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Speaking rate characteristics of elementary-school-aged children who do and do not stutter

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ABSTRACT

Purpose: To compare articulation and speech rates of school-aged children who do and do not stutter across sentence priming, structured conversation, and narration tasks and to determine factors that predict children's speech and articulation rates.

Method: 34 children who stutter (CWS) and 34 age- and gender-matched children who do not stutter (CWNS) were divided into younger (*M* age = 6;10) and older (*M* age = 9;6) subgroups. Speech samples were elicited using the Modeled Sentences, Structured Conversation, and Narration tasks from an experimental version of the *Test of Childhood Stuttering* (Gillam, Logan, & Pearson, 2009). Speech rates (based on both fluent and disfluent utterances), articulation rates (based on only fluent utterances), disfluency frequency, and utterance length were compared across groups and tasks.

Results: CWNS had faster speech rates than CWS. Older children had faster speech rates than younger children during Modeled Sentences, and their Modeled Sentences speech rates were faster than their Structured Conversation and Narration speech rates. Disfluency frequency predicted speech rate better than age or utterance length for CWS and CWNS. Speech rate was negatively correlated with stuttering severity for CWS. Articulation rates for CWNS and CWS were not significantly different; however, older children had faster articulation rates than younger children, and articulation rates for both age groups were fastest during Modeled Sentences.

Conclusions: Results provide age-based reference data for the speech and articulation rates of school-aged CWS and CWNS on three TOCS tasks and offer insight into the relative contributions of age, disfluency frequency, and utterance length to children's rate performance.

Learning outcomes: After reading this paper readers should be able to: (1) summarize the main findings from past studies of children's speech rate and articulation rate; (2) describe how school-aged children who stutter compare to age-matched children who do not stutter with regard to speech rate and articulation rate; (3) explain the extent to which age, speaking task, disfluency frequency, and utterance length affect children's rate performance; (4) discuss the advantages and disadvantages of various approaches to rate measurement.

1. Introduction

The communicative functioning of children who stutter can be assessed in a variety of ways. Quantitative measures of stuttering behavior (e.g., percent of syllables stuttered) and speech disfluency (e.g., number of speech disfluencies per 100 syllables) are the most familiar metrics of communicative functioning for this population; however, several alternative

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measures are noted in the fluency disorders literature (see, for example, ASHA, 1995; Bloodstein & Bernstein Ratner, 2008; Costello & Ingham, 1984; Davidow, Bothe, & Bramlett, 2006; Yairi & Ambrose, 2005). One such alternative measure is speaking rate. To date, much of the speaking rate research involves analyses of either conversation or narration with typically developing preschoolers. Consequently, relatively little is known about the speaking rate characteristics of school-aged children, how school-aged children's rate varies across speaking tasks, and how the rates of school-aged children who do and do not stutter compare. The present study examines these issues.

1.1. Rate assessment

In a broad sense, speaking rate measures are indices of communicative productivity. The most common approach to rate assessment is to determine the number of syllables or words that a speaker expresses per unit of time. Such measures are thought to capture multiple facets of speech production, including a speaker's ability to formulate intentions, translate intentions into linguistic codes, and then plan and execute the articulatory movements that correspond to the linguistic codes (Levelt, 1989).

Researchers have taken two general approaches to assessing speaking rate: articulation rate and speech rate. Articulation rate (referred to by some as "articulatory rate" or "articulatory speaking rate") measures the amount of speech produced per unit of time during fluent samples of speech (Amster & Starkweather, 1987; Bonnelli, Dixon, Bernstein Ratner, & Onslow, 2000; Hall, Amir, & Yairi, 1999). In contrast, speech rate (referred to by some as "overall speaking rate") measures the amount of speech produced per unit of time during all types of speech, including speech samples that contain disfluency (Kelly & Conture, 1992; Pindzola, Jenkins, & Lokken, 1989; Sturm & Seery, 2007). Speech rate is potentially useful in the assessment of communicatively disordered populations because it yields information about both the number and duration of disfluencies that a speaker produces (Bloodstein & Bernstein Ratner, 2008) as well as the amount of time it takes a speaker to convey a particular intention.

1.2. Articulation rate in typical children

Selected methodological characteristics and results from studies of age effects upon articulation rate are presented in Table 1. As noted above, most studies of articulation rate have featured typically developing 3- to 6-year-old children. Estimates of articulation rates for these children range from 2.9 to 4.2 syllables per second, with some researchers (i.e., Pindzola et al., 1989; Walker & Archibald, 2006) reporting mean articulation rates that lie in the lower end of this range, and others (i.e., Walker, Archibald, Cherniak, & Fish, 1992) reporting rates that lie in the upper end of this range. Researchers have used at least three approaches to defining fluent speech when assessing articulation rate. The most common method is to analyze whole utterances that contain no discernable disfluency (e.g., Kelly & Conture, 1992; Pindzola et al., 1989). Others (e.g., Miller, Grosjean, & Lomanto, 1984; Walker & Archibald, 2006), however, have analyzed fluent "runs," which are stretches of speech that span some minimum number of syllables and contain no disfluency. Still others (e.g., Bonnelli et al.,

Table 1
Methodological characteristics and selected results from studies examining the effect of age upon speaking rate.

Study	SG	Task	Sample	Tool	Mean rate by age									
					3	4	5	6	7	8	9	10	11	12
Articulation rate														
Pindzola et al. (1989)	NS	M	Unclear	SW	2.9	3.1	3.0	–	–	–	–	–	–	–
Hall et al. (1999)[c]	NS	C	~50 utt	DI	3.9	3.9	3.9	–	–	–	–	–	–	–
	RS	C	~50 utt	DI	3.2	3.9	3.8	–	–	–	–	–	–	–
	PS	C	~50 utt	DI	3.9	3.9	4.1	–	–	–	–	–	–	–
Walker et al. (1992)[a,b]	NS	N	10 runs	DI	3.8	–	4.3	–	–	–	–	–	–	–
Walker & Archibald (2006)[a,b,c]	NS	N	10 runs	DI	–	3.6	3.2	3.4	–	–	–	–	–	–
Sturm & Seery (2007)	NS	C	6 utt	SW	–	–	–	–	4.5	–	5.6	–	5.5	–
		N	6 utt	SW	–	–	–	–	4.5	–	5.3	–	5.3	–
Speech rate														
Pindzola et al. (1989)	NS	M	Unclear	SW	2.3	2.6	2.5	–	–	–	–	–	–	–
Kowal et al. (1975)	NS	N	~90 syl	DI	–	–	–	2.2	–	2.9	–	3.2	–	3.3
Sturm & Seery (2007)	NS	C	300 wd	SW	–	–	–	–	2.4	–	2.7	–	2.7	–
		N	300 wd	SW	–	–	–	–	2.4	–	2.7	–	2.9	–

Note. Rates are reported in syllables per second, ages are reported in years. All studies used a cross sectional design, except where noted. SG = Speaker Group, NS = Children who do not stutter, RS = Children who recovered from stuttering; PS = Children with persistent stuttering; C = conversation, N = narration; M = data from multiple speaking tasks were combined and then analyzed; Utt = utterances; Syl = syllables, Wd = words; SW = Measurements made using a stopwatch; DI = Measurements made using digitally imaged speech signals (e.g., amplitude waveform, spectrogram).
[a]This study included additional tasks.
[b] This study included age groups beyond age 12.
[c] This study featured a repeated measures design.

2000) have analyzed what might be termed ‘‘residual fluency;’’ that is, the speech that remains in an utterance after all disfluent segments have been removed. The impact of these methodological variations upon reported rate results is unknown. Flipsen, Jr. (2002) constructed 95% confidence intervals for articulation rate data from several of the articulation rate studies shown in Table 1 and noted that, when data are viewed in this way, findings are generally consistent across studies.

Sturm and Seery (2007) examined articulation rates for conversation and narration tasks in 7-, 9-, and 11-year-old typically developing children and found that the mean rate for 7-year-old children was significantly slower than that for both 9-year-old and 11-year-old children. When data from Sturm and Seery's study are compared to data from studies of preschoolers' speech (e.g., Hall et al., 1999; Walker et al., 1992), it appears that articulation rate gradually increases as children progress from the preschool years through the upper elementary-school years.

