Yairi & Ambrose, 2005; Zebrowski & Kelly, 2002). Different types of analyses may reveal more about the relationship between rate and disfluent speech. Howell and colleagues (1999) looked at rate variability on a more local level by measuring prosodic units, and found that longer prosodic units were spoken at a faster rate of speech and were more disfluent than shorter ones. An examination of prosodic units in the current data might reveal similar trends. Furthermore, the analyses of different types of utterances (i.e., perceptually fluent, normally disfluent, and abnormally disfluent utterances) and measurements of correlation among articulation rate, disfluencies and utterance length using a larger sample size would be useful.

The current study validated previous findings on the effects of speech rate, complexity, and utterance length on disfluent speech, but did so by looking at characteristics of the speech sample. Examining the entire speech sample by looking at the effects of rate, complexity, and length on fluent and disfluent utterances in these children, and comparing them to normally fluent children would further elucidate the influences of these parameters on disfluency.

Finally, questions remain unanswered about the speech sample itself. Perhaps the children produced longer utterances because they became familiar with the experimental environment and the setting, or became used to a particular speaking partner, or were talking about a subject that was most interesting to them. Future studies focusing on different speaking partners, settings, or topics might give more clues as to the disfluencies generated in a longer speech sample. Additionally, the relation between sample size and utterance length could be further explored. If MLU were held constant, one could determine if there were more disfluencies in utterances of specific lengths (for example 3, 4, 5, etc) in Section B than in Section A. If there were more disfluencies in Section B, that would provide further evidence for the sample size having an influence on speech disfluency.

### 4.6. Conclusions

The current study found that some of the factors which influenced disfluency in previous research seemed to be relevant at the end of a long speech sample, in which children became more disfluent. Specifically, on average, MLU was significantly longer in the speech section that contained more SLD. The data did not support differences in grammatical complexity, but clausal constituents were highly correlated with MLU, giving support to the perspective of length serving as a macrovariable affecting planning time and fluency. Rate differences between the speech samples were not significant, but there were indications of interactions between rate and length. There were trends, for example, of longer length and lower rate in the section that was more disfluent. Findings support the use of therapeutic measures that emphasize shorter utterance lengths to establish fluency.

## CONTINUING EDUCATION

Influences of rate, length, and complexity on speech disfluency in a single speech sample in preschool children who stutter

## QUESTIONS

1. Research regarding the effect of speech rate on disfluent speech has been inconsistent due to differences in:
    - **a.** the types of utterances measured
    - **b.** the instrumentation used to measure speech rate
    - **c.** the age of the participants
    - **d.** the metric used to measure speech rate
    - **e.** all the above
2. The present study came to its conclusions about the effects of utterance length on disfluency by examining:
    - **a.** mean length of utterance
    - **b.** number of clausal constituents
    - **c.** a comparison of MLU in a part of the sample with MLU in the entire speech sample
    - **d.** both a and c

   - **e.** all of the above

3. In regard to the relationship between speech rate and disfluency, this study suggests that:
   - **a.** children who stutter slow their rate to compensate for their disfluent speech
   - **b.** children who stutter slow their rate to process longer utterance lengths
   - **c.** a fast speaking rate contributes to speech disfluency in children who stutter
   - **d.** the relationship between speech rate and disfluency remains unclear
   - **e.** both a and b
4. Which statement best summarizes the relations this study found among length, rate, and complexity on disfluent speech:
   - **a.** there appeared to be a combined influence of length and complexity on stuttering
   - **b.** in the more disfluent section, utterances were more complex and spoken at slower rates
   - **c.** in the more disfluent section, utterances tended to be longer and spoken at slower rates
   - **d.** speech rate, rather than length or grammatical complexity, had the largest influence
   - **e.** grammatical complexity appeared to be a significant factor in the more disfluent section
5. The findings from this study indicate that toward the end of a long speech sample, the factor that appeared to have the biggest influence on children’s stuttering-like disfluency was:
   - **a.** a faster speech rate
   - **b.** a longer length of utterance
   - **c.** a larger number of clausal constituents
   - **d.** a slower speech rate
   - **e.** both b and c were equally influential

## ANSWERS

1. e
2. d
3. d
4. c
5. b

## Biographies

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Nicoline G. Ambrose, Ph.D., CCC-SLP, is an associate professor in Speech and Hearing Science at the University of Illinois at Urbana-Champaign. She has contributed extensively to the research literature on stuttering, and has been the PI of several large NIH/NIDCD grants devoted to early childhood stuttering.

