Slow Speech Rate Effects on Stuttering Preschoolers with Disordered Phonology

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Abstract

To study the differential effects of clinicians’ slow speech rate model on three- and four-year-old children’s articulation rate and fluency, an A-B-A-B single case design was used with six clinician-child dyads. Three children (two boys ages 50-54 months; one girl aged 49 months) with disordered phonology and stuttering (S+DP) were compared to three boys (ages 42-50 months) who only stuttered (S-Only). Articulation rates were measured in adjacent spontaneous utterance pairs of clinician and child by measuring fluent phones per second (p/s) and fluent syllables per second, converting to syllables per minute (spm). The independent variable was the clinician’s use of an average slow speech rate model (Mdn = 173.5 spm; 6.4 p/s) in Treatment versus Baseline (Mdn = 282 spm; 12.2 p/s). Dependent variables were number of stutters per 100 syllables, based on 400-1600 syllable samples, and child articulation rates to assess if entrainment to the slow clinician rate occurred. S+DP children did not entrain to the slower clinician rate at Treatment; they evidenced a significantly slower average speech rate at Baseline (Mdn = 179 spm; 7.1 p/s) compared to S-Only children (Mdn = 221 spm; 8.7 p/s). Three effect size calculations (mean baseline reductions, percent non-overlapping data, and percent zero data) are reported for the participants and/or groups. S-Only children showed a larger effect size (M - M / SD = -1.14) than did S+DP children (-0.61). Results corroborate findings that stuttering children who rate-entrained even by about 2-3 p/s tended to improve fluency.

Introduction

Use of a slow speech rate when conversing with preschoolers who stutter is often recommended as a way to facilitate their fluency, but the evidence base about its use is lacking. The available literature suggests that preschoolers who only stutter and have no concomitant speech/language disorder will speak more fluently when adults speak slowly to them. The jury is still out though on whether children slow their own speech rate or «entrain» [1-5]. To entrain means to draw another along with or after oneself, and various types of entrainment and mutual influence phenomena have been reported in both adult-child and adult-adult conversations [6-8]. Some stuttering children have been found to not entrain to a slow adult model and do not improve fluency [5], raising the question if there are subgroups of stuttering children who do and do not entrain and who do and do not improve fluency with slower speaking adult interlocutors.

“Articulation rate or articulatory rate” is operationally defined as fluent speech segment production per unit time [5,9-12]. Because time taken up by stuttering is excluded, children who stutter can be compared to normally fluent peers on articulation rate. In the Illinois longitudinal project, Hall et al. [13] found that normally fluent preschool-aged children averaged spontaneous speech production at between 11.4 and 12.2 phones/second (p/s), but their peers who stutter, both those who did and did not persist in stuttering, showed a significantly slower articulation rate of 7.7 to 10.2 p/s. Researchers have found no articulation rate differences between mothers of children who stutter and mothers of children who do not stutter [11,12, 14-18]. Fathers of boys who stutter produce an average speech rate in syllables per minute (spm) who do not differ from the rate of fathers of normally fluent sons [19].

Important caveats when considering speech rate findings are, first, that longer utterances are spoken more quickly than shorter ones [20,21], and so researchers need to control for the influence of utterance length on speech rate. Also, units of speech rate measurement appear to matter. Walker et al. [22] and Hall et al. [13] were among the first researchers to use the high-resolution measure of phones per second. Hall et al. [13] found initial-visit differences between the p/s rates of children who would eventually recover from stuttering (slowest, M = 7.7 p/s; SD = 1.1), those who would persist in stuttering (faster, M = 9.6; SD = 1.3) and normally fluent children (fastest, M = 11.4; SD = 2.8), but they found no differences in the children’s syllable per second rates (i.e., averages ranged between 3.18 s/s or 191spm and 3.83 s/s or 230 p/s). Hall et al. [13] stated that, “Apparently, because the phone metric is based on smaller units, the differences between groups are easier to detect (p. 1372).” Their findings suggest that phones per second (p/s) is a measure worthy of continued analysis, at least from children.