Most researchers have examined age effects upon articulation rate using relatively narrow time intervals (e.g., year to year). This approach has yielded mixed findings, with some (e.g., Pindzola et al., 1989) reporting no effect of age on articulation rate with each passing year, others (e.g., Walker et al., 1992) showing significant increases in articulation rate from year to year, and still others (e.g., Sturm & Seery, 2007; Walker & Archibald, 2004) reporting significant differences in articulation rate between some age intervals, but not others. Precise comparisons among these studies are difficult, given differences in how fluent speech was defined and which tasks were used. Overall, however, the findings suggest that maturational changes in children's articulation rate typically occur on a somewhat protracted time scale.

1.3. Speech rate in typical children

Also presented in Table 1 are results and methodological characteristics from studies of age effects upon speech rate with typical children. Overall, the reported speech rate values across studies are consistent, with speech rates for 3- to 7-year olds averaging 2.6 syllables per second or less, and speech rates for 8- to 12-year olds averaging between 2.7 and 3.3 syllables per second. Kowal, O'Connell, and Sabin (1975) reported significant increases in speech rate between ages 6 years and 8 years, and again between ages 8 years and 10 years for typical children performing a narration task. Similarly, Sturm and Seery (2007) found significant speech rate increases between ages 7 years and 11 years, with age accounting for about 40% of the variance in children's speech rate scores.

Speech rates for a given speech sample will almost always be slower than the corresponding articulation rates (see Table 1). This is because disfluencies are included in the determination of speaking time, but not in the determination of utterance length. For example, in the utterance ‘‘He- He- He is going home’’ the word ‘‘he’’ is counted once when tallying the number of words per utterance; however, utterance timing begins with the onset of the first ‘‘he’’ and ends after the word ‘‘home.’’ In Pindzola et al.'s (1989) study of typical preschool children, differences between speech rate and articulation rate were relatively modest (about 0.5 syllables per second); however, in Sturm and Seery's (2007) study of school-aged children, differences between the two rate measures at specific age intervals were as much as 3 syllables per second.

1.4. Speaking rate and stuttering

Numerous researchers have examined speaking rate in speakers who stutter. Johnson (1961) found that the speech rates during an oral reading task for adults who stutter were 30–50% slower than those for a comparison group of nonstuttering adults. Others (e.g., Andrews & Cutler, 1974; Minifie & Cooker, 1964; Prins & Lohr, 1972; Sander, 1961) have reported moderate to strong correlations between speech rate and stuttering severity measures. In some studies (e.g., Prosek, Walden, Montgomery, & Schwartz, 1979; Young, 1961), speech rate has been more strongly associated than disfluency frequency with clinicians' ratings of stuttering severity. Based on this, Bloodstein and Bernstein Ratner (2008, p. 8) concluded that speech rate measures reflect ‘‘. . .an aspect of severity that (other measures) do not adequately take into account.’’

Meyers and Freeman (1985) found that conversational articulation rates for children who stutter were significantly slower than those for children who do not stutter. However, other researchers have reported no differences in articulation rates between the groups (e.g., Kelly, 1994; Kelly & Conture, 1992). The reasons for the conflicting findings are unclear. Meyers and Freeman restricted their analysis to utterances that were considerably longer than those in other studies. Thus, it could be that speaking rate differences between children who do and do not stutter are most apparent in speech production contexts that are relatively demanding. Kelly (1994) proposed that the inconsistencies may stem from differences across studies in participants' stuttering severity. That is, studies that enroll mostly moderate to severely impaired speakers (e.g., Meyers & Freeman, 1985) are more likely to find rate differences than studies that do not.

1.5. Purpose and rationale

The primary purpose of the present study was to add to the clinical database on the articulation and speech rate characteristics of school-aged children. As noted, relatively few studies have examined speaking rate patterns during the elementary school years and even fewer studies have examined how the speaking rate patterns of elementary-aged children who stutter compare to those of children with typical fluency. A secondary purpose of the study was to explore the relative contributions of age, disfluency frequency, and utterance length to articulation and speech rates. Previous studies have focused primarily upon age, which, as noted in Sections 1.2 and 1.3, accounts for less than half of the variance in children's articulation and speech rates.

In the present study, these issues were addressed using three tasks from an experimental version of the *Test of Childhood Stuttering* (TOCS; Gillam, Logan, & Pearson, 2009), a norm-referenced assessment tool for use with children aged 4–12 years. In addition to providing norm-referenced measures of speech fluency, the TOCS features several informal fluency-related assessments, one of which pertains to rate. One limitation with existing reference data for speaking rate is that it is based on an assortment of experimenter-designed tasks, many of which would be difficult for others to replicate precisely. Use of tasks associated with a published assessment tool like the *TOCS* offers clinicians a means of assessing rate in a standardized manner, as it affords greater control over potentially confounding variables such as speaking topic, topic familiarity, elicitation stimuli, and the speaking partner's language usage.

The primary questions to be addressed were as follows: (1) Do children who stutter differ from children who do not stutter in articulation rate or speech rate? (2) Does age affect the articulation rates and speech rates of elementary-school children? (3) Do the articulation rates and speech rates of elementary school-aged children differ across speaking tasks? (4) To what extent are a child's age, disfluency frequency, and utterance length predictive of his or her speaking rate?

2. Method

2.1. Participants

Participants were 34 children who stutter (CWS) and 34 gender- and age-matched children who do not stutter (CWNS). The two fluency groups were evenly divided into "younger" and "older" subgroups ($n = 17$). Both younger subgroups consisted of 14 boys and 3 girls, and both older subgroups consisted of 16 boys and 1 girl. Participants in the two younger subgroups (*M* age = 6;10) ranged in age from 5;6 to 7;7, and participants in the two older subgroups (*M* age = 9;6) ranged in age from 8;0 to 10;7. The average age of all CWS was 8;2 (*SD* = 1;6) and the average age of all CWNS was also 8;2 (*SD* = 1;7). The subgroups were based on multi-year age ranges because past research has failed to consistently detect age effects using narrower intervals (e.g., one year).

Participants in the CWS group were randomly selected from a larger pool of children who had been recruited from throughout the United States to complete an experimental version of the *Test of Childhood Stuttering* (TOCS; Gillam et al., 2009). The CWS were enrolled in elementary schools at the time of data collection and had met local school district criteria for the diagnosis of stuttering. The initial diagnoses of stuttering were unanimously reconfirmed by the authors in the present study, based on their assessments of the children's performances on the TOCS tasks. Stuttering severity ratings were made by the first two authors for each CWS using a 9-point rating scale (1 = no stuttering, 9 = extremely severe stuttering) similar to that described by O'Brian, Packman, Onslow, and O'Brian (2004). Overall, 16 children were rated as stuttering mildly, 11 were rated as stuttering moderately, and 7 were rated as stuttering severely. In the young CWS subgroup, severity ratings were as follows: 10 mild participants, 4 moderate participants, and 3 severe participants. In the older CWS subgroup, severity ratings were as follows: 6 mild participants, 7 moderate participants, and 4 severe participants.

Each CWS was matched with a non-stuttering child of the same gender and similar age (± 2 months). All of the participants spoke English with native competence, had excellent speech intelligibility and were enrolled in mainstream educational settings. In the CWNS group, one child met school-district criteria for articulation impairment and another child met criteria for language impairment. Among the CWS, stuttering was the only identified communication disorder for 23 of the 34 (68%) participants. Among the remaining children, 2 (6% of the total) were identified as also having an articulation impairment, 6 (18% of the total) were identified as also having a language impairment, and 3 (12% of the total) were identified as also having both articulation impairment and language impairment. None of the participants in either group, however, were diagnosed as having intellectual disability or other concomitant neuro-developmental conditions such as autism that may have affected their speaking rate.

Basic details about therapy history were provided via questionnaire response by the examiners. Responses were available for only 23 of the 34 CWS. Of the 23 children, 6 (26% of total) had never received therapy, 2 (9% of total) had attended between 0 and 10 therapy sessions, 4 (17%) had attended between 11 and 15 therapy sessions, and 11 (48%) had attended 20 or more therapy sessions. With regard to reported treatment effects for the 15 children who had attended more than 10 sessions, 5 (33%) had shown either no improvement or slight improvement, 6 had shown moderate improvement (40%), and 4 (27%) had shown large improvement.

