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Article *in* Clinical Linguistics & Phonetics · February 2015

DOI: 10.3109/02699206.2014.1003970 · Source: PubMed

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Clinical Linguistics & Phonetics, 2015; Early Online: 1–24

ISSN: 0269-9206 print / 1464-5076 online
DOI: 10.3109/02699206.2014.1003970

informa
healthcare

Slow speech rate effects on stuttering preschoolers with disordered phonology

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(*Received 14 February 2014; revised 17 September 2014; accepted 20 December 2014*)

Abstract

To study the effects of clinicians' slow rate on the speech of children who stutter with and without a concomitant phonological disorder, an A–B–A–B single case design was used with six clinician–child dyads, where B = Clinician's slow speech rate model. Two boys and one girl, aged 49–54 months, stuttering with disordered phonology (S + DP), were compared to three boys aged 42–50 months, stuttering with normal phonology (S + NP). Articulation rates were measured in phones per second (pps) in clinician–child adjacent utterance pairs. The S + NP dyads showed improved fluency in the B condition through a larger effect size, higher mean baseline stutter reductions and lower percentages of non-overlapping data than did the S + DP dyads. The S + DP girl showed relatively improved fluency in the B condition. S + DP children showed no articulation rate alignment (Range: 16% decrease to a 1.2% increase), whereas S + NP children averaged a 20% pps rate reduction (Range: 19.6–25.4% decrease), aligning with their clinicians who averaged a 38% pps rate reduction from baseline. The S + DP group spoke significantly ($z = -4.63$; $p < 0.00$) slower at baseline (Mdn = 6.9 pps; SE = 0.07 pps) than S + NP children in previously published samples (Mdn = 9.8 pps; $SE = 0.22$ pps). Results suggest that a slow rate model alone is not effective for facilitating fluency in S + DP boys with time since onset of about 2 years.

Keywords: Articulation rate, children who stutter, dyadic gap, treatment efficacy, single-subject design

Introduction

Parents' and clinicians' adoption of a slow speaking rate when conversing with preschoolers who stutter is a core component of therapy. Speech rate reduction requires the speaker to increase the number and duration of pauses between words, and/or elongate speech sounds (Tiffany, 1980). When adults speak slower with normally fluent preschoolers, speech rate ''entrainment'' or ''alignment'' may occur, whereby the child speaks slower along with the adult (Guitar & Marchinkoski, 2001; Torrington Eaton & Bernstein Ratner, 2013). Most preschoolers who stutter do not show speech rate alignment, and yet their fluency is facilitated when an adult interlocutor slows his/her rate (Zebrowski, Weiss, Savelkoul, & Hammer, 1996). When measuring preschoolers' articulation rate or fluent speech rate in phones per second, children with phonological disorders speak slower than their peers with normal phonology (Flipsen, 2002, 2003), and children who

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stutter speak slower than their peers with normal fluency (Dailey Hall, Amir, & Yairi, 1999). We do not currently know the effect of adults' slow speech rate on the speech rate and fluency of children who stutter and show a concomitant phonological disorder, even though this is a frequently encountered subgroup of the population of children who stutter (Arndt & Healey, 2001; Louko, Edwards, & Conture, 1990; *cf.*, Nippold, 2002). The present investigation examines these topic areas in more detail.

Slow rate as a component of demands-capacity model treatment

The options for treatment approaches with preschoolers who stutter are: (1) indirect or demands-capacity model-based approach (Conture, 2001; Gottwald, 2010; Miller & Guitar, 2009; Millard, Nicholas, & Cook, 2008; Richels & Conture, 2010; Zebrowski & Kelly, 2002); (2) direct or response-contingent stimulation-based, parent-implemented (Lidcombe) approach (Harrison & Onslow, 2010; Jones, Onslow, Harrison, & Packman, 2000; Miller & Guitar, 2009; Shenker, 2011); or (3) an effective blend of the two approaches, based on data suggesting that each is equally efficacious (Franken, 2013; Franken, Kielstra-Van der Schalk, & Boelens, 2005; Frymark, Venediktov, & Wang, 2010). The demands-capacity model-based approach includes a slow speech rate model, intended to be used by clinicians and parents alike. The slow rate model presumably lowers the demands of speech and language processing and production to better match the child's capacity, thus increasing fluency (Gottwald, 2010; Richels & Conture, 2010; Zebrowski, 1994, 1995).

Gottwald (2010) cites the work of Levelt (1989) to support her contention that high demands upon one performance area, such as language processing, may lower a child's functioning in other domains, such as motor skill and fluency. Using evidence-based practice principles, the clinician should assess the degree to which caregiver rate reduction facilitates rate reduction and/or fluency in the child's speech (Bloodstein & Bernstein Ratner, 2008; Pellowski, 2010; Torrington Eaton & Bernstein Ratner, 2013). Some clinicians using treatment programs with 2–6 years old will first target the child's accurate identification of relatively fast (e.g. ''race car talk'') versus slow (''turtle talk''), and then encourage the child's slow articulation rate, along with parent and clinician slow rate modelling (Gottwald, 2010). Other programs (Richels & Conture, 2010) include baseline measures of the dyadic gap between the adult's and child's rate, and if the gap is greater than about one syllable per second or 60 syllables per minute, where the adult is speaking faster than the child, they would counsel the parent to slow his/her rate to help achieve a closer match. If the child consistently exceeded the adult's rate, ''turtle talk'' instruction might be warranted (Starkweather, Gottwald, & Halfond, 1990).

Teaching a child who stutters how to slow their own speech rate is often indicated at the older ages, when there is no longer the likelihood that the child would reduce rate in response to a caregiver's rate reduction. Logan, Byrd, Mazzacchi, and Gillam (2011) found no articulation rate alignment or entrainment between adult examiners and children, Kindergarteners through fourth-graders, during a variety of speech samples. In fact, they found that children spoke about one syllable per second faster than the examiners spoke during the ''modelled sentence task'' from the *Test of Childhood Stuttering* (Gillam, Logan, & Pearson, 2009).

In contrast, normally fluent preschoolers are likely to align with a fast adult speech rate. Torrington Eaton and Bernstein Ratner (2013) found that when 3–4 year olds ($n = 20$) were directed to correct a fast-talking puppet stimulus and reinforced for ''slowing her down'', these children nevertheless aligned to the fast talking puppet by increasing their speech rate to above 3 syllables per second. These findings imply that teaching preschoolers to slow their speech rate might not be effective, and the likelihood of alignment may be a stronger influence. The current problems in the field of fluency treatment are that: (a) we have very few preschool treatment efficacy studies (Chon, Sawyer, & Ambrose, 2012; Franken et al., 2005; Millard et al., 2008; Nippold & Rudzinski, 1995; Ryan, 1998), and (b) of those available efficacy studies, there is either no report about phonology status of the preschoolers (Millard et al., 2008), S + DP children are purposefully excluded (Costello Ingham & Riley, 1998) or S + DP children are described and included (Miller & Guitar, 2009). In Miller and Guitar (2009), 6/15 participants (40%) in a Lidcombe program were S + DP, but this factor did not determine their outcome, and neither did family history of stuttering, stuttering severity and other factors, when considering the average number of hour-long clinic sessions (*Mdn* = 17; Range = 6–44 h) needed to reach fluent or ''mild stuttering status''. For example, one of the six S + DP children in the Miller and Guitar (2009) study was left-handed and took 26 h to reach mild stuttering status.

Measuring and interpreting articulation rate

Articulation rate is operationally defined as fluent speech segment production per unit of time (Flipsen, 2002, 2003; Kelly & Conture, 1992; Ryan, 1992; Zebrowski et al., 1996). As time taken up by stuttering is excluded in the measurement of articulation rates, children who stutter can be compared to normally fluent peers on this measure. Articulation rate is either measured in phones per second or in syllables per second (converted to syllables per minute [spm]; Starkweather et al., 1990; Robb, Gilbert, Reed, & Bisson, 2003).

In the Illinois longitudinal project, Dailey Hall and associates (1999) found that preschoolers who stutter were significantly slower, speaking at a rate of 7.7–10.2 phones per second (pps), compared to their normally fluent peers whose articulation rates were in the 11.4–12.2 pps range. Yaruss and Conture (1995) found no articulation rate difference between preschoolers who do and do not stutter, but they reported data in syllables per second (sps). Also, measuring sps in an investigation of preschoolers who stutter, Tumanova, Zebrowski, Throneburg and Kulak Kayikci (2011) found that the higher the stuttering frequency and the longer the sound prolongation duration, the slower the children's articulation rate. At an acoustic level, the formant transition rates in F2 (Hz/ms) between bilabial consonants and vowels and between alveolar consonants and vowels are not as contrastive or easily identifiable in young children who stutter (Chang, Ohde, & Conture, 2002; Yaruss & Conture, 1993). These findings taken together suggest that young children who stutter have subtle articulatory/motoric deficits, evidenced in their relatively slow articulation rates.

Several considerations are important about articulation rate measures. First, in adults, longer utterances are spoken at faster rates than shorter utterances (Malecot, Johnston, & Kizziar, 1972). Using syllables per second (sps) as a measurement, Meyers and Freeman (1985) found that mothers of preschoolers who stutter spoke faster than mothers of normally fluent children, when their rates were measured talking with their own children and with the normally fluent children. However, only the longest maternal utterances were measured in Meyers and Freeman (1985). Investigators since then have found no difference between the rates of stuttering children's parents and non-stuttering children's parents (Kelly, 1994; Kelly & Conture, 1992; Kloth, Janssen, Kraaimaat, & Brutten, 1998; Ryan, 1992, 1998; Schulze, 1991; Yaruss & Conture, 1995).