In sentence-structure and lexical priming elicitation tasks, stuttering children show significantly longer speech reaction times than peers who do not stutter [23,24]. Also, Chang et al. [25] found that formant transition rates (FTRs) in F2 (Hz/ms) between bilabial consonants and vowels and between alveolar consonants and vowels are not as contrastive in young children who stutter as their normally fluent peers. This set of findings suggests that young children who stutter likely show articulatory or motoric deficits compared to their peers who do not stutter, which would explain their relatively slower articulation rates in phones per second as compared to their normally fluent peers [13].

Stephenson and Bernstein [4] were among the first researchers to report the effects of mothers’ slow rate model on their stuttering children’s speech fluency and speech rate. Two preschool-aged boys...
who stutter and their mothers participated. Baseline recordings were obtained, and then their mothers were taught to speak slower. Results indicated that, when mothers slowed, the children actually spoke faster than at baseline, and yet the children spoke more fluently. Helmer [3] corroborated these findings. The three children who stuttered in her study spoke more fluently when maternal rates were decreased, but the children's rates were slightly increased, that is, no rate entrainment occurred. A single-case study of a five-year-old girl who stutters [26] resulted in similar findings. Both the mother and father participated in this study over a four-month treatment span.

Although both parents slowed, the girl's articulation rate did not parallel that of her parents, that is, she did not rate-entrain. The girl was found to speak more fluently with her slower-talking mother, but not with her slower-talking father.

Zebrowski et al. [5] 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% to 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 [4,26,27], Zebrowski et al. [5] attempted to keep samples standard and included structured conversations [8] and a sentence repetition task. They found high variability among the five individual dyads and only a slight trend toward entrainment. Three of the five children were «rate-entrainers,» that is, they decreased their baseline rates by 11% to 22%, in an apparent response to their mothers' slower rates, and these were the only three who showed improved fluency. The other two children in Zebrowski et al. [5] study did not rate-entrain and did not speak more fluently in the maternal rate reduction condition. One (C5) was a five-year-old boy whose mother decreased her number of total spoken words from 200 to 54, thus increasing the child's verbal assertiveness and in turn increasing stuttering, as is known to occur [28,29]. The mother of the other child who did not improve fluency (C1) reduced her rate in a more natural manner, but may not have achieved a close enough match to her child's articulation rate to facilitate fluency, a concept known as «dyadic gap» (i.e., the difference between the parent's rate and the child's behavior, in this case in terms of speech rate).

Guitar and Marchinkoski [30] investigated six dyads of normally fluent preschoolers and their mothers using an ABAB single-subject design to manipulate maternal rate slowing. They found that when mothers were trained to speak slower in syllables per minute (spm), they did so by more than 50%, averaging about 300 spm in the baseline condition and about 140 spm 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, the children ranged from a 4% reduction of speaking rate from baseline, to a 28% rate reduction, averaging about 200 spm at baseline and about 177 spm when their mothers slowed.

Previously, findings suggested that normally fluent children do not follow the lead of their slow-talking mothers, that is, they do not "rate-entrain" [27], but Guitar and Marchinkoski [30] claimed this may have been because the twenty mothers in the Bernstein Ratner [27] study only reduced their speech rates by about 25%.

For children who stutter, one of the possible fluency-facilitating ingredients in an adult slow rate model is the achievement of a closer match or smaller "dyadic speech rate gap," or the difference between an adult's and a child's speech rate [5,17,19,31]. Preschool-aged children speak slower on average than adults, as can be seen in an overview of articulation rate norms for preschoolers in Flipsen [9]. But an adult could "undershoot" rate, for example, speaking at 180 syllables per minute (spm) when the child speaks at 200 spm, thus creating a negative dyadic gap (i.e., -20 spm). Based on clinical data, Starkweather et al. [31] estimated that matching within +/- 60 spm might be ideal, and empirical support for this estimate comes from Zebrowski et al. [5]. They found that a five-year-old stutterer who became the most fluent when compared to four peers had a mother who decreased her rate by 33% to achieve a dyadic gap of just 3 spm. In contrast, a child who continued stuttering in the maternal slower rate condition had a mother who also decreased her rate by 30%, which may not have been enough, because the result was an average dyadic rate gap of +53 spm, close to the upper limit guideline of +60 spm [31] and possibly problematic for fluency facilitation. Conture [32] offered an analogy of merging cars, where, if an adult travels at 60 mph and the child does also, child's fluency in merging and traveling with the adult is facilitated, but if the adult travels either much faster or much slower than the child, the merging and traveling will be a more accident-prone or disfluency-prone situation.