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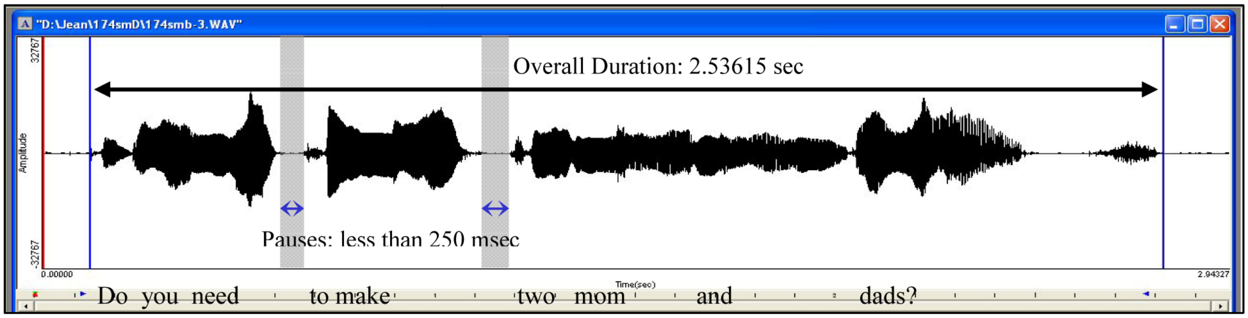

**Figure 1.**
An example of measuring articulation rate in a 9-syllable utterance. The shaded regions indicate pauses, all of which are less than 250 milliseconds.

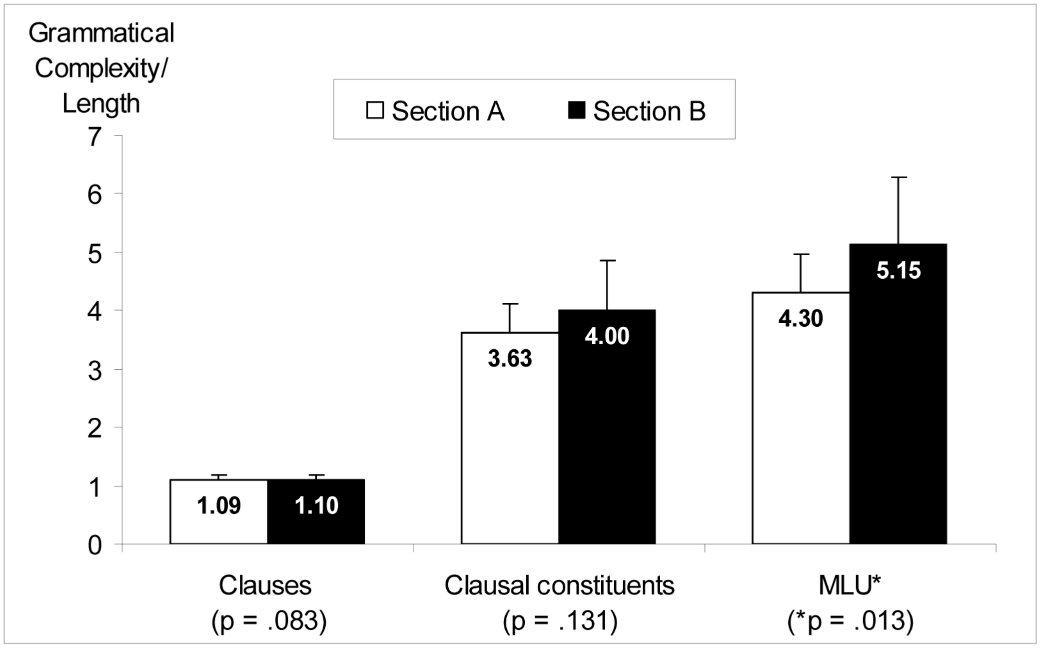

**Figure 2.**

A Comparison of mean number of clauses per utterance, clausal constituents per utterance, and mean length of utterance (MLU, measured in morphemes) in Sections A and B. The asterisk indicates a significant difference (repeated measures analysis of variance, $p < .05$). Vertical lines represent standard deviations.