In the speech samples of 14 preschoolers who stutter, Chon and associates (2012) excised stuttering-like disfluencies from the utterances that contain them, and only the remaining syllables and phones in these utterances were timed. They found, opposite of adults, that preschooler's longer utterances are significantly slower than shorter utterances. They speculated that, in preschoolers, a slower articulation rate surrounds the stuttered words as a possible compensation for the increased speech motor and linguistic demands of these longer, more complex utterances. In reports that have used this excised disfluency method for articulation rate, there is a trend for disfluent utterances to be somewhat slower, but not significantly slower when compared to perceptibly fluent utterances, both in preschoolers (Chon et al., 2012; Logan & Conture, 1997; Sawyer, Chon, & Ambrose, 2008; Yaruss & Conture, 1996) and in school-age children who stutter (Logan et al., 2011).

Units of speech rate measurement appear to matter. Tiffany (1980) was among the first to use the high-resolution measure of phones per second (pps), and he found a stable average of 13.5 pps in adults. In normally fluent boys and girls, Walker, Archibald, Cherniak and Fish (1992) found spontaneous speech articulation rate averages of 8.4 pps ($SD = 1.1$ pps; $n = 20$) for 3-year-olds and 9.5 pps (SD = 1.4 pps; $n = 20$) in 5-year-olds. In data that combined 3- to 4-year-old normally fluent children's articulation rates at the time of initial-visit, Dailey Hall et al. (1999) found an average rate of 11.4 pps (SD = 2.8 pps). Dailey Hall and associates found significant differences between normally fluent children who were the fastest, children who would persist in stuttering who were relatively fast, and those who would eventually recover from stuttering, who were the slowest in phones per second. However, when syllable per second measures were compared, Dailey Hall et al. found no differences in the children's rates. They stated that, ''Apparently, because the phone metric is based on smaller units, the differences between groups are easier to detect (p. 1372)''. Their findings suggested that the measure of phones per second (pps) is worthy of continued analysis.

Articulation rates increase with age in normally fluent speakers. Using pps as a measure, articulation rates for normally fluent preschoolers ranges from 8.4 to 11.4 pps (Dailey Hall et al., 1999; Walker et al., 1992). Adults average a maximum repetition (diadochokinetic) rate of 13.6 pps and an oral reading rate of 13.1 pps (Tiffany, 1980). However, preschoolers who stutter show below normal limit articulation rates (Dailey Hall et al., 1999), as do children with speech delay of unknown origin (Flipsen, 2002, 2003) when pps is the measure.

Dailey Hall et al. (1999) observed children in a control group and children who stutter in longitudinal subgroups of those who would eventually recover and those who would persist in stuttering. They found that at an initial visit, 3-year-olds who stutter but would go on to recover from stuttering spoke slower at 7.68 pps on average (SD = 1.08) as compared with the persistent subgroup ($M = 9.56$ pps; SD = 1.25) and the control group ($M = 11.42$; SD = 2.77). Dailey Hall et al.'s findings could be seen as support for the phenomenon that negative stuttering awareness is likely with stuttering persistence, leading to a child's perceived need to make up for the lost time taken up by stuttering, leading to fast runs of speech. Alternatively, their findings could imply that slow articulation rate is a factor in the recovery process. Dailey Hall et al.'s (1999) data at the 1-year follow-up visit (49–70 months old) shows that while the persistent group is most variable ($M = 9.66$ pps; SD = 1.16 pps), the average articulation rate is slightly faster in the recovery group 1 year later ($M = 9.78$ pps; SD = 0.62 pps). Perhaps these children, as they recover, are catching up to the articulation rates of normally fluent children, who are faster talkers on average, although variable ($M = 12.17$ pps; SD = 2.10 pps). It is possible that children who recover from stuttering remain relatively slow talkers ''part and parcel'' of their original stuttering condition, or they use a relatively slow rate as a method of maintaining their recently achieved fluency. In a longitudinal sample of children with a speech delay of unknown origin, Flipsen (2002, 2003) found below normal limit averages of 7.7 pps in 2;11 to 5;11 year olds, but by the age of 9;0 to 9;10, after speech therapy, these children increased to speaking at an average rate of 9.9 pps, and by the age of 12;8 to 16;9, these children averaged 12.01 pps, that is, close to that of normally fluent and normally articulating adults.

Articulation rate entrainment or alignment and dyadic speech rate gap

Articulation rate entrainment or alignment has been a focus in several investigations of preschoolers who stutter (Bernstein Ratner, 1997; Embrechts, Franken, Mugge, & Peters, 1995;

Helmer, 1995; Stephenson-Opsal & Bernstein Ratner, 1988; Zebrowski et al., 1996; Torrington Eaton & Bernstein Ratner, 2013; Yaruss & Conture, 1995). To ‘‘entrain’’ or ‘‘align’’ means to draw another along with or after oneself, as in the case of accents. Various types of mutual influence phenomena have been reported in both adult-child and adult-adult conversations (Brennan & Clark, 1996; Hood & Bloom, 1979; Welkowitz, Bond, Feldman, & Tota, 1990). Characteristics of (non)verbal behaviours could ‘‘converge on or diverge from’’ those of one’s interlocutor, based on a theoretical framework known as communication accommodation (Torrington Eaton & Bernstein Ratner, 2013, p. 1752).

Bernstein Ratner (1992) investigated 20 mothers with their normally fluent preschoolers and found little to no rate entrainment. Guitar and Marchinkoski (2001) claimed this may have been as the mothers in Bernstein Ratner’s study only reduced rate by 25% from baseline. Guitar and Marchinkoski (2001) investigated six dyads of normally fluent preschoolers and their mothers using an ABAB single-subject design. They found that when mothers were trained to speak slower, they did so by more than 50%, averaging 5.0 sps in the baseline condition and 2.33 sps in the ‘‘slow’’ condition. When the group of mothers slowed down this much, five out of six of their normally fluent children rate-entrained, showing a significant group effect, but not a dramatic one. That is, these normally fluent children ranged from 4% to 28% articulation rate reduction from baseline.

In an investigation of rate entrainment in preschoolers who stutter, Stephenson-Opsal and Bernstein Ratner (1988) reported the effects of mothers’ slow rate model on their children’s fluency and articulation rate. Two boys who stutter and their mothers participated. Baseline recordings were obtained, mothers were taught to speak slower, and the findings revealed that as mothers slowed, the boys actually spoke faster than at baseline, and yet still spoke more fluently. Helmer (1995) corroborated these findings. The three children who stutter in Helmer’s study spoke more fluently when maternal rates were decreased, but the children’s rates were slightly increased; thus, no rate entrainment occurred. A single-case study of a 5-year-old girl who stutters (Guitar, Kopff Schaefer, Donahue-Kilburg, & Bond, 1992) resulted in similar findings. Both the mother and father participated in this study over a 4-month treatment span. Although both parents slowed, the girl’s articulation rate did not entrain to that of her parents. The girl in Guitar et al.’s study spoke more fluently with her slower-talking mother, but not with her slower-talking father.

Zebrowski et al. (1996) designed sessions with five dyads of mothers and their children who stutter, three boys and two girls, ages 2;10 to 7;5. The first two sessions were baseline, and in four subsequent sessions held weekly, mothers were taught to slow their speech rate, practiced doing so, and did so (i.e. Mdn = 30% reduction; 16–44% reduction from baseline) by the fifth and final sessions. Based on earlier reports that parents tend to shorten utterances and increase turn-switching pauses when they slow articulation rate (Bernstein Ratner, 1992; Guitar et al., 1992; Stephenson-Opsal & Bernstein Ratner, 1988), Zebrowski et al. (1996) attempted to keep samples standard, included structured conversations (Welkowitz et al., 1990) and included a sentence repetition task. Zebrowski and associates found high variability among the five individual dyads and only a slight trend toward what they called ‘‘entrainment’’. Three of the five children decreased their baseline articulation rates by 11–22%, in an apparent response to their mothers’ slower rates, and these were the only three of the five who showed improved fluency. The other two children in Zebrowski et al.’s study did not rate-entrain, and they also did not increase fluency in the maternal slow rate condition. One (C5) was a 5-year-old boy whose mother decreased her number of total spoken words from 200 to 54. This decrease had the apparent effect of increasing the child’s verbal assertiveness and in turn increasing his stuttering, as is known to occur (Kaanta, 1997; Weiss & Zebrowski, 1992). As for the other child (C1) who did not improve fluency, her mother reduced her rate in a natural manner, but she presumably did not achieve a close enough match to her child’s rate to facilitate fluency.