Yaruss and Conture [17] investigated the naturally occurring fluent speech rates of ten preschoolers who stutter and their mothers during conversations, where mothers were simply instructed to "play as you would at home." Beyond learning that children who stutter and their parents do not differ from normally fluent peers and their parents in articulation rate averages, Yaruss and Conture [17] found a significant positive correlation, whereby the larger the difference between a mother's and her child's speech rates, the greater severity of the child's stuttering. This finding, paired with similar results reported by Kelly [19] on fathers and their children who stutter, points to the notion that large dyadic speaking rate gaps may be more negatively influential than fast adult speaking rates. Yaruss and Conture [17] used an adult-child adjacent utterance analysis procedure, arguing that this procedure might best represent the construct of entrainment because the first (adult) speaker immediately influences the second (child) speaker.

The situation described by Nippold and Rudzinski in 1995 [33] is still true almost twenty years later, where the effects of adults’ slow speech on children’s speech are as yet unknown.

However, parents – not clinicians – interactions with children who stutter have been the focus. While parent-child interaction research certainly is important, knowing the fluency and speech rate responses of children who stutter when exposed to clinicians’ slow speech model is critical for at least three reasons.

First, we need to know the efficacy of a clinician’s slow speech rate model because it is a core technique of the Demands-Capacity Model or «indirect» treatment approach for treating preschoolers who stutter [12,32,34-36], yet without much efficacy data to support its independent use. Secondly, children who regularly meet with a clinician should be in a more “at-risk” subgroup than those children we recommend for no treatment / re-evaluation [35-37], that is, parents may have already tried slowing at home with limited success. Studying these children who are beyond “borderline stutterer” status [38] would help expand clinical information. 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 [39], but clinician-child interactions are free of such histories.

Because most normally fluent children seem to rate-entrain to a
slower parental speech rate [30], but some stuttering children, that is, 3/5 [5] to 2/3 [3], do not rate entrain [4], we need to know about subgroups [40] within the heterogeneous group of children who stutter. One of the largest subgroups of children who stutter beyond that of persistent and recovery subgroups [41] has been those with a concomitant phonological disorder, estimated to comprise 30–40% of the population of children who stutter [42] and Flipsen [9,10] has contributed articulation rate data on a sample of the population of children with speech sound delays/phonological disorders that would inform our understanding of articulation rate entrainment.

Thus, the purpose of this study was to investigate the effects of clinicians’ significantly slower speech rates on the articulation rate entrainment and fluency of three- to four-year-old clients who stutter, those with and without a concomitant phonological disorder.

Method

Participants

Six clinician-child dyads participated. The six clinicians were female graduate students in a university clinic. They were trained in several group demonstration and practice sessions to consistently speak 3.4 syllables per second, [43]). Clinicians attempted to strike a balance between elongating phoneme duration and using inter-utterance pauses [43], especially “conventional” pauses (i.e., those at linguistic boundaries, [35]).

The six children who stutter were three- to four-year-olds (Mdn age = 49.5; Range: 42 - 54 months), five boys and one girl. 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 [44]. All children had persisted in stuttering for more than nine months. They were classified as children who stutter based on the following criteria:

a. Produced 3+ within-word disfluencies or “stutter-like disfluencies” (i.e., monosyllabic whole-word repetitions, sound-syllable repetitions, audible sound prolongations, and blocks) per 100 words (or syllables; [45]), based on a 1200-syllable conversational sample [46], 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).

Two of the boys and the one girl, half (3/6) of the sample, 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 [47] 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 [42]; and (2) Percent Consonants Correct-Revised was less than 85% [48]. 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” used by Flipsen [9]. In addition to a mild phonological disorder, Participant E, a girl, demonstrated a hypo-nasal resonance disorder due to enlarged adenoids. None of the six children had received speech therapy for stuttering, phonology and/or the resonance disorder (Participant E).

Design

This study is an A-B-A-B single case treatment efficacy design, where the Treatment condition attempted to be isolated is the clinician’s use of a slow rate model that is significantly slower than that used at Baseline and Withdrawal conditions. Six different participants, three with and three without concomitant Disordered Phonology were recruited in order to assess variable treatment effects.