Although it could be argued that rate-based analyses should be completed with participants who present only stuttering and have never attended therapy, the authors decided that it was preferable for external validity to use a broad-based sampling approach that captured the range of children who actually receive services in school settings. Indeed, the percentage of children in the present study who presented concomitant articulation or language impairments along with stuttering ($\sim$33%) was consistent with findings from a national survey on the caseload characteristics of school-based speech-language pathologists (i.e., Arndt & Healey, 2001). About 75% of the CWS had some experience with speech therapy. Again, this percentage seemed roughly consistent with what one might expect for American school children in this age range. Further, previous research (e.g., Wolk, Edwards, & Conture, 1993) has not supported the idea that stuttering severity of children who exhibit only stuttering differs significantly from that of children who stutter and have concomitant speech-language impairments.

2.2. Data collection

During speech sample elicitation, the examiner and the child were seated at a table in a quiet room with an analog or digital audio recorder placed near the child. All analog recordings were subsequently digitized by a research assistant (see below). Speech samples were elicited using experimental versions of three of the TOCS' speech elicitation tasks: Modeled Sentences, Structured Conversation, and Narration. Each task featured standard instructions and item prompts, which the examiner read aloud to the child prior to commencing the task (see Sections 2.2.1 and 2.2.2 for more details).

2.2.1. Modeled Sentences task

The Modeled Sentences task was similar to a sentence priming task described by Gordon and Luper (1989) and Gordon, Luper, and Peterson (1986). Participants were shown a series of picture cards, each of which featured a pair of pictures. The pictures portrayed familiar activities of daily living. The events illustrated in each of the paired pictures were similar, but differed by one critical feature. As the examiner presented a picture card to the child, the examiner read aloud a sentence that described the picture on the left half of the picture card (e.g., *Two kids are making a snowman*). The child then was asked to create a sentence, similar in form to the examiner's model, that described the picture on the right half of the picture card (e.g., *Three kids are making a snowman.*). To facilitate understanding of the task, each child completed two practice items prior to attempting the target sentences.

Most target sentences featured 6–9 words. Syntactic forms of the target responses included simple declarative statements, yes/no questions, negatives, prepositional phrases, embedded subordinate clauses, and passives. If a child did not respond to a particular item or produced a sentence that did not include the desired syntactic form, the examiner presented the model sentence again and encouraged the child to produce a sentence that was closer in form to the examiner's model.

2.2.2. Structured Conversation task

During the Structured Conversation task, participants were shown eight, 8.5″ × 11″ picture cards that depicted the story of an encounter between three children and two alien creatures. Picture cards were presented individually along with a prompt (e.g., "Are there any clues in the picture about what the children might do after they play soccer?"). If a child responded with "I don't know" or something similar, the examiner prompted him or her to produce a more elaborate response (e.g., "What do you think might happen?"). If these prompts were successful at eliciting a more elaborate response, then the child's initial response was not analyzed (see below).

2.2.3. Narration task

For the Narration task, children were presented with 4″ × 6″ versions of the eight full-paged illustrations that were used in the Structured Conversation task. The examiner arranged the eight smaller pictures in sequential order in front of the child, pointed to the first illustration, and said, "Now, I'd like you to tell me the whole story all by yourself. We'll start with the first card. Tell me the best story you can. You can use the questions I asked you before (i.e., from the Structured Conversation task) as guides." The children then proceeded to construct a narrative about the picture.

2.3. Data analysis

2.3.1. Response transcription

Participants' responses to each of the items across the three tasks were transcribed into a computer database using the transcript conventions from *Systematic Analysis of Language Transcripts* (SALT; Miller, Iglesias, & Nockerts, 2006). Responses to the Modeled Sentences task and the Narration task were entered as a series of individual sentences. For the Modeled Sentences task, a total of 29 items were presented to each participant; however, only responses to the 19 items that were ultimately used on the final version of the TOCS were analyzed for the present study. The experimental version of the TOCS' Structured Conversation task consisted of 40 items; however, speech samples for the present study were based upon a subset of 19 items, all of which were included in the final version of the TOCS. (The 19 verbal requests used in the present study for the Structured Conversation analysis are listed in Appendix A.) Responses to items on the Structured Conversation task sometimes began with an elliptical utterance (e.g., "Over there.") which was then followed by one or more complete sentences. In such cases, the first complete sentence within the response was selected for analysis. If a participant responded with only an elliptical utterance, then that utterance was selected for analysis.

Transcription was primarily orthographic; however, notes about the phonetic form of particular words were included when a child's word production contained a different number of syllables than the customary form of the word or when the number of syllables in a word might vary depending upon whether a casual or formal form was used. Participants sometimes prefaced their responses with off-target or tangential remarks (e.g., *Hmmm. . .what's happening here?*). Such remarks were separated from the children's primary responses and were not analyzed.

Transcripts were developed in a three-stage process. One transcriber developed an initial gloss of the child's responses. The initial gloss was then rechecked in its entirety by a second transcriber and revised as necessary to correct errors and omissions. Transcription was then rechecked for a third time by one of the authors and again revised as necessary to correct errors and omissions. Word, syllable, and disfluency counts (see below) were based upon the final transcript.

Disfluent speech was included in the transcription, but was separated from words that constituted the core content of the speaker's message (e.g., "The [um] alien is [go- go-]going back in the [sssss]sky."). Disfluent segments included interjections (e.g., "um"), revised speech (e.g., "[He-]She went. . ."), repeated sounds, syllables, and words (e.g., "[H-]He is [go-]going [in]in the spaceship."), and prolonged speech sounds (e.g., "[www]when the ship left. . ."). Following conventions described in previous research (Robb, Maclagan, & Chen, 2004; Walker et al., 1992), silent pauses lasting longer than 250 ms were also noted within the transcription, and considered to be instances of disfluency. Some disfluent segments featured more than one type of disfluency (e.g., "[um th-]the girl wasn't afraid [pause um t-]to argue. . ."), and some words featured more than one disfluent segment (e.g., ". . .and was [s-]su[sp-]spended in the air. . ."). Sentences featuring at least one disfluent segment were labeled as "disfluent." Sentences that featured no disfluent segments (i.e., no repeated, prolonged, or revised speech, no interjections, and no pause longer than 250 ms) were labeled as "fluent."

2.3.2. Syllable, word, and disfluency counts

Disfluency counts were made by tallying the number of bracketed disfluent segments within a sentence. Consistent with previous research (e.g., Hall et al., 1999), syllable and word counts were based upon speech associated with the speaker's core message (e.g., the sentence "*[The-]The boys are going in [the] the house*" was scored as having 7 words and 8 syllables). A syllable was defined as a peak of sonority within a word and was evidenced by the presence of a vowel (monophthong, diphthong) or syllabic consonant. Word boundaries were identified using conventions described by Miller et al. (2006). Syllable and word counts were used to compute summary statistics for rate (i.e., syllables per second; words per second).

2.3.3. Temporal measurements

Spectrographic images of the children's responses were generated from the digital audio files using speech analysis software (*Wavesurfer* version 1.8.3; Sjölander & Beskow, 2006). Sentence duration was measured by locating the onset of a response and then dragging the cursor through the spectrographic image until the end (offset) of the response was reached. This process yielded the elapsed time per response in seconds, which was rounded to three decimal places and entered into a database. Audio play back was used in conjunction with visual inspection of the spectrogram to ensure that the identified section of the participant's spectrogram corresponded to the transcribed response that was targeted for analysis.

Procedures used to identify response onset were identical to those used by Flipsen, Jr. (2002): the onset of F1 energy was considered to be the onset of any response that began with a vowel or a resonant consonant; the onset of broadband noise was considered to be the onset of any response that began with a fricative; and the onset of burst release was considered to be the onset of any response that began with a stop or affricate consonant. The offset of a response was defined as the point at which one of the following occurred: cessation of F1 energy (responses ending with a vowel or resonant consonant), cessation of broadband noise (responses ending with a fricative or affricate consonant), or the onset of a stop gap associated with articulatory occlusion (responses ending with a stop consonant).