For children who stutter, one possible fluency-facilitating ingredient in an adult slow rate model is the achievement of a closer match or smaller ''dyadic speech rate gap'', which is the difference between an adult's and a child's speech rate (Kelly, 1994; Starkweather et al., 1990; Torrington Eaton & Bernstein Ratner, 2013; Yaruss & Conture, 1995; Zebrowski et al., 1996). Based on clinical data, Starkweather et al. (1990) estimated that matching within ±60 spm (i.e. within the span of one syllable per second) might be ideal, and empirical support for this estimate comes from Zebrowski et al. (1996). Zebrowski et al. (1996) found that a stuttering 5-year-old who started speaking the most fluently when compared to four peers had a mother who decreased her rate by 33% to achieve a dyadic rate match (i.e. a gap of ~3 spm or 0.05 sps). In contrast, a child who continued stuttering frequently in the maternal slow rate condition had a mother who also decreased her rate by 30%, but only achieved an average dyadic rate gap of +53 spm, which was perhaps still too high considering the upper limit guideline of +60 spm. Conture (2001) offered an analogy of merging cars, where, if an adult travels at a given speed and the child matches that speed, the child's fluency in merging and travelling with the adult is facilitated, but if the adult travels either much faster or much slower than the child, the merging and travelling will be a more accident-prone or disfluency-prone situation.

Yaruss and Conture (1995) investigated the naturally occurring fluent speech rates of 10 preschoolers who stutter and their mothers during conversations, where mothers were simply instructed to ''play as you would at home''. They used an adult–child adjacent utterance analysis procedure, claiming that this procedure represents the construct of entrainment as the first (adult) speaker immediately influences the second (child) speaker. They found that the larger the dyadic gap between a mother's and her child's speech rates, the greater severity of the child's stuttering. Yaruss and Conture's (1995) finding, paired with similar results reported by Kelly (1994) on fathers and their children who stutter, suggests that large dyadic speaking rate gaps may be negatively influential. Knowing which subgroups of stuttering children (e.g. severe versus mild; concomitant disorders versus none) would speak more fluently if a dyadic gap were minimised or ''closed'' would yield clinically and theoretically useful information.

Co-occurrence of stuttering and disordered phonology related to articulation rates

We need to know more about subgroups within the heterogeneous group of children who stutter (Miller & Guitar, 2009; Schwartz & Conture, 1988). One of the largest subgroups of children who stutter beyond that of severity and of persistent and recovery subgroups (Yairi & Ambrose, 1999) has been those with a concomitant phonological disorder, estimated to comprise 30–40% of the population of children who stutter (Arndt & Healey, 2001; Louko et al., 1990; Wolk, Edwards, & Conture, 1993; Wolk, Blomgren, & Smith, 2000). Wolk et al. (1993) measured articulation rate via words per minute (wpm), which can be converted to spm (i.e. 1.15 syllables per word on average in preschoolers; Yaruss, 2000). In this study, Wolk and associates (1993) compared three groups of seven preschoolers each, those who were S + NP, S + DP and normally fluent DP, and they found no diadochokinetic rate and no articulation rate differences across the groups, ranging from 3.59 to 3.62 sps. Yaruss and Conture (1996) compared 3- to 6-year-old boys who stutter and who had a concomitant phonological disorder (S + DP; $n = 9$) to boys who stutter with normal phonology (S + NP; $n = 9$). They also found no between-group articulation rate difference and similar sps ranges to the Wolk et al. (1993) study (i.e. S + NP: $M = 3.82$ sps; SD = 0.30 sps and S + DP: $M = 3.65$ sps; SD = 0.24 sps). In an investigation of normally fluent and normal phonology 2- to 4-year-old boys and girls, speakers of Australian English ($n = 10$), Robb et al. (2003) found a similar articulation rate average and variability of 3.68 (SD = 0.30) sps.

Overall, researchers have reported a range of 2.78–3.94 sps in 2- to 4-year-olds who do and do not stutter, and in those who do and do not have a phonological disorder (Amster, 1984; Dailey Hall et al., 1999; Flipsen, 2002; Pindzola, Jenkins & Lokken, 1989; Robb et al., 2003; Wolk et al., 1990). The slowest rates reported among these sps findings were from 2-year-old (i.e. 2.78 sps; Amster, 1984) and from the ''recovered stutterer'' subgroup (i.e. 3.18 sps; Dailey Hall et al., 1999). Phones per second (pps) seems a more appropriate, high-resolution measure and only three sets of researchers to date have reported pps data on the following samples: (a) preschoolers with no disorders (Walker et al., 1992); (b) preschoolers who stutter (Chon et al., 2012; Dailey Hall et al., 1999); and (c) preschoolers with speech sound disorders of unknown origin (Flipsen, 2002, 2003).

Some debate exists as to whether treatment is protracted in S + DP children (Conture, 2001; Louko et al., 1990; *cf*., Guitar & Miller, 2009), but there is agreement about the need for an appropriate clinical approach for treating both disorders, and how a slow rate model might be involved in that approach (Bernstein Ratner, 1995; Logan & LaSalle, 2003). The possibility that S + DP children could be talking at a slower articulation rate in pps at baseline (Flipsen, 2002, 2003; *cf*., Yaruss & Conture, 1996) would mean that S + DP children may not rate-align and thus respond as fluently as would S + NP peers if an adult slow rate model is used as the only treatment strategy.

Clinician's models to stuttering children with and without disordered phonology

Most data on modelled rate reduction with preschoolers who stutter has focused on parents, not clinicians. Logan, Roberts, Pretto, and Morey (2002), for example, focused on how best to train parents to slow their rate and increase naturalness. Setting the topic of parent-administrated programs aside, there are a few reasons to investigate the effect of clinicians' slow rate on stuttering preschoolers. First, when clinicians have done the appropriate assessment work, children who regularly meet with a clinician are more ''at-risk'' than those for whom we recommend that parents slow their rate, and be re-evaluated (Yairi & Ambrose, 2005). The parents of these children may have already tried slowing speech rate at home with limited success. Studying these children who are beyond ''borderline stutterer'' status (Guitar, 2014) would help expand clinical information. Second, disordered phonology puts a child who stutters at a higher risk for persisting in stuttering (Yairi & Ambrose, 1999), and so clinicians are an important conversational partner when treatment has been recommended. Third, parents and their children who stutter have a history of negotiating and coordinating interpersonal timing in an altered manner since the onset of the child's stuttering (LaSalle & Conture, 1991; Savelkoul, Zebrowski, Feldstein, & Cole-Harding, 2007; Torrington Eaton & Bernstein Ratner, 2013; Weiss, 2002), but clinician–child interactions are free of such histories.

Adult-modelled rate reduction is a frequently used strategy with preschoolers who stutter, with as yet, a limited evidence base. Furthermore, preschoolers who stutter and exhibit disordered phonology may require protracted and/or a different type of treatment than do children who only stutter (Bernstein Ratner, 1995; Logan & LaSalle, 2003; *cf*., Miller & Guitar, 2009). The literature shows that adults modelling a slow rate benefits some, but not all, young children who stutter (Zebrowski et al., 1996). Children who stutter show a slower articulation rate measured in phones per second (pps) than their peers who do not stutter (Dailey Hall et al., 1999). Flipsen's (2002, 2003) research has shown that children with speech sound (phonological) disorders of unknown origin speak slower in pps than normal phonology peers. Thus, perhaps children who stutter with a co-occurring phonological disorder differ from normal phonology peers who stutter in articulation rate alignment with adults' slow models, the benefit of these models to their fluency, or both. Specifically, if stuttering plus disordered phonology preschoolers already speak at a slow articulatory rate, there may be little to no benefit gained from adult rate reduction.

Purpose and research questions

The purpose of this study was to investigate the effects of clinicians' significantly slower speech rates on the articulation rate and fluency of 3- to 4-year-old clients who stutter, those with and those without a concomitant phonological disorder. The research questions were: (a) how do children who stutter and show normal phonology respond in fluency and articulation rate outcomes to their clinician's slow speech rate model, compared to children who stutter and show disordered phonology? and (b) how do the articulation rates in phones per second (pps) of the children who stutter, those with and without disordered phonology, compare to published normative pps data?

Methods

Participants

Six clinician–child dyads participated. The six clinicians were female graduate students in a university clinic who spoke Standard American English (SAE). The six children who stutter were 3- to 4-year-olds (Mdn age = 49.5; Range*:* 42–54 months), five boys and one girl, also from SAE-speaking families. All children were referred to the university clinic because of parental concerns about stuttering, and the children were rated moderate to severe on the *Stuttering Severity Instrument-3* (Riley, 1994). All children had persisted in stuttering for more than 9 months. They were classified as children who stutter based on the following criteria, determined at the time of evaluation: (a) produced 3+ within-word disfluencies or ''stutter-like disfluencies'' (SLDs, i.e. monosyllabic whole-word repetitions, sound-syllable repetitions, audible sound prolongations and blocks) per 100 syllables, based on an initial 1200-syllable conversational sample (Sawyer & Yairi, 2006; Sawyer, Chon, & Ambrose, 2008), and (b) child's caregivers believed the child to be ''stuttering''. All of the children's hearing acuity, cognitive, expressive and receptive language skills were within normal limits. Table 1 shows their diagnostic profiles.

Two of the boys and one girl were diagnosed with a phonological disorder, using two criteria to arrive at this diagnosis: (1) two or more age-inappropriate ''phonological processes'' were exhibited, and according to McReynolds & Elbert's (1981) operational definition of a ''phonological process'', there had to be at least four opportunities for the phonological process to apply, with at least 20% application on all opportunities (Louko et al., 1990); and (2) percent consonants correct-revised was less than 85% (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). The parents of these three children who presented with stuttering plus disordered phonology (S + DP) reported concern about both stuttering and their child's low intelligibility. All three S + DP children met all five of the inclusion criteria for ''children with speech delay with unknown origin'' used by Flipsen (2002). In addition to a mild phonological disorder, Participant ''FE'', a girl, demonstrated a hypo-nasal resonance disorder due to enlarged adenoids. None of the six children had received prior speech therapy for stuttering, phonology and/or the resonance disorder in the case of Participant ''FE''.