Each child’s parent gave informed consent to participate in this A B A B design. It was described to the parents as an early phase of an “indirect” [32] or Demands-Capacity Model-based treatment program offered at the university clinic for about 9-10 weeks. It was also explained to the parents of the S+DP children that treatment for the child’s phonology would begin after this ABAB phase. Parents were counseled and encouraged to use the following fluency-facilitating techniques during this nine week span: Slow their speech rate for ten minutes a day every day, to allow the child to finish when he/she is stuttering, recast the child’s stuttered and mispronounced utterances, and to use carrier phrase or turn-taking, structured game activities with shorter, less complex utterances, especially on days when the child is more dysfluent. The plan was for each of the 50- minute A and B sessions to take place weekly. For all six children the span between A1 and B2 (in the A1, B1, A2, B2 sequence) was four to nine weeks, with a median of 6.5 weeks.

Data analysis

To measure articulation rates of clinicians (independent variable) and children (dependent variable), a graduate research assistant blind

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age in mos</th>
<th>Time since stuttering onset in mos</th>
<th>SSI-3 score and severity</th>
<th>PCC-R</th>
<th>Phonological processes (age-inapp. &amp; atypical)</th>
<th>Phonol. disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>M</td>
<td>42</td>
<td>9</td>
<td>Severe</td>
<td>91%</td>
<td>none</td>
<td>No</td>
</tr>
<tr>
<td>S</td>
<td>M</td>
<td>45</td>
<td>20</td>
<td>Moderate</td>
<td>90%</td>
<td>none</td>
<td>No</td>
</tr>
<tr>
<td>J</td>
<td>M</td>
<td>50</td>
<td>19</td>
<td>Moderate</td>
<td>91%</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>E</td>
<td>F</td>
<td>49</td>
<td>24</td>
<td>Moderate</td>
<td>84%</td>
<td>Velar fronting; Cluster reduction</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>M</td>
<td>50</td>
<td>28</td>
<td>Moderate</td>
<td>84%</td>
<td>Velar fronting; Cluster reduction; Interdentalization</td>
<td>Yes</td>
</tr>
<tr>
<td>JO</td>
<td>M</td>
<td>54</td>
<td>24</td>
<td>Moderate</td>
<td>82%</td>
<td>Velar fronting; Cluster reduction; Stopping of fricatives; Backing</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 1: Demographic, speech fluency and phonology characteristics of the six participants, 3- to 4-year-olds, who stutter. The Stuttering Severity Instrument-3 (SSI-3) [58] and Percent Consonants Correct-Revised (PCC-R) measure [48] were used.
to the methods of the present study reviewed each of the 24 digitally recorded sessions (i.e., Initial Baseline and Withdrawal, A1 & A2 sessions and two Treatment sessions, B1 & B2, per each of the six clinician-child dyads). She prepared orthographic transcripts of both clinician and child utterances, using phonological transcription when words were mispronounced (intended phonemes were then used for Percent Phonemes Correct and phones per second). She then identified all clinician utterances that were intelligible, fluent, three or more words in length, and immediately preceded a child utterance in a non-overlapped or non-interrupted manner. If the subsequent child utterance (i.e., at least three consecutive words and grammatically complete, as per Hall et al. [13] was also intelligible, fluent, and spontaneous (i.e., non-elicited, non-imitated), then it was included. This pair of fluent utterances, the clinician's and the child's, were identified as adjacent «utterance pairs» (UPS), and they were orthographically and phonetically transcribed, as per the methods of Yaruss and Conture [17].

Phones and syllables were counted according to procedures explained by Hall et al. [13] and Kloth et al. [14]. The duration of each utterance was acoustically determined using spectrographic displays (www.praat.org). 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 marked segment was played-back. Then the corresponding duration in milliseconds was saved. This was done for all clinicians' and children's utterances in the UPS per session.