2.3.4. Rate computation

Syllable counts, word counts, and temporal measurements were made on a sentence-by-sentence basis and then summed across sentences to yield the total number, per participant, of syllables and words produced within a task as well as the total time spent talking across all measured sentences for the task. To compute speech rate for a particular task, a participant's syllable (or word) counts across all sentences within the task were summed and divided by the sum of the time he or she spent talking across those sentences to yield the number of syllables (or words) spoken per second. Articulation rate for a particular task was derived by summing the total number of syllables (or words) a participant produced across all fluent sentences within a particular speaking task (e.g., Modeled Sentences), and then dividing the sum by the total time spent talking during those sentences.

2.4. Measurement reliability

Reliability for rate-related measures was done by re-assessing Modeled Sentences and Narration data from 4 randomly selected children who stutter and 4 randomly selected children with typical fluency (i.e., 12% of the total participants). Participants' responses to the speech elicitation tasks were re-transcribed and disfluent speech was marked. The number of disfluent segments and the number of syllables within the ultimate sentence form were re-counted, and the total elapsed time taken to say the sentence was re-measured.

2.4.1. Intra-judge reliability

Overall mean difference scores for rate-related measures were as follows: 0.01 syllables per utterance (SEM = 0.02); 0.03 s per utterance (SEM = 0.03); 0.02 syllables per second (SEM = 0.04); and 0.04 disfluencies per utterance (SEM = 0.02). These results suggest that intra-judge syllable counts, sentence timings, speaking rate values, and disfluency counts were performed with a satisfactory level of precision.

2.4.2. Inter-judge reliability

Overall mean difference scores for rate-related measures were as follows: 0.01 syllables per utterance (SEM = 0.02); 0.04 s per utterance (SEM = 0.03); 0.03 syllables per second (SEM = 0.03); and 0.07 disfluencies per utterance (SEM = 0.4). These results suggest that inter-judge syllable counts, sentence timings, speaking rate values, and disfluency counts were performed with a satisfactory level of precision.

3. Results

3.1. Speech rate

3.1.1. Sample characteristics

All of the utterances that were elicited across the three speaking tasks (fluent and disfluent) were included in the speech rate analysis. Summary statistics for the numbers of syllables, words, and utterances are reported in Table 2. These samples formed the basis of the speech rate analyses. As indicated in Table 2, the targeted number of Modeled Sentence and Structured Conversation responses was attained for nearly all participants. Mean sample sizes were similar for CWS and CWNS, and ranged from 144 syllables during Structured Conversation for younger CWS to 233 syllables during Narration for the older CWNS.

Additional summary statistics for utterances that were elicited in each of the three tasks are presented in Table 3. As can be seen, mean disfluency frequencies for CWS were about twice as high as those for CWNS. The effects of fluency group, age, and speaking task upon children's mean response lengths (in syllables) were examined using a mixed-model ANOVA. The main effect for Fluency Group ($F(1, 64) = 0.195$, $p = .66$) was not significant; however, the main effects for Age Group ($F(1, 64) = 13.348$, $p = .001$, partial eta^2 = .173) and Speaking Task ($F(2, 128) = 17.881$, $p < .001$, partial eta^2 = .218) were significant, as was the Task $\times$ Age Group interaction ($F(2, 128) = 6.729$, $p = .002$, partial eta^2 = .095). Post hoc testing showed that younger children produced longer utterances in the Modeled Sentences ($p = .001$) and Narration ($p = .002$) contexts than in the Structured Conversation context. In contrast, older children produced longer sentences in the Narration context than in the Modeled Sentences ($p < .001$) and Structured Conversation ($p < .001$) contexts. All other utterance-length comparisons were not statistically significant.

3.1.2. Fluency and age effects

Exploratory data analysis revealed a very strong positive correlation between the syllables per second and words per second measures of speech rate ($r = .995$). Because the two rate measures were strongly correlated and nearly all previous rate-related studies have reported rate data in reference to syllable production, statistical analyses in the present study were limited to the syllables per second data. Pertinent summary statistics for these analyses are presented in figure form below to illustrate the various group differences and variable interactions. However, to enhance the clinical utility of these data and to facilitate descriptive comparisons between the present findings and findings from other studies, means and standard deviations for the syllable-based as well as the word-based measures are also included in Appendix B.

Fig. 1 depicts mean speech rates for both fluency groups, and Fig. 2 depicts mean speech rates for both age groups. As can be seen, sample means for CWS were slower than those for CWNS during all tasks and at all age levels. A three-way Repeated Measures ANOVA, with between-subjects factors of Fluency Group (CWS, CWNS) and Age Group (older, younger), and a within-subjects factor of Speaking Task (Modeled Sentences, Structured Conversation, Narration) was used to address the research questions related to speech rate. There were significant main effects for both of the between-subjects factors: Fluency Group, $F(1, 64) = 6.775$, $p = .011$, partial eta^2 = .096; and Age Group, $F(1, 64) = 5.426$, $p = .023$, partial eta^2 = .078. There was also a significant main effect for the within-subjects factor, Speaking Task, $F(2, 128) = 10.854$, $p < .001$, partial eta^2 = .145. In addition, there was a significant Speaking Task $\times$ Age Group interaction, $F(2, 128) = 4.847$, $p = .009$, partial eta^2 = .07. There were, however, no significant Speaking Task $\times$ Fluency Group or Fluency Group $\times$ Age Group interactions, suggesting that the younger and older children showed different speech rate patterns across the speaking tasks and that this difference was not mediated by their speech fluency.

A decomposition of the interaction between Speaking Task and Age Group was assessed using pair-wise comparisons. These post hoc analyses revealed a significant difference between age groups on the Modeled Sentences task with the older children demonstrating a significantly faster speech rate than younger children ($p = .001$). No such differences were noted, however, for speech rate in the Narration or the Structured Conversation tasks. Further analysis of the interaction revealed that within the younger group of children, speech rate was not significantly different between any of the three speaking tasks. However, for the older children, speech rate significantly differed between the Modeled Sentences task and both the Structured Conversation ($p < .001$) and the Narration tasks ($p < .001$). Specifically, the speech rate of older children was significantly faster in the Modeled Sentences task than it was in either of the other two speaking tasks.

3.2. Articulation rate

Articulation rate was assessed by comparing the number of syllables produced per second during fluent utterances. Sample size information for this analysis is summarized in Table 4. There were 8 CWS who did not produce any fluent utterances in at least one speaking task. Thus, these 8 children were excluded from the statistical analyses for articulation rate. Fig. 3 shows the summary statistics for participants across the three speaking tasks. As was the case with the speech rate analysis, a three-way Repeated Measures ANOVA, with between-subjects factors of Fluency Group and Age Group and a within-subjects factor of Speaking Task, was used to address the research questions related to articulation rate. The main

Table 2
Group means and standard deviations (in parentheses) for sample sizes used in speech rate analyses.

Group		Tasks								
Fluency	Age	Modeled Sentences			Structured Conversation			Narration		
		Sylls	Words	Utts	Sylls	Words	Utts	Sylls	Words	Utts
CWS	Younger	160.35 (13.47)	135.29 (11.72)	18.41 (1.33)	144.06 (20.66)	111.53 (17.19)	19.00 (0.00)	157.59 (69.29)	123.47 (53.38)	18.41 (7.35)
	Older	166.65 (4.87)	139.53 (4.08)	18.94 (0.24)	164.88 (43.88)	126.71 (31.47)	19.00 (0.00)	170.53 (68.68)	129.41 (52.76)	15.71 (5.41)
CWNS	Younger	164.18 (6.65)	138.24 (4.88)	18.82 (0.53)	150.47 (36.29)	117.35 (28.05)	19.00 (0.00)	138.94 (70.23)	109.88 (57.84)	15.35 (7.30)
	Older	166.06 (4.17)	141.24 (3.46)	19.00 (0.00)	169.94 (41.53)	132.47 (31.19)	19.00 (0.00)	233.12 (75.97)	183.29 (60.48)	22.71 (8.17)

Note: CWS = children who stutter; CWNS = children who do not stutter; Sylls = syllables, Utts = utterances.