Design

This study is an A–B–A–B withdrawal treatment efficacy design, where the isolated treatment condition (B1, B2) is the clinician's use of a slow rate model that is significantly slower than that used at baseline or withdrawal (A1, A2) conditions. Six children, three with and three without a concomitant phonology disorder, were recruited to assess variable treatment effects.

Table 1. Demographic, speech fluency and phonology characteristics of the six children, 3- to 4-year-olds, who stutter.

Child	Sex	Age in months	Time since stuttering onset in months	SSI-3 score, severity and rank	PCC-R	Phonological processes (age-inapp. and atypical)	Phono. disorder
''A''	M	42	9	29 Severe 89–95th percentile	91%	None	No
''S''	M	45	20	22 Moderate 41st–60th percentile	90%	None	No
''J''	M	50	19	23 Moderate 41st–60th percentile	91%	None	No
''FE''	F	49	24	18 Moderate 41st–60th percentile	84%	Velar fronting; Cluster reduction	Yes
''D''	M	50	28	25 Moderate 61st–77th percentile	84%	Velar fronting; Cluster reduction; Interdentalisation	Yes
''JO''	M	54	24	19 Moderate 41st–60th percentile	82%	Velar fronting; Cluster reduction; Stopping of fricatives; Backing	Yes

The *Stuttering Severity Instrument-3* (SSI-3) (Riley, 1994) and Percent Consonants Correct-Revised (PCC-R) measure (Shriberg et al., 1997) were used.

The clinicians were trained in several group demonstration and practice sessions to speak slowly, as consistently and naturally as possible, so as to average between 2.0 and 3.3 syllables per second. Clinicians were trained to balance tasks of elongating word duration and using relatively frequent and longer pauses at linguistic boundaries (Logan et al., 2002; Tiffany, 1980).

Procedure

Each child's parent gave informed consent to participate. The research design was described to the parents as an early phase of an ''indirect'' or demands-capacity model-based treatment program (Conture, 2001; Richels & Conture, 2010) offered at the university clinic, lasting 1–2 months. The parents of the S + DP children were told that treatment for the child's phonology would begin after this ABAB phase. The standard set of recommendations given at the time of the evaluation to the parents about how to help their children at home were as follows: (1) allow the child to finish utterances; (2) recast the child's stuttered and mispronounced utterances; (3) slow your speech rate for at least 10 min a day every day; (4) encourage the child to play carrier phrase-based games (e.g. Memory; Go Fish) as these activities include shorter, less complex utterances which often generalise into better spontaneous fluency. The plan that was explained to the parents at the time of the evaluation was for each hour-long session to take place weekly, beginning 1–2 weeks following the evaluation. For all six children, the time span of the A1–B2 session/condition of the ABAB design was 4–9 weeks, with a median of 6.5 weeks, so that 1–2 weeks transpired between each session. This meant that 24 sessions were analysed, four per each of the six children.

Each session proceeded by allowing the child to choose two carrier-phrase-based games or activities to participate in for several 15- to 20-min segments across the hour. Standard toys and materials were used (i.e. flashlight and small toys or pictures, find-it game, find objects/picture cards in a bean box, Play-Doh, Mr. Potato Head). For the ''A'' baseline condition sessions, the clinician was instructed to use a naturally fast speech rate, and for the ''B'' slow model condition sessions, she was instructed to attain and maintain the slow natural-sounding rate by increasing pauses between phrases and elongating some words (Logan et al., 2002; Tiffany, 1980).

Data analysis

Each of the 24 digitally recorded four sessions, two baseline/withdrawal sessions, A1 and A2, and the two slow rate model sessions, B1 and B2, were reviewed per each of the six clinician–child dyads. Both clinician and child utterances were orthographically transcribed, and phonological transcription was used when words were mispronounced. The phonological transcription was then used to determine percent phonemes correct. All clinician utterances were selected that met the following criteria: (1) intelligible; (2) fluent; (3) did not include a pause >250 ms; (4) three or more words in length; and (5) immediately preceded a child utterance in a non-overlapped or non-interrupted manner. If the subsequent child utterance met all of same first four criteria, and the child's utterance was spontaneous (i.e. non-imitated, non-carrier phrase, e.g. Clinician: ''I found a lion''; Child: ''I found a tiger'' pairs were excluded), then an adjacent utterance pair (AUP) was identified. If all five of the criteria were met for the clinician and the child utterances, that AUP was selected for articulation rate measurement, as per the methods of Yaruss and Conture (1995). Table 2 shows, for the two subgroups of S + NP and S + DP, the number of AUPs obtained per dyad and the number of consecutive 100-syllable samples obtained per child, and then the number in medians and ranges of stuttering-like disfluencies (SLDs) produced by each child.

The top of Table 2 displays the number of AUPs per dyads in each subgroup. The number of AUPs was evenly distributed across A and B conditions (i.e. percentages of AUPs occurring in each condition ranged from 0.20 to 0.32 for the S + NP dyads, and 0.16 to 0.31 for the S + DP dyads). However, the S + DP children and their clinicians produced significantly ($z = -2.64$; $p = 0.004$) more analyzable AUPs (Sum = 325; Mdn = 108; Range = 94–123) than their S + NP peers (Sum = 164; Mdn = 47; Range = 40–77). This difference could have been due to the inclusion of S + NP Child ''A'' who was rated as ''severe'', wherein many of his utterances were disfluent and thus excluded. Because of significantly more AUPs occurring in the S + DP dyads than in the S + NP dyads, AUPs were limited to the lowest common denominator, equal to 40 AUPs per dyad. Forty AUPs were then randomly selected across all four conditions per dyad, retaining all AUPs per condition when AUPs $\leq$10 per condition.

To determine the dependent variable or treatment effects, each occurrence of a stuttering-like disfluency (SLD; i.e. a monosyllabic word repetition, sound-syllable repetition, audible sound prolongation and block) was coded to determine stutter frequency per 100 syllables. Utterances were counted by syllables, excluding syllables involved in revisions and iterations of repetitions, and rounded to the nearest 100, with the intent of collecting the longest possible speech sample across the hour session or condition, as per the methods of previous researchers (Sawyer & Yairi, 2006; Sawyer et al., 2008). Table 2, middle section, shows how many 100-syllable samples were collected across the hour for each child in each group. In a similar pattern to the differences found in AUP numbers, there was an even distribution across A and B conditions (i.e. proportions of total 100-syllable samples collected ranged from 0.19 to 0.30 for the S + NP children and 0.20 to 0.28 for the S + DP children). However, the S + DP children provided significantly ($z = -2.00$; $p = 0.02$) more analyzable 100-syllable samples (Sum = 135; Mdn = 40; Range = 46–49 100-syllable samples) than their S + NP peers (Sum = 86; Mdn = 34; Range = 16–36 100-syllable samples). In Table 2, the bottom third shows the median and range of SLDs/100 syllables each child produced across all 100-syllable samples using the original 221 000 total syllables.

Table 2. The top chart displays the number of adjacent utterance pairs per dyad, per condition, per subgroup, i.e. children who stutter with normal phonology (S + NP) and children with disordered phonology (S + DP).

	Clinicians and S + NP children: number of adjacent utterance pairs				Clinicians and S + DP children: number of adjacent utterance pairs			
Condition (1 hr)	"A"	"S"	"J"	Totals	"FE"	"D"	"JO"	Totals
Base1	7	7	21	35	34	10	27	71
Slow1	7	10	26	43	42	28	32	102
Base2	14	13	26	53	21	35	43	99
Slow2	12	17	4	33	11	21	21	53
Totals	40	47	77	164*	108	94	123	325*
Totals/Group		164				325		

	S + NP children: number of 100-syllable spontaneous samples				S + DP children: number of 100-syllable spontaneous samples			
Condition (1 hr)	"A"	"S"	"J"	Totals	"FE"	"D"	"JO"	Totals
Base1	4	8	4	16	16	5	15	36
Slow1	9	13	4	26	12	6	10	28
Base2	11	6	4	21	12	14	12	38
Slow2	10	9	4	23	6	15	12	33
Totals	34	36	16	86	46	40	49	135
Totals/Group		86				135		

	S + NP children: median and range of SLDs/100-syll in spontaneous samples				S + DP children: median and range of SLDs/100-sylls in spontaneous samples			
Condition (1 h)	"A"	"S"	"J"	Mdn	"FE"	"D"	"JO"	Mdn
Base1	17 (12–25)	24 (10–27)	4.5 (4–6)	17 (4–27)	6 (4–8)	14 (10–17)	6 (1–10)	6 (1–17)
Slow1	10 (3–20)	11 (6–17)	2 (1–3)	10 (1–20)	2 (0–12)	6 (1–8)	2 (0–6)	2 (0–12)
Base2	15 (9–25)	16 (4–19)	12.5 (3–14)	15 (3–25)	7.5 (5–12)	5 (1–18)	6 (3–13)	6 (1–18)
Slow2	4.5 (3–15)	4 (2–7)	1.5 (1–3)	4.5 (1–15)	2 (1–4)	7 (1–20)	6 (1–14)	6 (1–20)
Mdn of Baselines	16 (9–25)	20 (4–27)	8.5 (3–14)	16 (3–27)	6.75 (4–12)	9.5 (1–18)	6 (1–13)	6.75 (1–18)
Mdn of Slow conditions	7.25 (3–20)	7.5 (2–17)	1.75 (1–3)	7.25 (1–20)	2 (0–12)	6.5 (1–20)	4 (0–14)	4 (0–20)
Mdn ($N = 4$)	12.5 (3–25)	13.5 (2–27)	3.25 (1–14)	12.5 (1–27)	4 (0–12)	6.5 (1–20)	6 (0–14)	6 (0–20)

As indicated with a *, S + DP dyads contributed significantly ($p = 0.004$) more adjacent utterance pairs. The middle chart shows the number of 100-syllable spontaneous samples collected from the child across each hour-long condition. In the bottom chart, the median and range of stuttering-like disfluencies (SLDs) per 100 syllables (100-syllable) are shown.