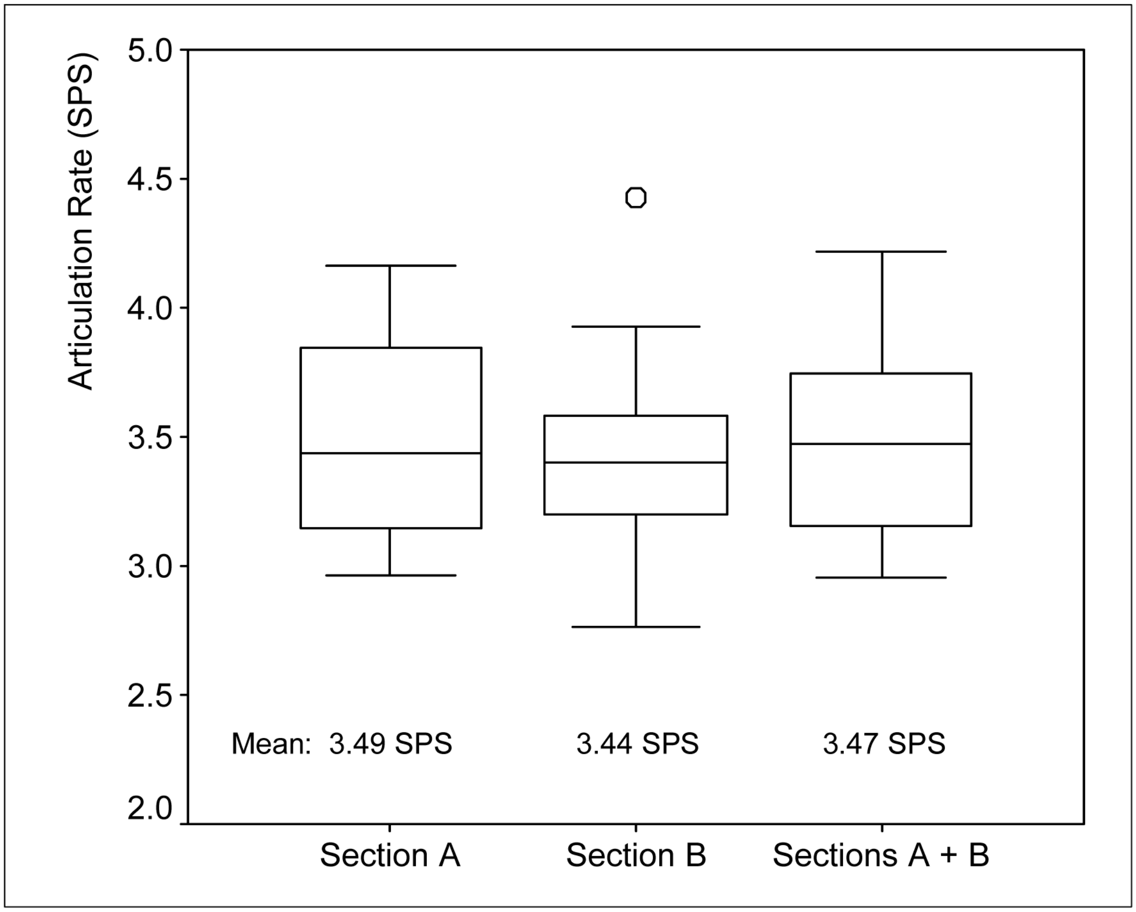

**Figure 3.**
Mean articulation rate, measured in syllables per second, in Sections A and B and overall mean.

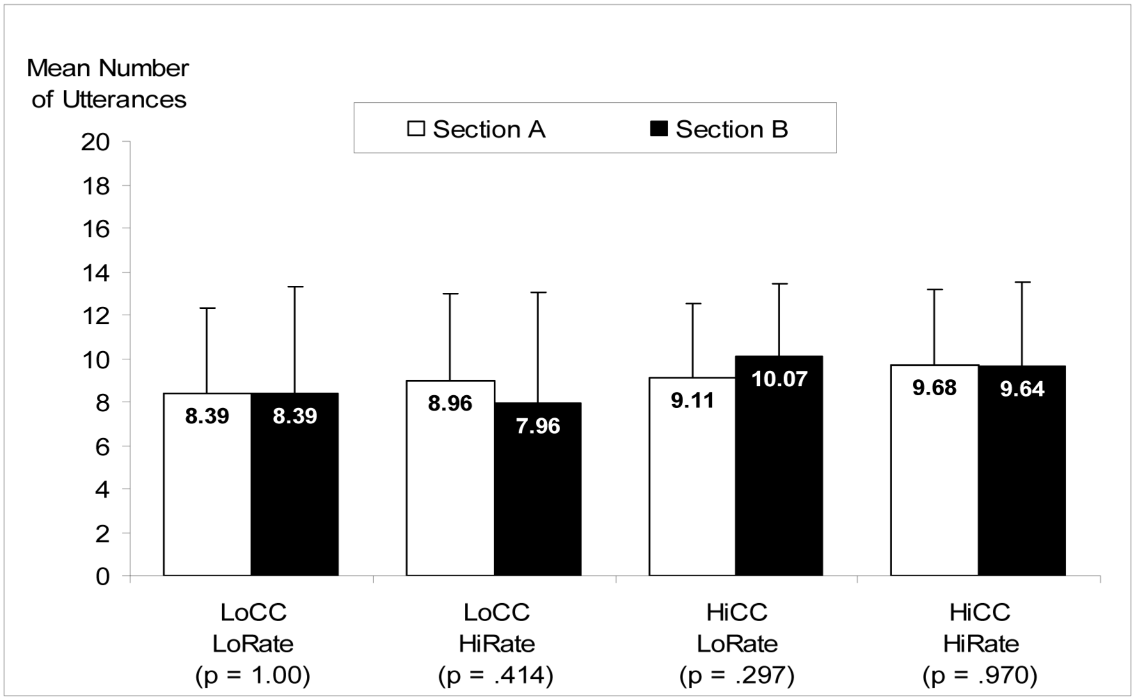

**Figure 4.**

Mean number of utterances (with SD denoted by vertical lines) which were found to be low (Lo) or high (Hi) in grammatical complexity, measured by the number of clausal constituents (CC) or articulation rate (Rate), in Sections A and B, with *p* values for paired sample *t-tests* included.