Table 3

Group means and standard deviations (in parentheses) for disfluency frequency and mean length of utterance within sentences used for the speech rate analysis.

Group		Task								
Fluency	Age	Modeled Sentences			Structured Conversation			Narration		
		Disf freq	MLU_s	MLU_w	Disf freq	MLU_s	MLU_w	Disf freq	MLU_s	MLU_w
CWNS	Younger	8.06 (3.64)	8.73 (0.28)	7.35 (0.22)	9.57 (3.59)	7.98 (1.97)	6.22 (1.53)	8.89 (4.18)	8.93 (1.95)	7.02 (1.56)
	Older	6.70 (2.93)	8.74 (0.25)	7.43 (0.18)	8.20 (3.03)	9.16 (2.33)	7.10 (1.76)	8.36 (3.07)	10.54 (2.61)	8.23 (1.81)
	All	7.38 (3.32)	8.73 (0.26)	7.39 (0.20)	8.89 (3.34)	8.43 (2.09)	6.57 (1.59)	8.62 (3.61)	9.78 (2.39)	7.66 (1.76)
CWS	Younger	11.92 (4.04)	8.71 (0.28)	7.35 (0.28)	13.42 (4.25)	7.58 (1.09)	7.57 (1.20)	12.64 (5.19)	8.61 (1.98)	8.55 (1.97)
	Older	11.46 (7.84)	8.80 (0.22)	8.80 (0.22)	14.29 (7.81)	8.68 (2.32)	8.63 (2.24)	15.88 (8.52)	10.80 (1.65)	10.79 (1.67)
	All	11.69 (6.14)	8.75 (0.25)	7.36 (0.22)	13.85 (6.20)	8.13 (1.87)	6.27 (1.38)	14.26 (7.14)	9.70 (2.11)	7.47 (1.66)

Note: Disf freq = disfluencies per 100 syllables; MLU_s = mean length of utterance in syllables; MLU_w = mean length of utterance in words; CWNS = children who do not stutter; CWS = children who stutter.

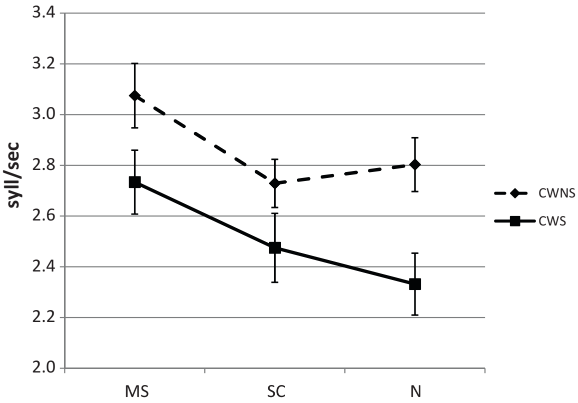

Fig. 1. Mean speech rates (±1 SE) for children who do not stutter (CWNS) and children who stutter (CWS) during the Modeled Sentences (MS), Structured Conversation (SC), and Narration (N) tasks. The speech rates for CWNS were faster than those of CWS for all three tasks.

effect for the between-subjects factor of Fluency Group was not significant ($p > .05$); however, the main effect for Age Group was significant, $F(1, 56) = 15.595$, $p < .001$, partial eta^2 = .218, indicating that older children had faster articulation rates than younger children. There was also a significant main effect for the within-subjects factor of Speaking Task, $F(2, 112) = 11.816$, $p < .001$, partial eta^2 = .174. The large effect sizes suggest that age and speaking task accounted independently for a large proportion of the variance on the articulation rate measure. None of the interactions were significant ($p > .05$). Post-hoc tests for the significant Speaking Task effect showed that children's articulation rates were faster during Modeled Sentences than during either Structured Conversation or Narration ($p < .001$).

3.3. Additional post hoc tests for speaking rates

Additional post hoc tests were performed to examine the potential effects that therapy history, presence of a concomitant communication problem, and examiner articulation rate might have had upon the participants' performance. Potential effects of therapy history were examined by comparing 8 CWS who had little to no previous speech therapy against 8 CWS who had attended 16 or more therapy sessions. The mean age difference between groups was 1.4 months and 7 of 8 pairs were matched for stuttering severity. Results of independent samples *t*-tests showed no significant difference between groups in either speech rate, [$t(14) = 0.124$; $p = .903$] or articulation rate [$t(14) = 1.119$; $p = .282$].

Potential effects of concomitant speech-language disorders were examined by comparing 11 CWS who had concomitant articulation and/or language impairment against 11 children who presented only stuttering. Participant pairs were age-matched within 4 months and 10 of 11 pairs were matched for stuttering severity. Results of independent samples *t*-tests showed no significant difference between groups for either speech rate [$t(20) = 0.966$; $p = .346$] or articulation rate [$t(20) = 0.260$; $p = .800$].

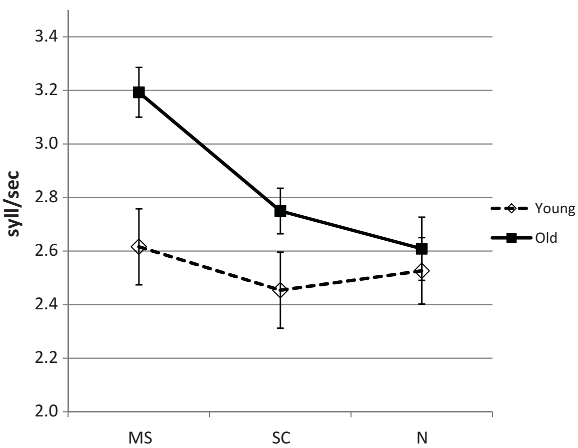

Fig. 2. Mean speech rates (±1 SE) during the Modeled Sentences (MS), Stuctured Conversation (SC), and Narration (N) tasks for Younger and Older participants. Older children had faster speech rates than Younger children during the Modeled Sentences task. Older children also had faster speech rates during the Modeled Sentences task than they did during for the Structured Conversation and Narration tasks. (The "Younger" and "Older" groups included both children who stutter and children who do not stutter.)

Table 4
Sample sizes for articulation rate analyses.

Group		Tasks											
Fluency	Age	Modeled Sentences				Structured Conversation				Narration			
		Sylls	Words	Utts	MLU_s	Sylls	Words	Utts	MLU_s	Sylls	Words	Utts	MLU_s
CWS	Younger	57.29 (26.66)	46.93 (22.01)	6.86 (3.06)	8.28 (0.64)	37.71 (21.90)	29.14 (17.08)	6.64 (3.39)	5.49 (1.31)	45.79 (37.45)	35.71 (28.42)	6.86 (4.70)	6.51 (2.35)
	Older	84.58 (34.74)	70.08 (29.41)	10.08 (4.06)	8.37 (0.47)	54.00 (28.33)	41.42 (22.58)	8.17 (3.66)	6.72 (1.77)	33.25 (29.98)	24.67 (21.43)	4.42 (3.94)	7.04 (2.03)
CWNS	Younger	81.41 (30.03)	67.36 (24.92)	9.71 (3.33)	8.30 (0.64)	60.18 (16.75)	46.82 (13.60)	10.06 (2.84)	6.06 (0.97)	54.47 (40.33)	43.24 (32.39)	7.24 (5.18)	7.73 (1.82)
	Older	97.94 (22.67)	81.47 (18.82)	11.41 (2.69)	8.59 (0.24)	66.71 (33.29)	50.00 (24.32)	9.53 (3.18)	6.86 (2.00)	79.35 (42.38)	63.53 (35.07)	10.12 (6.38)	8.40 (1.86)

Note: Y = Younger, O = Older; Sylls = syllables, Utts = utterances; CWNS = children who do not stutter; CWS = children who stutter; MLU_s = mean length of utterance in syllables.