These uneven samples of spontaneous speech for single subject design analysis showed a need to equate opportunities to stutter between the S + DP and S + NP children. While Sawyer and Yairi (2006) and Sawyer et al. (2008) recommend at least 600 syllable samples in preschoolers who stutter, the one S + NP child ''J'', who was less spontaneous but relatively fluent, produced only 400 syllable samples in each of the four sessions. Thus, 400 spontaneous syllables was the least common denominator used per session. The decision of how to truncate samples that ranged from 1600 syllables (Child ''J'') to 4900 syllables (Child ''JO'') was based on prior evidence. Sawyer and Yairi (2006) observed an upward fluctuation in number of stuttering-like disfluencies (SLDs) per 100 syllables after 600 had been produced and Sawyer et al. (2008) found that preschoolers produced significantly longer utterances in later samples, so it was clear that the sample should be truncated by removing early utterances. Thus, either all of the 400 syllable samples or the middle 400 syllable samples were selected for display in the ABAB plotting. When there was an odd number of 100 syllable samples, a greater number before the middle 400 syllables were excluded, rather than after (e.g. Child ''S'' produced 1300 syllables in the Slow1 condition; thus, the initial 500 were excluded, the next 400 retained and the remaining 400 syllables excluded).

Phones and syllables were counted according to procedures explained by prior researchers. Actual phonemes were counted (e.g. [bu] for /blu/ = 2 phonemes (e.g. Flipsen, 2002, 2003; Dailey Hall et al., 1999; Kloth et al., 1998). The duration of each utterance was acoustically determined using a spectrographic display on Praat software (www.praat.org; Boersma & Weenink, 2011), using a 44 100 Hz sampling rate. Utterance onset was operationally defined as the first peak in the waveform, and utterance offset as the last peak in the waveform, corresponding to a burst and termination of spectral energy. Utterance onset and offset times were decided based on two criteria: (1) all visible energy in less easily measurable phones (e.g. trailing fricatives) was captured, and (2) all phones in the utterance were judged intact when the segment was played-back. Then the corresponding duration in milliseconds was saved for each of the clinicians' and children's utterances in the AUPs per session. To determine treatment fidelity, phones per second (pps) measures were made of the clinicians' articulation rates in baseline (A) and Slow (B) conditions, yielding a clinician articulation rate reduction median of 38% (Range = 28–46% reduction from baseline).

To determine potential threats to internal validity that clinicians' or children's utterance lengths might have contributed, Wilcoxon signed-ranks tests were computed for the baseline (A) versus slow (B) conditions for the clinicians' and the children's average utterance length in syllables and in phonemes. No significant differences ($p > 0.05$) were found between the median length of the clinicians' utterances in syllables or in the phones in the A (Mdn = 6.5; Range = 5.25–8.75 syllable/utterance; Mdn = 17.13; Range = 12.0–19.75 phones/utterance) versus B (Mdn = 5.5; Range = 4.5–7.5 syllable/utterance; Mdn = 12.5; Range = 11.5–16.5 phones/utterance) conditions. Also, there were no differences ($p > 0.05$) between the median length of the children's utterances in syllables and phones in the A (Mdn = 5.34; Range = 4.5–6.0 syllable/utterance; Mdn = 13.13; Range = 10.5–13.75 phones/utterance) versus B (Mdn = 5.0; Range = 4.25–5.5 syllable/utterance; Mdn = 11.4; Range = 9.5–13.0 phones/utterance) conditions.

Inter- and intra-judge reliability

Dailey Hall et al. (1999) report 100% agreement within ±3 ms, so this standard was followed for data re-measurement before submitting the utterances to statistical analyses. A graduate research assistant independently verified the author's original measures, and disagreed-upon utterances were identified. Disagreements included acoustic utterance duration differences that exceeded ±3 ms or any transcription/fluency judgment differences. All disagreed-upon utterances were re-measured until agreement could be reached. During this re-measurement process, 36 of the original 489 UPs (7.4%) were excluded because of inter-observer differences in three areas: (1) transcription differences that affected syllable and phone counts; (2) fluency differences, that is, both adult and child utterances had to be perceived as completely fluent by both judges (i.e. author and research assistant) in order to be included (i.e. no repetitions, prolongations or idiosyncratic, non-conventional pauses); and (3) utterance duration differences still exceeding ±3 ms even after the two judges attempted to be reach agreement through repeated listening. Following this stringent reliability procedure meant that there was 100% agreement for all sps and pps measures.

The presence or absence of SLDs and their types was re-measured by the author (intra-judge) and by the graduate assistant (inter-judge) on a randomly selected 20% of the recordings (i.e. 5 min segments across all 24 sessions) and agreements were corrected for chance using Cohen's Kappa: 0.693–0.905 (i.e. ''good to excellent'').

Statistical analysis

Campbell (2004) offers three effect sizes to be computed for single-case designs: mean baseline reduction (MBLR), percentage of non-overlapping data (PND) and percentage of zero data (PZD). Because PZD measures behaviour suppression rather than reduction (i.e. from ≥3 stutters/100 syllables to 0–2 stutters per 100 syllables), it was not considered appropriate to use in this study due to its sensitivity to disparate baseline stutter frequency evidenced by the six participants. The other two of Campbell's (2004) effect sizes were considered appropriate for the purposes of this study, as well as a third – effect size calculation (Meline, 2010). These three effect sizes were calculated as follows:

(1) Mean baseline reduction (MBLR) $= M_A - M_B/M_B \times 100$, per participant or per group: $M_A =$ the mean of stutters/100 syllables (''stutter frequency'') at baseline (A1 + A2) and $M_B =$ the mean stutter frequency at Treatment (B1 + B2; Campbell, 2004).
(2) Percentage of non-overlapping data (PND) = per participant, the percentage of treatment data points (B1 and B2) that do not overlap with baseline (A1 and A2) data points (Campbell, 2004).
(3) Effect size: Calculation $M_B - M_A/SD_A$ was used, where $M_B =$ Mean stutter frequency at Treatment (B1 + B2), $M_A =$ Mean stutter frequency at baseline (A1 + A2), and their difference is divided by the Standard Deviation at baseline (Meline, 2010).

Median baseline articulation rates from the S + NP group (Mdn = 3.15 sps; Range = 2.74–3.56 sps; Mdn = 8.15 pps; Range = 7.47–8.35 pps) and from the S + DP group (Mdn = 3.03 sps; Range = 2.88–3.15 sps; Mdn = 6.93 pps; Range = 7.47–8.35 pps) were compared. While the average pps articulation rate appeared appreciably slower in the S + DP group (6.93 pps) than in the S + NP group (8.15 pps), the Mann–Whitney *U* non-parametric test for the significance of the difference between the distributions of these two independent samples, was insufficient at an $n = 3$ per group. Therefore, *Z*-scores were used to compare the baseline articulation rates of the present sample to the means and standard deviations for pps and sps from 10 samples of 4-year-old children who stutter with and without disordered phonology available through three publications. These included five published subgroups: the S + DP children from Yaruss and Conture (1996); the children who stutter who recovered and persisted and the matched control children who did not stutter, seen at initial visit (ages 37–58 months) and at 1-year follow-up (ages 49–70 months) from Dailey Hall et al. (1999); and DP-only children from Flipsen (2002). A Bonferroni correction was made to an overall alpha of 0.05 divided by 36 comparisons [i.e. 2 groups, S + NP and S + DP, ×2 articulation rate measures, pps and sps, ×10 samples, minus 4 comparisons not made because

Yaruss & Conture (1996) only measured sps]. Thus a two-tailed $p = 0.0014$ was set, so a z-score had to exceed 3.19 to reject the null hypothesis of no difference between other sample articulation rate data and the present data.