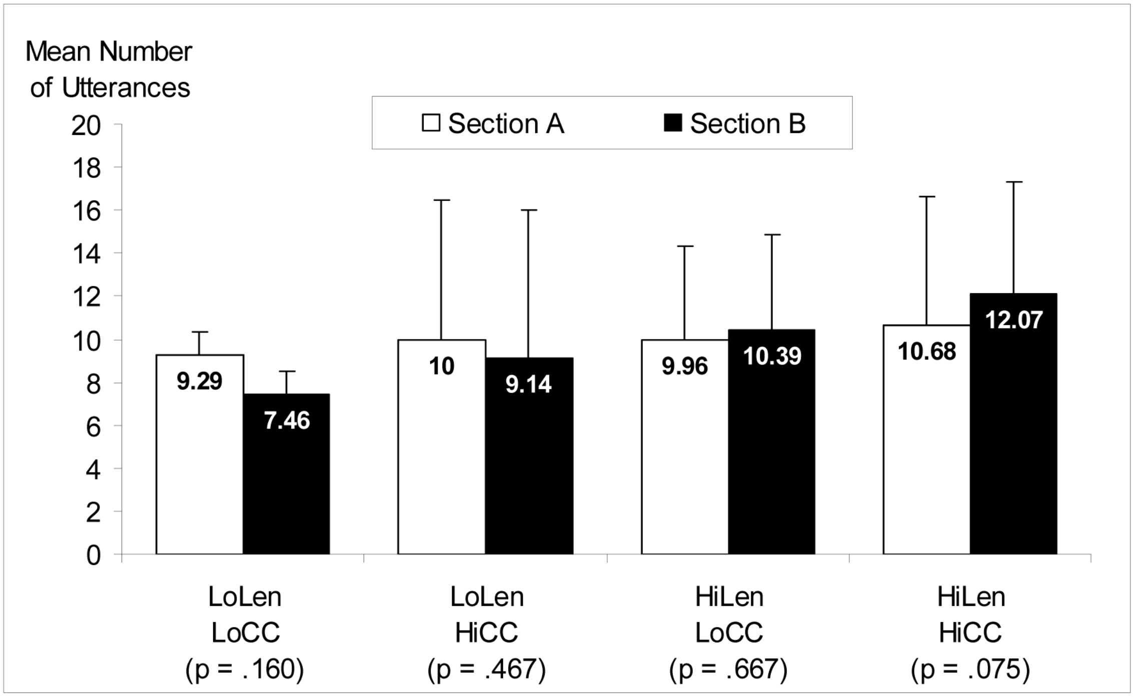

**Figure 5.**

Mean number of utterances (with SD denoted by vertical lines) which were found to be low (Lo) or high (Hi) in grammatical complexity, measured by the number of clausal constituents (CC) or utterance length (Len), in Sections A and B, with *p* values for paired sample *t-tests* included.