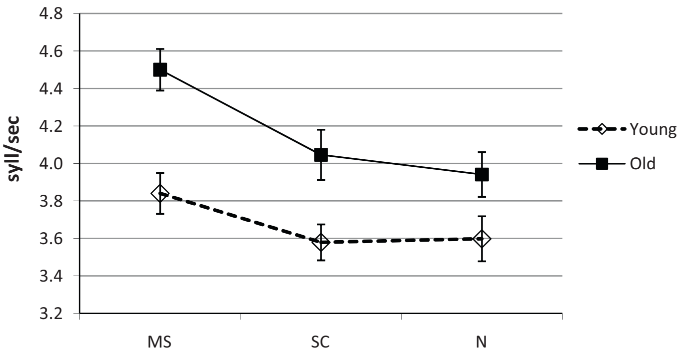

Fig. 3. Mean articulation rates (±1 SE) during the Modeled Sentences (MS), Stuctured Conversation (SC), and Narration (N) tasks for Younger and Older participants. (The Younger and Older groups included both children who stutter and children who do not stutter.).

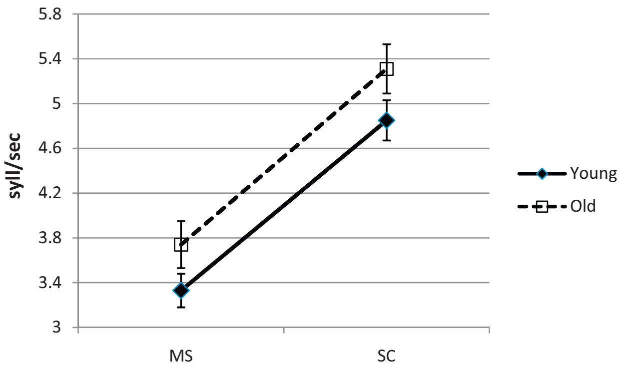

Fig. 4. Articulation rates in syllables per second (±1 SE) for examiners during interactions with Younger and Older children in the Modeled Sentences (MS) and Structured Conversation (SC) tasks.

It was not feasible to precisely control the examiner's articulation rate during the course of the present study. Thus, one other post hoc analysis was performed to examine the possibility that examiners' articulation rates might have influenced the children's articulation rates and contributed to the significant Age Group × Speaking Task interaction. For each examiner, articulation rate was computed for one fluent utterance from both the Modeled Sentences task and the Structured Conversation task.[1] Examiner articulation rates were then analyzed to determine whether they differed according to the age of the child in the interaction or the task they were performing. The examiners' resulting rate patterns were then compared to the children's rate patterns described in Section 3.2. If the examiners' and children's rate patterns were similar, it would support the idea that the differences observed in children's articulation rates across age groups and speaking tasks resulted from entrainment with the examiner.

Mean examiner rates for this analysis are shown in Fig. 4. Results of a mixed-model ANOVA showed a significant main effect for the between-subjects factor, Age Group [$F(1, 63) = 5.131$; $p = .027$, partial $eta^2 = .075$] and a significant main effect for the within-subjects factor, Speaking Task [$F(1, 63) = 72.857$; $p < .001$, partial $eta^2 = .536$]. The Age Group × Speaking Task interaction was not significant ($p > .05$). When the examiners' rate results were compared to the children's rate results, the overall pattern did not fit well with the rate entrainment hypothesis. Although the examiners did speak faster to older children than younger children, the examiners showed rate patterns across the speaking tasks that were opposite those of the children. That is, the examiners spoke faster during Structured Conversation than Modeled Sentences. However, as explained in Section 3.2, the children spoke faster during Modeled Sentences than during Structured Conversation. Further, the effect size for the Speaking Task effect with examiners was very large and much greater than that for the Age Group comparison, and examiners' articulation rates during the Modeled Sentences interactions were nearly 1 syllable per second slower than rates produced by older children during that task.

[1] The analysis was limited to fluent utterances because it was felt that such utterances offered the most comparable point of comparison for studying potential entrainment in Examiner–CWS and Examiner–CWNS interactions. Narration was excluded from the analysis because examiners rarely spoke during a child's narrative.

3.4. Predictors of speech and articulation rate

Further statistical analysis explored the extent to which selected predictor variables (i.e., disfluency frequency, age, utterance length) contributed to the speech and articulation rates observed in the two fluency groups. To determine if the contribution of these variables differed for each fluency group, separate regression models were constructed for both CWNS and CWS.

3.4.1. Children who do not stutter

A regression model was constructed to examine the extent to which the speech rates of CWNS could be predicted from three variables: age in months, disfluency frequency (i.e., total number of disfluencies across tasks per 100 syllables), and average utterance length in syllables across the three speaking tasks. This model was significant [R^2 = .699, ADJ R^2 = .669, F(3, 30) = 23.213, $p < .001$]. Results revealed that age in months, [t(30) = 2.504, p = .018], and disfluency frequency [t(30) = $-$7.051, $p < .001$], were both significant predictors of the child's speech rate across the three speaking tasks. The standardized beta coefficient was .276 for age in months and $-$.731 for disfluency frequency, indicating that disfluency frequency was a stronger predictor of speech rate than age in months.

For the articulation rate data, the same predictor variables (with the exception of disfluency frequency) yielded a significant regression model [R^2 = .352, ADJ R^2 = .310, F(2, 31) = 8.414, p = .001]. However, results revealed that age in months, [t(31) = 3.600, p = .001], was the only significant predictor of a child's articulation rate across the three speaking tasks.

3.4.2. Children who stutter

Results for speech rate for the CWS were similar to the results found for the CWNS. Specifically, an overall regression model predicting speech rate from three variables: age in months, disfluency frequency (i.e., total number of disfluencies across tasks per 100 syllables), and average MLU in syllables across the three speaking tasks was significant [R^2 = .672, ADJ R^2 = .639, F(3, 30) = 20.511, $p < .001$]. Results further revealed that only age in months, [t(30) = 2.972, p = .006], and disfluency frequency [t(30) = $-$7.333, $p < .001$], were significant predictors of a child's speech rate across the three speaking tasks. The standardized beta coefficient was .328 for age in months and $-$.768 for disfluency frequency. Thus, consistent with findings for CWNS, disfluency frequency was a stronger predictor of speech rate than age in months.

For the articulation rate data, age in months and mean length of utterance were again used as predictor variables, and they yielded a significant regression model [R^2 = .307, ADJ R^2 = .254, F(2, 26) = 5.771, p = .008]. As was the case with CWNS, results revealed that age in months [t(26) = 2.478, p = .020] was the only significant predictor of the child's articulation rate across the three speaking tasks.

3.4.3. Stuttering severity and speaking rate

Pearson product–moment correlations were used to examine the extent to which stuttering severity was correlated with speech rate and articulation rate for CWS. Results indicated a moderate negative correlation between stuttering severity rating and speech rate (r = $-$0.485, p = .004). There was, however, no significant correlation between stuttering severity rating and articulation rate (r = .07; p = .735).

4. Discussion

Findings from the present study add to the relatively limited literature on the speaking rate characteristics of school-aged children, particularly with regard to how quickly children talk during various speaking tasks. Findings also provide additional insight into how the speaking rates of children who stutter compare with those of children who do not stutter and the extent to which age, disfluency frequency, and utterance length contribute to speaking rates. More generally, the present results illustrate the utility of basing rate analyses on speech samples that are elicited from standardized assessment tasks. As noted above, the use of such tasks affords control over variables that can make cross-clinical rate comparisons imprecise.

4.1. Speech rate patterns

Consistent with previous research (e.g., Johnson, 1961; Meyers & Freeman, 1985; Sturm & Seery, 2007), speech rates (i.e., rate during fluent and disfluent utterances) for children who stutter were significantly slower than those for children with typical fluency. When the present data were collapsed across all tasks (see Appendix A), speech rates for CWS were about 13% slower than those for typical children, which is congruent with the medium effect size associated with this comparison. The present findings reinforce the contention that speech rate is a relatively sensitive clinical measure that is capable of distinguishing between children who do and do not stutter (e.g., Bloodstein & Bernstein Ratner, 2008).

Also consistent with previous research (e.g., Kowal et al., 1975; Sturm & Seery, 2007), was the finding that chronological age affects a child's speech rate. In the present study, however, age effects were limited to the Modeled Sentences task. That is, older children (M age $\sim$ 9.5 years) spoke more rapidly than younger children (M age $\sim$ 7 years) during the Modeled Sentences task, but not during the Structured Conversation or Narration tasks. Further, older children spoke more rapidly during the Modeled Sentences task than they did during the Structured Conversation and Narration tasks. In contrast, younger children exhibited similar speech rates across all three tasks. Taken together, these findings suggest that, as children becoming increasingly competent with using basic syntactic forms (Nippold, 1998) prompted tasks such as Modeled Sentences become easier to perform than tasks that require a greater amount of open-ended, self-generated linguistic formulation.