Results

Figure 1 shows the dyads of clinicians and children who stutter with normal phonology (S + NP) and Figure 2 shows dyads of clinicians and children who stutter with normal phonology (S + DP). Table 3 shows the phones per second (pps) articulation rate data for both the clinicians and the

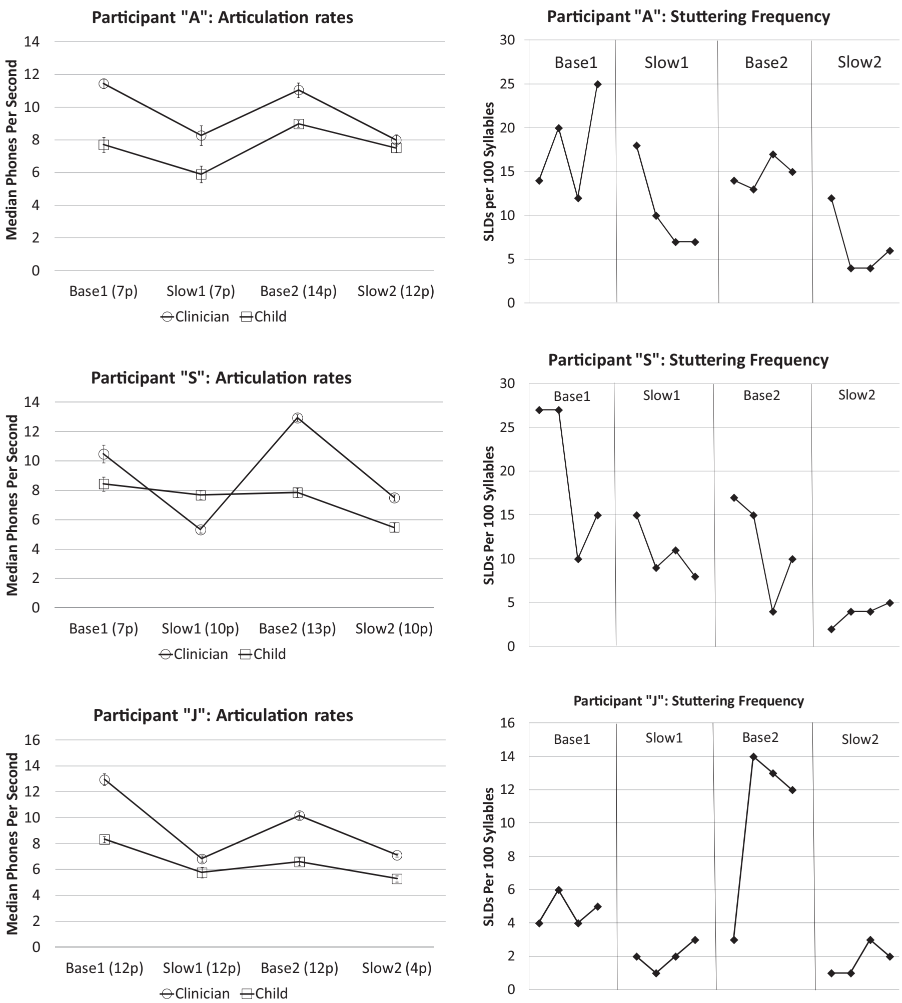

Figure 1. Dyads of clinicians and children who stutter with normal phonology (S + NP) for each of the three children. On the left is a plot of the median phones per second (p/s) of the clinician's and the child's articulation rate for a random selection of between 4–13 adjacent utterance pairs (p) per session, totalling 40 adjacent utterance pairs (p) per dyad. On the right is the frequency of the child's stutter-like disfluencies (SLD) per 100 syllables, during the approximate middle consecutive 400 syllables, plotted against each of the ABAB segments (i.e. A1, A2 = ''Base1'', ''Base2''; B1, B2 = Clinician's slow rate model use or ''Slow1'' ''Slow2'').

children. As can be seen in Table 3, clinicians paired with the S + NP children reduced articulation rate in pps by a median of 38.8% (Range: 27.7–45.6%), and the S + NP children ‘‘rate-aligned’’, that is, they reduced their pps rate along with the clinician by a median of 19.9% (Range: 19.6–25.4%). However, while clinicians with the S + DP children also reduced their pps rate by a similar average (Mdn = 37.8%; Range: 36.4–46.2%), the S + DP children did not rate-align, that is, they averaged only a 1.3% rate reduction (Range: 16% decrease to a 1.2% increase). This can also be seen in Figure 1.

For stuttering frequency reduction, the effect size was larger for S + NP participants (i.e. $M_B - M_A/SD_A = [5.88 - 13.17]/6.94 = -1.05$) than for S + DP participants (i.e. $M_B - M_A/SD_A = [4.58 - 7.54]/3.16 = -0.94$), as can be confirmed through visual inspection of the two figures. When all 100-syllable samples were included, S + NP children showed an even larger

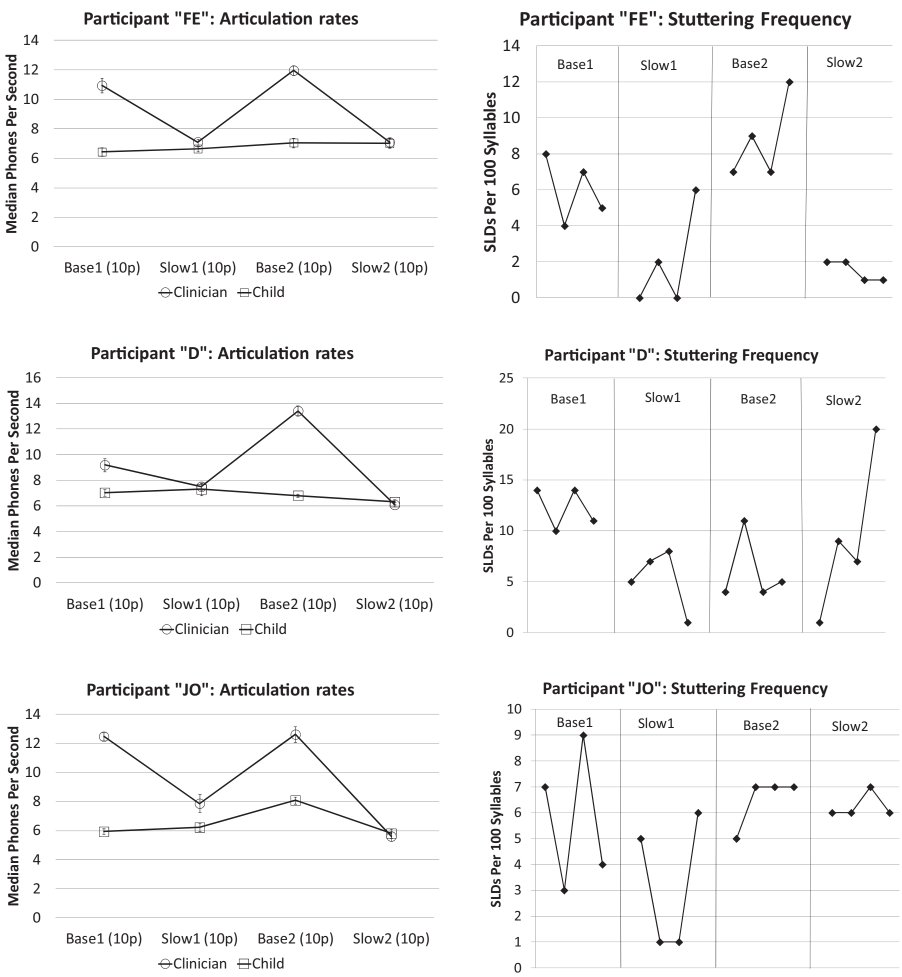

Figure 2. Dyads of clinicians and children who stutter with disordered phonology (S + DP) for each of the three children. On the left is a plot of the median phones per second (p/s) of the clinician’s and the child’s articulation rate for a random selection of between 4–13 adjacent utterance pairs (p) per session, totalling 40 adjacent utterance pairs (p) per dyad. On the right is the frequency of the child’s stutter-like disfluencies (SLD) per 100 syllables, during the approximate middle consecutive 400 syllables, plotted against each of the ABAB segments (i.e., A1, A2 = ‘‘Base1’’, ‘‘Base2’’; B1, B2 = Clinician’s slow rate model use or ‘‘Slow1’’ ‘‘Slow2’’). Participant ‘‘FE’’ is the only girl participant in the study.

Table 3. Phones per second (pps) and percent change from baseline (Base1, Base2) to Slow (1,2) condition per each stuttering and normal phonology (S + NP) child dyad and per each stuttering and disordered phonology (S + DP) dyad.

	S + NP dyads: Phones per second (pps) and % change								
	"A"			"S"			"J"		
	Clinician		Child	Clinician		Child	Clinician		Child
Base1 pairs		7			7			12	
Base1 pps	11.45		7.71	10.48		8.44	12.95		8.33
Slow1 pairs		7			10			12	
Slow1 pps	8.27		5.90	5.32		7.67	6.82		5.76
% Change1	−27.8%		−23.5%	−49.2%		−9.1%	−47.4%		−30.9%
Base2 pairs		14			13			12	
Base2 pps	11.06		8.98	12.93		7.86	10.18		6.60
Slow2 pairs		12			10			4	
Slow2 pps	8.00		7.52	7.50		5.49	7.11		5.28
% Change2	−27.7%		−16.3%	−41.2%		−30.2%	−30.3%		−20.0%
M % change	−27.8%		−19.9%	−45.6%		−19.6%	−38.8%		−25.4%
Clinicians	Mdn = 38.8% (range: 27.8–45.6% rate reduction)								
Children	Mdn = 19.9% (range: 19.6–25.4% rate reduction)								
	S + DP Dyads: Phones per second (pps) and % Change								
	"FE"			"D"			"JO"		
	Clinician		Child	Clinician		Child	Clinician		Child
Base1 pairs		10			10			10	
Base1 pps	10.94		6.45	9.20		7.04	12.48		5.94
Slow1 pairs		10			10			10	
Slow1 pps	7.11		6.66	7.52		7.31	7.87		6.23
% Change1	−35.0%		+3.3%	−18.3%		+3.7%	−36.9%		−4.7%
Base2 pairs		10			10			10	
Base2 pps	11.96		7.07	13.42		6.82	12.62		8.09
Slow2 pairs		10			10			10	
Slow2 pps	7.10		7.02	6.10		6.32	5.61		5.81
% Change2	−40.6%		−0.7%	−54.5%		−7.3%	−55.5%		−28.2%
M % change	−37.8%		+1.3%	−36.4%		−1.8%	−46.2%		−16.4%
Clinicians	Mdn = 37.8% (range: 36.4–46.2% rate reduction)								
Children	Mdn = 1.82% (range: +1.27 increase to a 16.4% rate decrease)								

effect size ($M_B - M_A/SD_A = -1.14$) of improved fluency in the Slow condition than did S + DP children (−0.61).