To determine the dependent variable or treatment effects, each occurrence of a within-word disfluency or «stutter» (i.e., a monosyllabic word repetition, sound-syllable repetition, audible sound prolongation and block) were counted per 100 syllables, based on all intelligible utterances per session (400 - 1600 syllable samples) to determine stutter frequency per 100 syllables. The minimum number of usable syllables per spontaneous utterances per session was determined to be 400 syllables, as recommended by Sawyer and Yairi (2006) to capture the natural variability of childhood stuttering at this age. One participant, J (S-Only) was less talkative and less spontaneous, but did meet these minimum criteria for each of four recordings.

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<table>
<thead>
<tr>
<th>Child</th>
<th>UPS</th>
<th>Baseline</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clin.'s rate</td>
<td>Child's rate</td>
</tr>
<tr>
<td>A-S*</td>
<td>15</td>
<td>284 spm</td>
<td>221 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(222 to 470)</td>
<td>(123 to 303)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.7 p/s</td>
<td>8.7 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8.7 to 20.2)</td>
<td>(4.1 to 10.6)</td>
</tr>
<tr>
<td>S-S*</td>
<td>9</td>
<td>342 spm</td>
<td>253 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(181 to 391)</td>
<td>(178 to 288)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.8 p/s</td>
<td>9.8 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7.2 to 17.4)</td>
<td>(7.0 to 14.4)</td>
</tr>
<tr>
<td>J-S*</td>
<td>25</td>
<td>261 spm</td>
<td>192 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(128 to 398)</td>
<td>(102 to 274)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.7 p/s</td>
<td>8.7 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.8 to 17.2)</td>
<td>(5.5 to 11.4)</td>
</tr>
<tr>
<td>E-SDP</td>
<td>13</td>
<td>280 spm</td>
<td>201 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(171 to 413)</td>
<td>(92 to 407)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.5 p/s</td>
<td>7.9 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.2 to 13.9);36%</td>
<td>(5.5 to 12.7);11%</td>
</tr>
<tr>
<td>D-SDP</td>
<td>21</td>
<td>219 spm</td>
<td>178 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(143 to 236)</td>
<td>(129 to 262)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.8 p/s</td>
<td>6.9 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.0 to 12.1)</td>
<td>(5.3 to 12.0)</td>
</tr>
<tr>
<td>JO-SDP</td>
<td>30</td>
<td>314 spm</td>
<td>179 spm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(112 to 434)</td>
<td>(87 to 349)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.8 p/s</td>
<td>7.1 p/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.1 to 17.8)</td>
<td>(2.3 to 16.0)</td>
</tr>
</tbody>
</table>

Table 2 Articulation rates in medians (and ranges) of syllables per minute (spm) and phones per second (p/s), based on number of clinician-child adjacent spontaneous utterance pairs (UPS). Dyadicgap=Clinician’s rate-Child’s rate in spm & p/s. Percent reduction from Baseline to Treatment are listed as decreases (↓) and increases (↑). Rate-entrainers (>11% reduction) are designated with *.
Treatment fidelity of speech rate model

When Baseline/Withdrawal (A1 & A2) and Treatment (B1 & B2) sessions were combined, clinicians’ attempts to consistently use the slow rate they were trained to use resulted in a median 39% reduction (Range = 18% to 55% reduction) for both syllables per minute (spm) and for phones per second (p/s) (Range = 24% to 62% reduction) (Table 2). These clinician speech rate reductions are comparable to parental rate reductions achieved by researchers who trained and instructed parents to speak slower [4,5,26,27,30]. That is, in treatment sessions, these clinicians achieved an ideally slow articulation rate of < 200 syllables per minute (spm) on more than two-thirds of their utterances (Mdn = 71%; Range = 44% - 89%), thus realizing the recommended ideal average dyadic speech rate match of +/- 50 spm (Mdn = -6.7 spm; Range = -218 to +284 spm), corresponding to a median of -0.08 p/s (Range = -9.3 to 12.0 p/s). These close clinician-child rate matches were not found in the baseline sessions (Mdn = +78.6 spm; Range =

![Figure 1: Single case design for A-B-A-B Design (n=6). Stuttering-only (S-Only) participants (n=3) are shown on the left; Stuttering plus Disordered Phonology participants (S+DP) (n=3) are shown on the right. Spontaneous utterances representing between 400 and 1600 syllables were sampled to determine number of stutters per 100 syllables.](image-url)
-153 to +290 spm; Mdn = +3.6 p/s; Range = -3.6 to 14.0 p/s), yielding significant differences for both spm (Z = -6.69; p = 0.000) and p/s (Z = -6.57; p = 0.000) dyadic gap comparisons.