Two of the three predictor variables – disfluency frequency and chronological age – were significantly associated with speech rate. This was true for both CWS and CWNS. Of the two, disfluency frequency was the stronger predictor. As noted in Section 3.1, age effects in the present study were limited to the Modeled Sentences task; thus, the relationship between age and speech rate would have been even weaker had only data from Narration and Structured Conversation tasks been analyzed. The third factor in the regression model, mean utterance length in syllables, was not significantly associated with mean speech rate. Thus, the use of relatively long utterances did not translate into relatively fast (or slow) speech rates for the children. The lack of association between utterance length and speech rate may reflect the tendency for language complexity to have less of an effect upon children's fluency as they move beyond the preschool years (Logan, 2001; Silverman & Bernstein Ratner, 1997).

Speech rates in the present study were derived from a broad sampling of school-aged children. However, post hoc assessment with a subset of participants did not support the idea that children who presented both stuttering and articulation and/or language problems spoke at markedly different rates than children who presented only stuttering. This finding is consistent with previous research by Wolk et al. (1993) on differences in stuttering severity for CWS with and without concomitant phonological disorders. The participants who stutter also varied in their exposure to speech therapy. Rate management is a component of many behavioral stuttering therapies, and to the extent that children may have been actively employing such strategies during data collection, their speech rates may have been suppressed. However, post hoc tests with a subset of participants showed no difference in speech rate or articulation rate between children who had and had not received therapy. These findings were consistent with the researchers' informal observation that none of the CWS appeared to be systematically employing slow, deliberate articulation (or, for that matter, any other rate-related stuttering management strategies). Further, two of the four children who reportedly had made substantial improvements in fluency over the course of therapy exhibited moderate to severe stuttering during data collection for this study. Thus, while some of the participants may have had the capacity to manage stuttering successfully in some settings, they did not appear to be actively attempting to do so in the present context.

4.2. Articulation rate patterns

Analyses of children's articulation rate (i.e., rate during fluent utterances) showed that older children produced significantly more syllables per second than younger children, regardless of their fluency group or the speaking task. This finding is consistent with results from previous studies that have examined age-related changes in children's articulation rate (e.g., Flipsen, Jr., 2002; Hall et al., 1999; Sturm & Seery, 2007). Similar to the speech rate analyses, findings showed that a speaker's average utterance length was not a significant predictor of articulation rate. The latter finding is consistent with results of other recent research (e.g., Sturm & Seery, 2007; Walker & Archibald, 2006). The present analyses were confined to utterance length effects *between* subjects. Some researchers (e.g., Amster & Starkweather, 1987; cf. Walker & Archibald, 2006) have reported modest correlations between utterance length and articulation rate *within* subjects. That is, speakers tend to produce their long utterances at a faster rate than they produce their short utterances. This relationship was not specifically examined in the present study and is not necessarily precluded by the present findings.

There was no significant difference in articulation rate between children who do and do not stutter. Articulation rate analyses in the present study were performed at a suprasegmental level (i.e., syllables per unit of time). Other researchers (Borden, Kim, & Spiegler, 1987; McKnight & Cullinan, 1987; Starkweather & Meyers, 1979; Zebrowski, Conture, & Cudahy, 1985) have reported differences – albeit usually subtle ones – between speakers who do and do not stutter using finer-grained rate-related measures such as consonant and vowel duration and transition duration. Comparisons of selected speech sound segments and segment transitions within fluent utterances produced by children who do and do not stutter using a controlled-content task such as Modeled Sentences would be an interesting extension of the present study.

In the present study, eight participants from the CWS group (24% of total) failed to produce any entirely fluent utterances in at least one of the three speaking tasks. Accordingly, these individuals were excluded from the articulation rate comparisons. The effect of stuttering severity upon behavioral performance with speakers who stutter is not entirely clear, with some studies showing that individuals with severe stuttering perform more poorly than individuals with mild or moderate stuttering on speech-related measures (e.g., Boberg & Kully, 1994) and others showing no differences (e.g., Logan, 2001). Thus, it is difficult to say how the exclusion of these more severe individuals may have affected the articulation rate analyses. Nonetheless, it is interesting to speculate whether the between-group comparisons for articulation rate might have turned out differently had these relatively severe cases not been excluded. One solution to this problem would be to replace or supplement utterance-based articulation rate measures with measures of fluent "runs," i.e., stretches of fluent speech that exceed a certain number of syllables, but do not necessarily constitute an entire utterance (see Walker et al., 1992; Walker & Archibald, 2006 for examples). Such an approach would likely yield more data points per participant, along with fewer excluded participants. Even this methodological alternative may not be satisfactory, however. For instance, the sampled runs would need to be carefully matched for utterance position because articulation rate has been shown to vary over the course of an utterance (e.g., van Lieshout, Starkweather, Hulstijn, & Peters, 1995), and very disfluent speakers may produce only very short spans of perceptually fluent speech.

The effect of examiners' articulation rate upon children's articulation rate has received very little attention in past studies that have reported age-based speaking rate data. There is evidence that the presentation rate of instructional models can influence young children's speaking rate, at least for some types of tasks (Hupp & Jungers, 2009). It was not plausible to precisely control examiner rate within the dynamic testing environment of the TOCS; however, the possibility that examiner–child rate entrainment might explain the significant age and speaking task effects observed in children was analyzed in post hoc testing. Interestingly, examiners' rate patterns did not correspond closely with the children's rate patterns: examiners and children showed opposite rate patterns during Modeled Sentences and Structured Conversation tasks. Examiners spoke nearly 1 syllable per second slower than children in the task that featured children's fastest articulation rates (i.e., Modeled Sentences), and the effect size for the difference in examiners' articulation rates across speaking tasks was much greater than the effect size for the difference in examiners' articulation rates across age levels. Overall, the analysis of examiners' articulation rates suggest that the articulation rate patterns observed for children in this study were more likely to have been influenced by other factors, including task complexity and the intrinsic skills and abilities that children brought to such tasks. In contrast, the relatively slow articulation rates used by examiners in the Modeled Sentences task suggest that they sought to present children with distinct examples of the types of sentences they were to produce.

4.3. Cross study comparisons

The mean speech rates during narration for both younger (*M* age ~ 7 years) and older (*M* age ~ 9.5 years) CWNS in the present study were comparable to the speech rates reported for similar age intervals in studies by Kowal et al. (1975) and Sturm and Seery (2007). The mean articulation rate for older children during Structured Conversation in the present study was also comparable to conversational articulation rate data reported by Flipsen, Jr. (2002) for 9-year-old children with a past history of phonological delay.

The mean articulation rates in the present study fit well with the articulation rates for 4- to 6-year old children studied by Walker and Archibald (2006). However, the mean articulation rates for younger children in the present study were approximately 0.90 syllables per second slower than those reported for 7-year-old typical children by Sturm and Seery (2007). Further, articulation rates for older children in the present study were approximately 1.3–1.5 syllables per second slower than the articulation rates for typical 9-year-old children in Sturm and Seery's study. Temporal measurements in the present study were based on spectrographic images, whereas Sturm and Seery's measurements were based on averaged stopwatch timings. It could be argued that spectrographic measurements are more precise than stop watch measurements. However, given the similarities between the two studies in reported speech rates and elicitation tasks, it is not clear how instrumentation could have had such a disproportionate effect on articulation rate assessment.

Another possible explanation involves sample sizes. The present study featured more than twice as many participants per age group and nearly twice as many analyzed utterances per participant as the Sturm and Seery study. Accordingly, the group standard deviations for articulation rates in the present study were 30–50% smaller than those in Sturm and Seery's study. Thus, it may be that the mean articulation rates in the present study were less affected by outlying values than was the case in the Sturm and Seery study. In any case, the differences between the reported results in these two studies underscore the extent to which articulation rate measures can be affected by methodological factors. In both studies, sample sizes for articulation rate analyses were relatively small, demonstrating how few utterances – even for ostensibly normal speakers – are entirely free of disfluency. As noted above, the use of "fluent runs" might be one way to circumvent this problem.