Mean baseline reduction (MBLR; $M_A - M_B/M_B \times 100$) was computed per participant and per group. All three S + NP Participants showed a MBLR that was ≥91% stutter reduction from baseline: Child A showed a 91.2%, Child S, an 115.5% and Participant J, a 306.7% MBLR. Only one of the three S + DP participants, the girl, "FE", showed ≥91% MBLR, at a 321.4% decrease of stuttering frequency. In contrast, the S + DP boy "D" showed only a 25.9% and S + DP boy "JO" showed only a 28.9% stutter reduction from baseline. S + NP participants as a group showed a greater Mean baseline reduction of 124.1% ($M_A = 13.2$; $SD_A = 6.9$; $M_B = 5.9$; $SD_B = 4.6$ SLD/100 syllable) than did S + DP participants, at 64.5% ($M_A = 7.5$; $SD_A = 3.2$; $M_B = 4.6$; $SD_B = 4.4$ SLDs/100 syllable).

In terms of the percentage of non-overlapping data (PND), in the S + NP group, Child "A" and "J" (6/8 = 75%) showed better treatment effects or less variable stuttering than did Child

Table 4. Articulation rates in phones per second (pps) and syllables per second (sps) from children who stutter with normal phonology (S + NP) and children who stutter with disordered phonology (S + DP). Means and standard errors from the present sample are compared to published samples in publication order (i.e. Yaruss & Conture, 1996; Dailey Hall et al., 1999; Flipsen, 2002).

	pps	sps
Present sample		
• S + NP (*n* = 3) (42–50 mos)	7.99 (0.27)	3.15 (0.24)
• S + DP (*n* = 3) (49–54 mos)	6.90 (0.07)*	3.02 (0.08)
Yaruss & Conture (1996)		
• S + NP (*n* = 9) (49–82 mos)	–	3.82 (0.10)
• S + DP (*n* = 9) (45–74 mos)	–	3.65 (0.08)
Dailey Hall et al. (1999)		
• CWNS (*n* = 8) Initial visit ''control''/(37–55 mos)	11.42 (0.98)	3.84 (0.16)
• CWNS (*n* = 8) 1-year-visit ''control''/(49–67 mos)	12.17 (0.74)	3.94 (0.28)
• S-Only (*n* = 8) Initial visit ''persistent'' (39–55 mos)	9.56 (0.44)	3.84 (0.18)
• S-Only (*n* = 8) 1-year-visit ''persistent'' (51–67 mos)	9.66 (0.41)	3.94 (0.16)
• S-Only (*n* = 8) Initial visit ''recovered'' (38–58 mos)	7.68 (0.38)	3.18 (0.20)
• S-Only (*n* = 8) 1-year-visit ''recovered'' CWS (50–70 mos)	9.78 (0.22)*	3.87 (0.11)
Flipsen (2002)		
• DP-Only (*n* = 17) ''Early follow-up'' (35–63 mos)	7.65 (1.18)	3.35 (0.44)
• DP-Only (*n* = 36) Late follow-up (39–71 mos)	7.81 (1.02)	3.43 (0.43)

*Significant at $p < 0.004$.

''S'' (1/8 = 12.5%). In the S + DP participants, the only one with a high PND was ''FE'' a girl (7/8 = 87.5%). The other two S + DP children who were boys showed low to no effects using this PND measure: (''D'' and ''JO'': 2/8 = 25%).

Table 4 shows the results of comparing the baseline articulation rates from the S + NP group and from the S + DP group to each of the available published samples. The only difference found that reached statistical significance ($z = -4.63$; $p < 0.0014$) was that the three S + DP children, ages 49–54 months, in the present sample spoke at a slower articulation rate in pps ($M = 6.90$ pps; SE = 0.07 pps) than did the eight slightly older (50–70 months old) children who eventually recovered from stuttering from the Dailey Hall et al. (1999) longitudinal study, a group that showed relatively low variance ($M = 9.78$ pps; SE = 0.22 pps), compared to the control group ($M = 12.17$ pps; SE = 0.74 pps; Table 4).

Discussion

Articulation rate alignment and fluency effects of S + NP and S + DP children

In the present findings, the focus was on articulation rate measured in phones per second. Using this measure, children who stutter with normal phonology (S + NP) averaged a 20% rate reduction, which aligned with their clinicians' 38% rate reduction and greater fluency facilitation. This finding was in contrast to children who stutter with disordered phonology (S + DP) who did not rate align. This relatively low child articulation rate reduction, which ranged up to 31%, was similar to that found by Guitar and Marchinkoski (2001) in six normally fluent children, where children's maximum rate reduction was 28% from baseline. The present data on the dependent variable of fluency appear consistent with previous results showing that some but not all stuttering children tend to speak more fluently when a caregiver slows (Helmer, 1995; Stephenson-Opsal & Bernstein Ratner, 1988; Torrington Eaton & Bernstein Ratner, 2013; Zebrowski et al., 1996). The contribution of this study is that the S + NP dyads showed improved fluency in the B (''slow'') condition through a larger effect size, higher mean baseline stutter reductions and lower percentages of non-overlapping data than did the S + DP dyads. The S + DP girl showed improved fluency in the B (''slow'') condition compared to the S + DP boys. The data presented here suggests that because S + DP children are already relatively slow talkers as measured in pps, they do not respond to adult rate reduction as do S + NP children. S + DP preschoolers may be less likely than S + NP preschoolers to show articulation rate alignment and improved fluency, with several qualifications discussed below.

In the present results, children's articulation rate reduction was 2–3 phonemes per second (pps) at the most, whereas clinicians who were trained and instructed to slow articulation rate reduced as much as 5–7 pps (Figures 1 and 2). The current data reflect the statement made by Zebrowski et al. (1996): ''A 'significant' decrease in speech rate for stuttering children who are already producing articulatory rates within normal limits to begin with... might not be feasible or advisable (p. 203)''. That is, an adult who reduces articulation rate may be slowing enough relative to the child's rate to ''close the gap'' (i.e. attain a dyadic gap under one syllable per second or ±60 spm), and that small gap or closer match may be enough to facilitate child fluency. Using Conture's analogy, a car merging into traffic from a freeway onramp needs to be at the same speed as other cars so as not to disaffect the fluency of traffic. Dyadic articulation rate gaps were ''closed'' in 5/6 out of the slow conditions for the S + DP dyads (Figure 2) but only closed in 2/6 of the slow conditions for the S + NP dyads, and yet greater fluency facilitation occurred in the S + NP dyads. The S + DP girl was an exception, showing fluency improvement. This data implies that the fluency facilitating effect of dyadic rate matching is nuanced.

It is possible that caregivers may not slow articulation rate enough with stuttering children. Guitar and Marchinkoski's (2001) data showed that caregiver rate reduction has to exceed 25% to improve fluency. Present results of an average 38% pps articulation rate reduction (Range = 18–56%; Table 3) suggest that clinicians are no better and no worse than parents at slowing their own articulation rates (Guitar & Marchinkoski, 2001; *cf*. Zebrowski et al., 1996).

Fluency facilitation in stuttering children with and without disordered phonology

Based on visual inspection of all participants in both Figures 1 and 2, and from the three effect sizes computed, four out of the six, all but ''D'' and ''JO'', showed improved fluency when clinicians slowed their rate. This present finding corroborated results of Zebrowski et al. (1996) and Helmer (1995), who also found that 4 out of 5, to 4 out of 6 stuttering children improved fluency in response to maternal slow rate models. Different explanations have been offered as to why about a third (i.e. 33–40%) of the children does not improve fluency. Helmer (1995), for example, posited that the one boy showing no fluency gain in her study was the oldest of the three boys, a 7-year-old, who may have reached the point in stuttering progression where maternal slow rate model no longer facilitates fluency. However, the 7-year-old in Zebrowski et al.'s study did speak more fluently, apparently in response to maternal slow rate. Instead, two others (4- and 5-year-old) of the five children in this study were the no-fluency-gainers. Zebrowski et al. (1996) explained that they were no fluency-gainers for these possible reasons: (a) too large of a dyadic speech rate gap and (b) too drastic of a reduction in maternal verbal output, engendering greater verbal assertiveness on the part of the child. In contrast, in this study, only 3- and 4-year-olds were included, clinician–child dyadic gaps were ideal in all ''Slow'' condition sessions, the clinicians spoke frequently enough to produce representative rate samples, so as not to allow too much verbal assertiveness from children who stutter. Finally, clinician and child utterance lengths were essentially equivalent within and across conditions and groups.