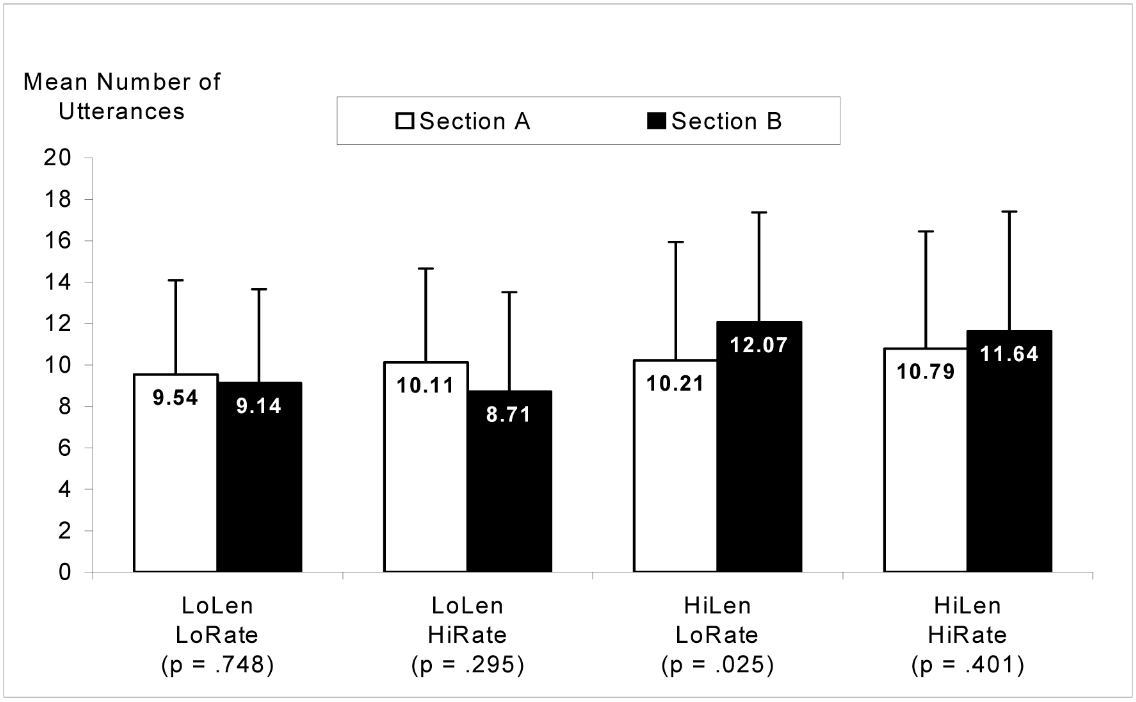

**Figure 6.**
Mean number of utterances (with SD denoted by vertical lines) which were found to be low (Lo) or high (Hi) in articulation rate (Rate) or utterance length (Len), in Sections A and B, with *p* values for paired sample *t-tests* included.

## Table 1

Individual Age, Expected MLU (SD), MLU for 1200 Syllables, and MLU for Sections A and B, Including Means and Standard Deviations, with Items in Bold Indicating Where MLU for the Section Exceeded MLU for the 1200-Syllable Speech Sample

| Participant | Age (in months) | Expected MLU (SD*) | MLU for 1200 syllables | MLU A | MLU B |
|---|---|---|---|---|---|
| 1 | 40 | 3.47 (0.756) | 5.39 | 4.55 | **5.63** |
| 2 | 33 | 2.85 (0.633) | 3.69 | 3.52 | **3.82** |
| 3 | 41 | 3.78 (0.817) | 3.57 | 3.30 | **4.22** |
| 4 | 40 | 3.47 (0.756) | 5.47 | 5.49 | **5.65** |
| 5 | 54 | 5.02 (1.064) | 4.02 | **4.43** | 3.82 |
| 6 | 33 | 2.85 (0.633) | 4.82 | 4.34 | **5.52** |
| 7 | 36 | 3.16 (0.694) | 4.70 | 3.51 | **5.05** |
| 8 | 36 | 3.16 (0.694) | 4.93 | 4.41 | **5.58** |
| 9 | 34 | 2.85 (0.633) | 3.93 | 3.80 | **4.03** |
| 10 | 51 | 4.71 (1.002) | 5.74 | 4.44 | **7.67** |
| 11 | 41 | 3.78 (0.817) | 4.26 | 3.82 | **4.53** |
| 12 | 37 | 3.16 (0.694) | 6.05 | 4.35 | **6.95** |
| 13 | 48 | 4.4 (0.94) | 5.51 | 5.40 | 5.10 |
| 14 | 49 | 4.4 (0.94) | 4.80 | 4.80 | 4.43 |
| M | 40.93 | 3.65 | 4.78 | 4.30 | 5.14 |
| SD | 6.94 | 0.73 | 0.79 | 0.66 | 1.14 |

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[*] Values are from Miller, J. F. (1981).

## Appendix

Previous studies which investigated speech rate of children who stutter (CWS) and/or children who do not stutter (CWNS)