4.4. Concluding remarks

Results from the present study provide reference data that clinicians can consider when using speaking rate measurements to supplement norm-referenced scores on the TOCS or, perhaps, other formal assessment tools that incorporate similar tasks. Findings from the present study show that, among school-aged children, both speech rate and articulation rate are age and task dependent, and that children who stutter tend to have slower speech rates than children who do not stutter. Robust speech rate differences were observed between fluency groups, even though many of the children who stutter fell into the mild range of severity.

Findings from regression models in the present study showed that disfluency frequency and age together accounted for about 70% of the variance in the children's speech rates, with disfluency frequency alone accounting for just over half of the variance in speech rate. Although these two variables account for much of the variance in speech rate, neither is so well correlated with speech rate to be considered its equivalent. In contrast, the regression models used to predict articulation rate, while statistically significant, accounted for only about one-third of the children's variance. Consistent with the speech rate analysis, age was found to be a significant, though not particularly strong, predictor of articulation rate. This may be because age is a rather broad construct that encompasses many facets of development and performance.

The present study, like many previous rate-related studies, focused upon describing the speaking rate characteristics of particular age groups and speaker groups. Another goal of the present study was to identify the extent to which disfluency frequency, age, and utterance length predict how fast children will speak. In future research, it would be worthwhile to extend this approach by systematically exploring the ways in which particular linguistic (e.g., lexical diversity), cognitive (e.g., short-term memory), and motor system (e.g., spatio-temporal stability) variables affect rate performance, as such variables have been shown in previous research to be related to speaking rate (e.g., Hulme, Thomson, Muir, & Lawrence, 1984; Smith & Kleinow, 2000; Watkins, Kelly, Harbers, & Hollis, 1995). Specific information about these and other aspects of performance may have been useful in the present study to more fully interpret the difference in speech rate that was observed for CWS and CWNS. Future research will be necessary to determine the utility of such an approach for furthering our understanding of the factors that contribute to children's speaking rate.

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Appendix A. Examiner requests used during the Structured Conversation task, along with the number (in parentheses) of the associated stimulus picture from the *Test of Childhood Stuttering* (Gillam et al., 2009)

1. Are there any clues in the picture about what the children might do after they play soccer? (Picture 1)
2. What do you think might happen with the spaceship? (Picture 1)
3. What is the spaceship doing now? (Picture 1)
4. What's going to happen with the bikes? (Picture 2)
5. Why is the girl smiling? (Picture 2)
6. Why isn't the girl happy anymore? (Picture 3)
7. Why do you think the children are running away? (Picture 3)
8. Describe the alien. (Picture 3)
9. What are the boys thinking? (Picture 4)
10. What is the girl saying to the alien? (Picture 4)
11. How are the aliens different from the children? (Picture 5)
12. The girl is happy. How do you know that? (Picture 5)
13. What is the alien giving the girl? (Picture 6)
14. Why did the alien give the girl a present? (Picture 6)
15. The girl is surprised. How do you know that? (Picture 6)
16. Why did the boys come outside? (Picture 7)
17. What is this boy thinking? (Picture 7)
18. What is the girl doing (now)? (Picture 8)
19. The girl feels happy. Why does she feel that way? (Picture 8)

Appendix B. Speech rate results in syllables and words per second

Fluency group	Age group	Modeled Sentences				Structured Conversation				Narration				All Tasks			
		Syll/sec		Words/sec		Syll/sec		Words/sec		Syll/sec		Words/sec		Syll/sec		Words/sec	
		M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
CWNS	Y	2.82	0.57	2.37	0.47	2.58	0.37	2.01	0.30	2.72	0.67	2.13	0.53	2.71	0.43	2.17	0.34
	O	3.33	0.82	2.83	0.67	2.88	0.67	2.25	0.51	2.89	0.57	2.27	0.45	3.03	0.58	2.45	0.46
CWS	Y	2.41	0.43	2.04	0.37	2.33	0.58	1.81	0.48	2.33	0.66	1.82	0.48	2.36	0.38	1.89	0.31
	O	3.06	0.84	2.56	0.71	2.62	0.96	2.01	0.71	2.33	0.77	1.75	0.56	2.67	0.78	2.11	0.60

Note: CWNS = children who do not stutter; CWS – children who stutter; Y = younger participants (*M* age 6;10); O = older participants (*M* age = 9;6). Speech rate statistics are based on analysis of both fluent and disfluent utterances. Syll = syllables, sec = second.

Appendix C. Articulation rate results in syllables and words per second

Fluency group	Age group	Modeled Sentences				Structured Conversation				Narration				All Tasks			
		Syll/sec		Words/sec		Syll/sec		Words/sec		Syll/sec		Words/sec		Syll/sec		Words/sec	
		M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
CWNS	Y	3.89	0.73	3.21	0.60	3.54	0.53	2.75	0.49	3.87	0.42	3.11	0.36	3.76	0.42	3.02	0.33
	O	4.56	0.54	3.79	0.43	3.99	0.63	3.00	0.50	3.95	0.49	3.12	0.39	4.16	0.49	3.30	0.38
CWS	Y	3.77	0.43	3.10	0.33	3.63	0.56	2.78	0.45	3.27	0.77	2.59	0.59	3.56	0.38	2.82	0.29
	O	4.42	0.69	3.64	0.57	4.13	0.86	3.17	0.71	3.93	0.83	3.07	0.85	4.16	0.64	3.29	0.56

Note: CWNS = children who do not stutter; CWS – children who stutter; Y = younger participants (*M* age 6;10); O = older participants (*M* age = 9;6); Articulation rate statistics are based on analysis of only fluent utterances. Syll = syllables, sec = second.

Appendix D. Continuing education

(1) Which of the following is an accurate statement regarding speech rate?
  (a) Speech rate is calculated by measuring the fluent speech segments only.
  (b) Speech rate measures the amount of speech produced per unit of time during fluent samples of speech.
  (c) Speech rate measures the amount speech produced per unit of time during all types of speech, including samples that contain disfluency.
  (d) Speech rate is calculated by measuring the number of disfluent speech segments divided by the number of fluent speech segments (i.e., as measured in syllables).
  (e) Speech rate is calculated by measuring disfluent segments only.
(2) Which of the following is not an accepted manner in which to measure articulation rate?
  (a) Analyze whole utterances that contain no speech disfluency.
  (b) Analyze only those utterances that contain both fluent and disfluent speech.
  (c) Analyze stretches of speech that contain no pauses greater than 250 ms.
  (d) Analyze the speech that remains in an utterance after all disfluent segments have been removed.
  (e) Analyze speech that does not contain disfluencies.
(3) Results from the present study revealed which of the following findings related to articulation rate for younger versus older children?
  (a) Older children produced significantly more fluent syllables per second than younger children, regardless of their fluency group or the speaking task.
  (b) Younger children produced significantly more fluent syllables per second than older children, regardless of their fluency group or the speaking task.
  (c) Older children produced a comparable amount of fluent syllables per second compared to younger children, regardless of their fluency group or the speaking task.
  (d) Differences in articulation rates between younger versus older children were limited to children who do not stutter.
  (e) Older children who stutter produced significantly more fluent syllables per second than older children who do not stutter.
(4) According to the results from the present study, which one of the following variables is the strongest predictor of speech rate?
  (a) Mean length of utterance.
  (b) Gender.
  (c) Age.
  (d) Disfluency frequency.
  (e) Time since onset of stuttering.
(5) Which of the following is an accurate statement regarding the speech rate findings from the present study?
  (a) Speech rates for children who stutter were significantly slower than those for children with typical fluency.
  (b) Speech rates for older children were slower than younger children during the Modeled Sentences task, but not during the Structured Conversation or Narration tasks.
  (c) Speech rates for children who stutter were significantly faster than those for children with typical fluency.
  (d) Speech rates for older children were slower than those of younger children across all three speaking tasks.
  (e) The speech rates of younger children were comparable to the speech rates of older children.

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