The two children presented here who did not improve fluency, ''D'' and ''JO'' were both boys from the S + DP group. The only S + DP child who improved fluency in the slow condition was a girl, ''FE''. The most fluent child of the five in the Zebrowski et al. study of maternal rate modifications was a girl. Girls who stutter are more likely than boys to spontaneously recover, all other factors being equal (Ambrose, Yairi, & Cox, 1993; Bloodstein & Bernstein Ratner, 2008). There are three other noteworthy differences in these two S + DP participants who did not show improved fluency, ''D'' and ''JO''. First, in terms of their phonology, as can be seen in Table 1, while they all had similar percent consonants correct (PCC) scores, D and JO demonstrated 3–5 phonological processes, compared to FE's two processes. Second, as can also be seen in Table 1, D and JO had a reported time since onset of stuttering of 28 and 24 months, respectively, whereas the three boys in the S + NP group averaged a 19-month time since onset (Range = 9–20 months). Third, as can be seen in Figure 2, D's and JO's articulation rate showed a lower variability (~6 to 8 pps) in across both baseline and treatment sessions, whereas the three boys in the S + NP group showed ~5 to 9 pps range. This difference lends support to Flipsen's (2002) conclusions that a disordered phonology diagnosis entails a slower and possibly less variable pps rate than normal.

Longitudinal data from Kloth et al. (1998) lend support for the possibility that it might be the child's articulation rate that matters more than adult–child dyadic rate matches. Kloth et al. researched 26 very young children genetically predisposed to stutter who began stuttering as they were being tracked. They found these children to be speaking significantly faster pre-stuttering onset, averaging 3.68 sps (SD = 0.50), as compared with their normally fluent peers, who averaged 3.45 sps (SD = 0.42). As the mothers of these children did not differ in their maternal articulation rates, mother–child dyadic rate gaps were equally larger than ideal for both the stuttering children (+2.03 sps gap) and for the normally fluent children (+2.13 sps gap). Kloth et al.'s (1998) data support the possibility that a fast child articulation rate could trigger stuttering onset, which would imply that getting a child to reduce his/her articulation rate could improve fluency. Based on the results of this single-case research study, it is still an open question as to whether clinicians should: (a) model a slower rate and monitor whether or not a child has passively achieved rate alignment, and more importantly, greater fluency and intelligibility; or (b) help the child achieve a slower articulation rate via more direct or ''active'' means, such as teaching ''turtle talk'' (Gottwald, 2010; *cf*. Torrington Eaton & Bernstein Ratner, 2013). Certainly, it is important to consider the active and passive roles of the child with stuttering and disordered phonology, both of which need addressing in therapy. There are at least a couple tutorials on how to conceptualise work with children who stutter and show a concomitant (Bernstein Ratner, 1995; Logan & LaSalle, 2003).

Limitations

Several limitations of this study require consideration. First, parents were given a standard set of recommendations at the time of the evaluation, and yet no systematic monitoring took place across the approximate 6-week time span of this study to determine the extent to which parents followed-through with these recommendations. Thus, it is possible that results were influenced by parents' differential use of techniques at home. There could also be some influences of ''slow-to-warm-up'' or sensitivity temperament differences between preschoolers who stutter with their clinicians versus with their more familiar parents (*cf*., Tumanova et al., 2011).

Second, as this was a single case research design, the potential breadth of learning about a larger group of stuttering children was sacrificed for learning in depth how each of the six children who stutter responded to their clinicians' slow rate. Group ranges and medians are reported here as a way to compare the three children who stutter and showed a phonological disorder to the three who did not, and yet a higher level of evidence could be obtained from recruiting larger subgroups of children who stutter, completing and by systematic reviews.

Third, the number of adjacent utterance pairs and 100-syllable samples were reduced to a least common denominator to correct for unequal sample sizes. As can be seen in Table 1, S + DP children were milder in stuttering severity than S + NP children, and S + DP children had a longer time since onset, both of which are recruitment and selection concerns.

Future research considerations

In the present methods, the fluency of 221 000 syllables was originally analysed, based on 8600 syllables from the 12 sessions of the S + NP children and 13 500 syllables from the 12 sessions of the S + DP children before the samples were truncated to an approximate middle 400 syllables per child per condition (i.e. a total of 9600 syllables for fluency analysis). S + NP children spoke more disfluently (Mdn = 16–17; Range*:* 4–27 SLDs/100 syllable) in the first averaged baseline sessions than did the S + DP children (Mdn = 6–7; Range*:* 1–18 SLDs/100 syllable; 0 syllable), as well as in the truncated samples (S + NP children: Mdn = 16; Range = 9–17 SLDs/100 syllable, versus S + NP children: Mdn = 7; Range = 6–9 SLDs/100 syllable).

Some prior findings show that S + NP and S + DP groups are similar in average stutter frequency, when collected from children in mother–child conversations (Louko et al., 1990; Yaruss & Conture, 1996; *cf*., Wolk et al., 1990). As these early reports used words rather than syllables, the 1.15 syllable-to-word conversion (Yaruss, 2000) is used here for comparison: Louko et al.'s (1990) 12 S + DP children averaged 11.25 (SD = 5.3) SLDs, and 18 S + NP children averaged 11.3 (SD = 4.95) SLDs per 100 syllables. Yaruss and Conture (1996) found in two groups of nine preschoolers each, that both groups averaged 11 SLDs (i.e. S + DP: 11.3 [SD = 3.1] and S + NP: 11.0 [SD = 3.9] SLDs per 100 syllables). In a study of seven S + DP 4- and 5-year-old boys with no control group, Wolk et al. (2000) found a median of 10.4 (Range = 8.1–40.3) SLD/100 syllables. However, present findings that S + NP children showed a higher stutter frequency than S + DP children corroborates the findings of Wolk et al. (1993), who found that seven S + NP children averaged 27 SLDs per 100 syllables and seven S + DP children averaged 18 SLDs/100 syllable. These findings of a higher stuttering frequency in S + NP than in S + DP warrants future investigation, and an appropriate theoretical framework is needed to organise current findings about the differences between these two subgroups.

One important consideration for future researchers is choosing how phones per second have been measured. The present investigator followed the apparent methods of Dailey Hall et al. (1999), Flipsen (2002, 2003) and Tiffany (1980) by counting actual phones and allophones produced by the speaker. Walker et al. (1992), however, did not provide sufficient clarity of their methods for phone counts. When a child with a phonological disorder deletes final consonants and reduces consonant clusters, then ''You need blue'' produced as [ju ni bu] in 0.971 s could either be calculated as 6.18 p/s (6 produced phones/sec, as has been done thus far), or as 8.24 p/s (8 intended/target phonemes/s), quite a wide discrepancy. Intended or target phonemes per second might be a more robust measure of articulation rate for future researchers to add, considering that Flipsen (2002, 2003) discussed the possibility of artefacts of cluster reduction in his sample of children with Speech Delay of unknown origin. All three of the S + DP children in this study reduced consonant clusters, so the same artefact that Flipsen noted was present here. Based on his follow-up data, Flipsen (2003) was able to infer that children with speech delay may begin speaking at a slow rate, due to slower motoric ability and/or due to deleted phonemes effecting the calculation, but then catch up to typically developing peers as they either gain articulatory speed or produce formerly deleted phonemes. Reducing the artefact of deleted phonemes in future research would clarify the same type of issue that has been a source of confusion with speakers who clutter and evidence a high occurrence of weak syllable deletion. In the case of those who clutter, if intended syllables are counted for the syllable per unit time calculations (i.e. the ''linguistic word form instead of speech motor output''), then articulation rate is appropriately inflated and thus fits the perception of fast rate in speakers from the population of those who clutter (van Zaalen, Wijnen & Dejonkere, 2011, p. 144). Therefore, the question posed for future research is, if S + DP children's phoneme targets were included in the linguistic unit, would their average articulation rates be on par with their peers who only stutter or with their peers with normal phonology?

Conclusions

As treatment efficacy research for preschoolers who stutter continues, investigation into the effects of adult rate reduction, parent or clinician, is warranted. Slow rate modelling puts the child who stutters in a passive role (Logan & LaSalle, 2003) and is central to the demands capacity model-based approach. Slow rate modelling could be used with the Lidcombe program to improve the outcomes of the children who require more than the average 17 (Range = 6–44) treatment hours to reach fluent status (Miller & Guitar, 2009). While slow rate modelling can be easily combined with techniques within either approach, it is helpful to have appropriate expectations of the extent of its fluency facilitating effect with a number of different subgroups of children who stutter. Here, two boys who presented with both moderate severity stuttering and disordered phonology did not show improved fluency in response to a slow rate model. This could be because of being male, exhibiting more phonological processes than their female peer, having a relatively long time since onset of stuttering (24–28 months), and/or showing no rate alignment due a slower, less variable baseline phone per second rate.

In conclusion, the present results contribute data that suggesting a need to attend to the following factors: which speech segments are timed, boys' and girls' articulation rate reduction from baseline and associated rate alignment with an (un)familiar adult, time since onset of stuttering and the presence and severity of a concomitant phonological disorder, so as not to overlook the importance of one of these potential treatment factors over the others in treatment efficacy with preschool children who stutter.

Acknowledgements

The author would like to acknowledge the children and parents for participating in this study, graduate student clinicians and research assistants and the reviewers for their comments on previous versions of this manuscript.

Declaration of interest

The author reports no conflicts of interest.

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