| Authors | Participants | Age Range | Stuttering Severity | Measurements | Analysis* | Disfluencies | Results |
|---|---|---|---|---|---|---|---|
| Kowal, O'Connell, & Sabin (1975) | 168 CWNS<br>- Seven age groups | (Mean) 5:10,8:0, 9:11,11:11, 14:1,16:2 18:1 | N/A | Audio signal (Bruel and Kjaer audio frequency spectrometer & level recorder) | SPS | Included unfilled pauses (more than 270 msec) and filled pauses (i.e., uh, ah, um) | Kindergarten: 2.15 SPS<br>Grade 2: 2.86 SPS<br>Grade 4: 3.24 SPS<br>Grade 6: 3.26 SPS<br>Grade 8: 3.83 SPS<br>Sophomores: 4.00 SPS<br>Seniors: 3.84 SPS |
| Meyers & Freeman (1985) | 12 CWS<br>12 CWNS | 4:0 – 5:11 | 5 moderate<br>7 severe | Video time-code | SPS | Disfluent utterances excluded | CWS: 3.51 SPS<br>Severe: 3.29 SPS<br>Moderate:3 84 SPS<br>CWNS: 4.04 SPS |
| Stephenson-Opsal & Bernstein Ratner (1988) | 2 CWS (p1 & p2) | 3:3 (p1)<br>6:2 (p2) | Severe (p1)<br>Moderate (p2) | Audio signal (Bruel and Kjaer graphic level recorder) | SPS | Excluded | Specific articulation rates were not reported |
| Pindzola, Jenkins & Lokken (1989) | 30 CWNS<br>- Three age groups | 3:0 – 3:9<br>4:0 – 4:9<br>5:0 – 5:9 | N/A | Stop watch | OS & AR<br>SPM | Included in OS<br>Excluded in AR | 3 yrs:<br>140.3 SPM (OS)<br>170.8 SPM (AR)<br>4 yrs:<br>152.7 SPM (OS)<br>186.2 SPM (AR)<br>5 yrs:<br>152.2 SPM (OS)<br>180.8 SPM (AR) |
| Kelly & Conture (1992) | 13 CWS<br>13 CWNS | 3:3 – 4:8 | 5 mild<br>7 moderate<br>1 severe | Acoustic analysis (Micro Speech Lab) | OS & AR<br>WPM, SPM | Excluded | CWS:<br>164.18 WPM (OS)<br>189.72 SPM (OS)<br>174.41 WPM (AR)<br>200.21 SPM (AR)<br>CWNS:<br>153.63 WPM (OS)<br>177.54 SPM (OS)<br>157.33 WPM (AR)<br>180.74 SPM (AR) |
| Ryan (1992) | 20 CWS<br>20 CWNS | 2:10 – 5:9 | No explanation | Stop watch | SPM | No explanation WPM | CWS:<br>174.6 SPM, 131.1 WPM<br>CWNS:<br>167.2 SPM, 131.7 WPM<br>3yrs:<br>Spontaneous:<br>3.82 SPS, 8.42 PPS<br>Imitated: |

| Authors | Participants | Age Range | Stuttering Severity | Measurements | Analysis* | Disfluencies | Results |
|---|---|---|---|---|---|---|---|