Reliability

In the 24 recorded sessions, a total of 294 fluent clinician-child utterance pairs (i.e., 588 utterances) were originally identified. Hall et al. [13] report 100% agreement within +/-3 ms, so this standard was followed for data re-measurement before submitting the 294 AUPs or 588 utterances to statistical analyses. The graduate research assistant independently verified the author's original measures, and disagreements 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, 21 of the 294 AUPs (7.1%) 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 reach agreement through repeated listening. Following this stringent reliability procedure set forth by Hall et al. [13] meant that there was 100% agreement for all s/s and p/s measures for the 273 clinician-child utterance pairs or 546 utterances submitted to data analysis.

The presence or absence of stutters and their stutter type 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 to 0.905 (i.e., “good to excellent”).

Statistical analysis

Meline [49] simplifies the effect size statistic for single-case designs as MB - MA / SD A where, in the case of this study design, M B = the chance using Cohen's Kappa: 0.693 to 0.905 (i.e., “good to excellent”).

Results

Figure 1 presents the dependent variable of stutter frequency (number of stutters per 100 syllables) plotted against each of the ABAB segments per participant. The three children who only stutter (S-Only) are presented in the left column; the three children with concomitant disordered phonology (S+DP) are presented on the right. The effect size of stutter reduction was larger for S-Only participants (i.e., MB - MA / SD A = [7.16 - 15.03]/6.89 = -1.14) than for S+DP participants (i.e., MB - MA / SD A = [4.89 - 6.89]/3.28 = -0.61).

Mean baseline reduction (MBLR; M B - M A / x M A x 100) was computed per participant and per group. All three S-Only Participants showed a MBLR that was greater than ~100%, whereby Participant A showed a 99%, Participant S, an 118%, and Participant J, a 307% decrease from baseline. However, only one of the S+DP Participants, Female E showed a similar trend with a MBLR = 153%. Participant JO only showed a 59.4% reduction from baseline, and Participant D showed little to none, at 9%. So, as a group, S-Only Participants showed a greater Mean baseline reduction of 109.8% (M B = 15.0; SD A = 6.9; M A = 7.2; SD A = 4.9 stutters/100 syll) than did S+DP Participants, with an MBLR only equal to 41.1% (M B = 6.9; SD A = 3.3; M A = 4.9; SD A = 4.0 stutters/100 syll).

In terms of the Percentage of non-overlapping data (PND), in the S-Only group, Participant A (12/19 = 63%) and Participant J (6/8 = 75%) showed better treatment effects or less variable stuttering than Participant S (2/22 = 9%). In the S+DP Participants, the only one with a high PND was Female E (13/18 = 72%). The other two S+DP Participants showed low to no effects using this PND measure: (D) 0/21 = 0%; (JO) 1/22 = 4.5%.

However, when Percentage of zero data (PZD) was calculated to determine stutter suppression per 100 syllables, only one S-Only Participant, J (5/6 = 83%) and two S+DP Participants, again Female E (9/11 = 82%) and JO (6/8 = 75%) showed this «stutter suppression» effect using the PZD. The other Participants showed low to no effects using this PZD measure: (A) 0/0 = 0%; (S) 0/2 = 0%; (D) 0/2.

Table 2 presents the clinician-child dyad articulation rate data. As can be seen from Table 2, the S-Only children rate-entrained, but the S+DP children did not. The S-Only children ranged from a 17% to a 29% reduction from baseline in syllables per minute (spm) measures, but they showed an even higher (33-40%) baseline reduction when using the more sensitive rate measure of phones per second (p/s). The S+DP children only showed a 13% reduction to a rate maintenance, to an 11% increase (i.e., S+DP Participant D) in the Treatment conditions. It can also be seen from Table 2 that the median S+DP child articulation rate at Baseline was 179 spm (Range: 87 - 407 spm) or 7.1 p/s (Range: 2.3 to 16.0 p/s), whereas the median S-Only child articulation rate at Baseline was 221 spm (Range: 102 - 303 spm) or 8.7 p/s (Range: 4.1 to 11.4 p/s). This difference was statistically significant (p = 0.000; N=78 utterances for S+DP; N=49 utterances for S-Only children).