| Walker, Archibald, Cherniak, & Fish (1992) | 40 CWNS | 2:11 – 3:2 | N/A | Acoustic analysis | AR | | 3.58 SPS, 7.09 PPS<br>Overall:<br>3.70 SPS, 7.92 PPS |
| | - Two age groups | 4:11 – 5:2 | | (MacSpeech) | SPS, PPS | No explanation | 5yrs:<br>Spontaneous:<br>4.28 SPS, 9.47 PPS<br>Imitated:<br>3.94 SPS, 8.54 PPS<br>Overall:<br>4.11 SPS, 9.00 PPS |
| Kelly (1994) | 11CWS<br>11CWNS | 2:7 – 10:1 | 4 mild<br>5 moderate<br>2 severe | Acoustic analysis (Micro Speech Lab) | OS & AR<br>SPM | Excluded | CWS:<br>191.2 SPM (OS)<br>197.2 SPM (AR)<br>CWNS:<br>194.7 SPM (OS)<br>195.3 SPM (AR) |
| Logan & Conture (1995) | 15 CWS | 3:0 – 5:6 | 5 mild<br>10 moderate | Video time-code | AR<br>SPM | Excluded | Fluent utterances:<br>230.46 SPM<br>Stuttered utterances:<br>222.32 SPM |
| Yaruss & Conture (1995) | 10 CWS<br>10 CWNS | 4:0 – 5:10 | 4 mild<br>6 moderate | Frame-by-frame (33ms per frame) | AR<br>SPS | Disfluent utterances excluded | CWS: 3.40 SPS (overall)<br>Mild: 4.03 SPS<br>Moderate: 2.93 SPS<br>CWNS: 3.56 SPS |
| Yaruss & Conture (1996) | 18 CWS<br>- Normal (NP) / disordered (DP) phonological development | 3:9 – 6:10 | 4 very mild<br>10 mild<br>4 moderate | Frame-by-frame (33.33ms per frame) | AR<br>SPS | Excluded | CWS+NP: 3.82 SPS<br>CWS+DP: 3.65 SPS |
| Yaruss (1997) | 12 CWS | 3:4 – 5:6 | 3 very mild<br>6 mild<br>3 moderate | Frame-by-frame (33.33ms per frame) | AR<br>SPS | Excluded | 3.69 SPS |
| Howell, Au-Yeung, & Pilgrim (1999) | 8 CWS | 9 – 11 yrs | 4.91 – 35.83 (Stuttering rate) | Acoustic analysis | SPS | Excluded | Specific articulation rates were not reported |
| Hall, Amir, & Yairi (1999) | 16 CWS<br>- 8 persistent<br>- 8 recovered<br>8 CWNS | 3:1 – 4:10 | No explanation | Acoustic analysis (Cspeech) | AR<br>SPS, PPS | Disfluent utterances excluded | CWS (persistent)<br>Initial: 3.84 SPS, 9.56 PPS<br>1yr: 3.94 SPS, 9.66 PPS<br>2yr: 4.12 SPS, 10.22 PPS<br>CWS (recovered)<br>Initial: 3.18 SPS, 7.68 PPS<br>1yr: 3.87 SPS, 9.78 PPS<br>2yr: 3.75 SPS, 9.38 PPS<br>CWNS<br>Initial: 3.84SPS, 11.42PPS<br>1yr: 3.94 SPS, 12.17 PPS<br>2yr: 3.92 SPS, 11.88 PPS |
| | | | | | OS | | |