Finally, dyadic gaps for spm and p/s are presented in Table 2. Using the guideline provided clinically by Starweather et al. [30], and using research data from Zebrowski et al. [5] for < 60 spm gap in either direction, it can be seen that all dyadic gaps at Baseline were assumed problematic for fluency except for that of Participant D, whose clinician was relatively slower than the other five, and only achieved an average gap of +33 spm. Treatment dyadic gaps, however, were all considered ideal, ranging between -15 spm to +30 spm for all Participant Dyads.
Discussion

The present results appear consistent with previous results showing that stuttering children tend to speak more fluently but not all rate-entrain when a caregiver slows [3-5]. The contribution from the present study is that preschoolers who stutter and have a concomitant phonological disorder did not rate-entrain and were less likely to show fluency improvement, based on an effect size that is smaller than the stuttering-only participant’s dyad’s (-1.14), and based on visual inspection of Figure 1. Two of three options for effect sizes in single subject designs (i.e., mean baseline reduction, percentage of non-overlapping data) also showed better stutter reduction in the S-Only than in the S+DP participants. However, two of the three S+DP participants (the girl E and boy JO) compared to only one of the S-Only children (boy J) showed stutter suppression to the normally fluent limits of 0-2 stutters per 100 syllables, using the percent zero data measure [30].

It is important to point out that rate-entrainment comes from percent reduction from baseline data, and yet the child’s new speech rate is only affected by 2 to 3 phonemes per second (p/s) at the most, whereas clinicians reduce as much as 5-7 p/s. The current data reflect the statement made by Zebrowski et al. [50] “It is likely that the magnitude of change required for statistical significance to be obtained represents an abnormally slow rate … and therefore would not be likely maintained. Thus, 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 slows articulation rate may be slowing enough relative to the child’s rate to attain a dyadic gap of +/- 50 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 highway onramp needs to be at the same speed so as not to disaffect the fluency of traffic.

One question that the current results prompt is: Why should stuttering children rate-entrain when they derive fluency benefit from the close dyadic rate gap that adult speakers help create? Guitar and Marchinkoski [30] suggested that stuttering children do not rate entrain because they perceive a more fluency-facilitating environment when the adult speaks slowly, so they can afford to increase rate. An alternative viewpoint is that children’s rate increases are simply a side effect of becoming more fluent speakers, parallel in a motoric way to the linguistic “vaulting” that children tend to do when they use longer, more complex utterances in response to adults’ short, simple utterances [1].

Finding a significantly slower p/s rate at baseline in children who stutter and have a concomitant phonological disorder (S+DP; Mdn = 7.1 p/s) as compared to their normal phonology peers who stutter (S-Only; Mdn = 8.7 p/s), should be viewed with caution because the small sample part of the current single-case research design. However, Flipsen [9] reported a comparable group mean articulation rate of 7.65 p/s from his sample of 25 three- to five-year-old children with speech delays of unknown origin. He noted that this 7 to 8 p/s rate is considerably slower than the 8.4 to 12.4 p/s average from typically developing three- to five-year-old children reported by previous investigators [13,22 ].

It is possible that the p/s rate difference between S+DP (slower) and S-Only (faster) could be an artifact. That is, children with phonological disorders may produce utterances that are difficult for researchers to measure in phones per second, due to the phonetic component of these children’s “disordered phonology” diagnosis. Flipsen [9] acknowledges this caveat with his sample of phonologically disordered children. So, while intended phonemes were counted in the speech rate analysis present and former studies (e.g., if a child with liquid cluster reduction produced /pliz/ as [piz] in 0.5 sec, then 4 intended phones / 0.5 seconds = 8.0 p/s, not 3 actual phones / 0.5 sec = 6.0 p/s), future researchers would need to proceed with caution due to perceptible and acoustic evidence of phones, allophones and marked phones. However, if the present findings of slower articulation rate of stuttering children with concomitant phonological disorders is supported in future research, Flipsen [10] suggests that a slower articulation rate in children with speech sound delays, especially those who do not normalize speech but persist with residual articulation deficits, may represent some sort of compensation to cope with motoric differences and/or to increase intelligibility.