| Authors | Participants | Age Range | Stuttering Severity | Measurements | Analysis* | Disfluencies | Results |
|---|---|---|---|---|---|---|---|
| Ryan (2000) | 30 CWS<br>30 CWNS | 2:10 – 5:9 | No explanation | Stop watch | (WPM,<br>SPM)<br>AR<br>(SPS) | OS: excluded<br>AR: Disfluent utterances excluded | CWS<br>170.0 WPM (OS)<br>202.6 SPM (OS)<br>4.1 SPS (AR)<br>CWNS<br>169.1 WPM (OS)<br>205.6 SPM (OS)<br>3.8 SPS (AR) |
| Chon, Ko, & Shin (2004) | 10 CWS<br>10 CWNS<br>(Korean speaking children) | 4:0 – 5:10 | 3 mild<br>5 moderate<br>2 severe | Acoustic analysis (PCQuirer 4.9.6) | OS (SPS)<br>AR (SPS) | OS: excluded<br>AR: Disfluent utterances excluded | CWS<br>Spontaneous:<br>4.84 SPS (OS)<br>5.26 SPS (AR)<br>Story telling:<br>3.36 SPS (OS)<br>4.32 SPS (AR)<br>CWNS<br>Spontaneous:<br>4.94 SPS (OS)<br>5.07 SPS (AR)<br>Story telling:<br>3.66 SPS (OS)<br>3.99 SPS (AR) |
| Walker & Archibald (2006) | 16 CWNS<br>- Three visits | 4:0 – 4:2<br>5:0 – 5:2<br>6:0 – 6:2 | N/A | Acoustic analysis<br>(MacSpeech) | AR<br>SPS, PPS | No explanation<br>(The authors did not provide the results of PPS.) | 4 yrs (first visit):<br>Spontaneous: 3.56 SPS<br>Imitated: 3.37 SPS<br>Automatic: 3.93 SPS<br>Repetition: 4.14 SPS<br>Overall: 3.75 SPS<br>5 yrs (second visit):<br>Spontaneous: 3.19 SPS<br>Imitated: 3.11 SPS<br>Automatic: 3.52 SPS<br>Repetition: 3.74 SPS<br>Overall: 3.39 SPS<br>6 yrs (third visit):<br>Spontaneous: 3.38 SPS<br>Imitated: 3.30 SPS<br>Automatic: 4.30 SPS<br>Repetition: 4.08 SPS<br>Overall: 3.76 SPS |

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[*] Overall speaking rate (OS), Articulation rate (AR), Phones per second (PPS), Syllables per second (SPS), Syllables per minute (SPM), Words per minute (WPM)