Based on visual inspection of Participants A, S, J, and E versus Participants D and JO in Figure 1 and the three effect sizes computed, it appears that four out of six or two-thirds of the present children who stutter showed improved fluency when clinicians slowed their rate, corroborating results of Zebrowski et al. [5] and Helmer (1995), who found 60 – 67% of stuttering children improving fluency in response to maternal slow rate models.

Different explanations have been offered as to why 33 – 40% of the children studied show no fluency improvement. Helmer [3], for example, posited that the one boy showing no fluency gain in her study was the oldest of the three boys, a seven-year-old, and he may have passed the point in the progression of his stuttering where his mother’s slow rate model would facilitate his fluency. However, the seven-year-old in Zebrowski et al. [5] study did speak more fluently, apparently in response to maternal slow rate. Instead, two others (a 4- and 5-year-old) of the five children in Zebrowski et al. [5] study were the no-fluency-gainers, performances explained by these researchers as: (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 the present study, only three- and four-year-olds were included, clinician-child dyadic gaps were ideal (i.e., +/- 30 spm) in all treatment sessions, and the clinicians spoke frequently enough to produce representative rate samples and not to allow too much assertiveness from children who stutter.

However, the two children who did not improve fluency were both S+DP and the one S+DP child who improved fluency in treatment was a girl. Female gender was one of several explanations for the most fluent child of the five in the Zebrowski et al. [5] study of maternal rate modifications, and girls who stutter are more likely than boys to pass the point in the progression of his stuttering where their normal phonology peers who stutter (S-Only; Mdn = 8.4 p/s; SD = 0.5), as compared with their normally fluent peers, who averaged 207 spm (M = 3.45 s/s; SD = 0.42). Because the mothers of these children did not differ in their maternal articulation rates of 335 – 343 spm, mother-child dyadic rate gaps were equally larger than ideal (i.e., 343 spm, mother-child dyadic rate gaps were equally larger than ideal for both the stuttering children (+122 spm gap) and for the normally fluent children (+128 spm gap). Kloth et al. [14] data suggest that a fast articulation rate could trigger stuttering onset, which would imply...
that getting a child to reduce his/her articulation rate should improve fluency. Whether clinicians should model a slower rate and monitor for the child’s passive slow-rate-entrainment or help a child who stutters to achieve a slower articulation rate via more direct or “active” means remains an open question.

Certainly, the active and passive roles of the child who has two disorders, stuttering and disordered phonology, that both need addressing in therapy, need to be considered [53,54].

The presence of a disordered phonology diagnosis, if it entails a slower-than-normal p/s rate at baseline [9], may mean that there is no need for a S+DP child to slow his/her articulation rate from baseline. Perhaps in these cases, the Anticipatory Struggle Hypothesis (Bloodstein, 1958; Bloodstein & Bernstein Ratner, 2008) applies, whereby if the child believes that s/he will have difficulty communicating, a perception that has a basis in fact for the unintelligible child, than treating the child’s phonology may affect greater fluency improvement than just a passively receiving a slow caregiver model.

Alternatively, do caregivers slow articulation rate enough with stuttering children? Present results indicate that clinicians are no better and no worse than parents in reducing articulation rates, averaging about a 38 - 40% spm or p/s rate reduction. While important to consider Guitar and Marchinkoski’s [30] caution that caregiver rate reduction has to perhaps exceed 25% to improve a change in the child’s fluency, it is also true that speaking too slowly may negatively affect speech naturalness [3,55] and/or a child’s ability to imitate adult utterances [56,57], an issue especially pertinent to S+DP children.

Results presented here suggest that future investigators of adult-child speech rate should continue efforts to: (a) use the phones per second metric for speech rate analysis; (b) subgroup members of the population of preschool-aged boys and girls who stutter; and (c) determine if stuttering children with disordered phonology improve fluency in response to techniques other than adult caregiver slow speech rate model. We will need to balance clinical research attention across the factors of adult rate reduction, children’s rate reduction and thus entrainment, and the attainment and maintenance of close dyadic rate matches, so as not to overlook the importance of one of these factors over the others.

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