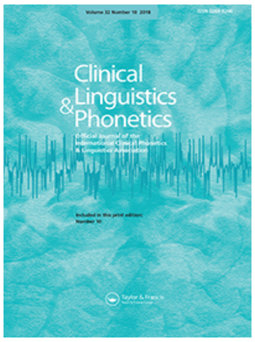

Clinical Linguistics & Phonetics

ISSN: 0269-9206 (Print) 1464-5076 (Online) Journal homepage: www.tandfonline.com/journals/iclp20

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To cite this article: Thomas Law, Ann Packman, Mark Onslow, Carol K.-S. To, Michael C.-F. Tong & Kathy Y.-S. Lee (2018) Rhythmic speech and stuttering reduction in a syllable-timed language, Clinical Linguistics & Phonetics, 32:10, 932-949, DOI: 10.1080/02699206.2018.1480655

To link to this article: https://doi.org/10.1080/02699206.2018.1480655

CLINICAL LINGUISTICS & PHONETICS
2018, VOL. 32, NO. 10, 932–949
https://doi.org/10.1080/02699206.2018.1480655

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Rhythmic speech and stuttering reduction in a syllable-timed language

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ABSTRACT
Speaking rhythmically, also known as syllable-timed speech (STS), has been known for centuries to be a fluency-inducing condition for people who stutter. Cantonese is a tonal syllable-timed language and it has been shown that, of all languages, Cantonese is the most rhythmic (Mok, 2009). However, it is not known if STS reduces stuttering in Cantonese as it does in English. This is the first study to investigate the effects of STS on stuttering in a syllable-timed language. Nineteen native Cantonese-speaking adults who stutter were engaged in conversational tasks in Cantonese under two conditions: one in their usual speaking style and one using STS. The speakers' percentage syllables stuttered (%SS) and speech rhythmicity were rated. The rhythmicity ratings were used to estimate the extent to which speakers were using STS in the syllable-timed condition. Results revealed a statistically significant reduction in %SS in the STS condition; however, this reduction was not as large as in previous studies in other languages and the amount of stuttering reduction varied across speakers. The rhythmicity ratings showed that some speakers were perceived to be speaking more rhythmically than others and that the perceived rhythmicity correlated positively with reductions in stuttering. The findings were unexpected, as it was anticipated that speakers of a highly rhythmic language such as Cantonese would find STS easy to use and that the consequent reductions in stuttering would be great, even greater perhaps than in a stress-timed language such as English. The theoretical and clinical implications of the findings are discussed.

ARTICLE HISTORY
Received 26 October 2017
Accepted 20 May 2018

KEYWORDS
Stuttering; syllable-timed speech; syllable-timed language; Cantonese; fluency inducing condition

Introduction

Rhythmic speech and stuttering

Rhythmic speech involves a person speaking syllables or words in time to a regular beat. In a variant of rhythmic speech known as syllable-timed speech (STS), each syllable is spoken in time to a beat (Packman, Onslow, & Menzies, 2000). Speaking in this way has been known for centuries to be one of the most powerful fluency-inducing conditions for people who stutter (Andrews & Harris, 1964; Bloodstein & Bernstein Ratner, 2008; Ingham, 1984). Research has shown that stuttering can reduce to near zero with STS (Andrews, Howie, Dosza, & Guitar, 1982;

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Davidow, Bothe, Andreatta, & Ye, 2009; Ingham et al., 2009; Ingham, Bothe, Wang, Purkhiser, & New, 2012; Martin & Haroldson, 1979; Packman, Hand, Cream, & Onslow, 2001; Packman, Onslow, & van Doorn, 1997). The ameliorative effects on stuttering of rhythmic speech have been supported by brain studies (Stager, Jeffries, & Braun, 2003; Toyomura, Fujii, & Kuriki, 2011). These studies, using PET and fMRI, showed that functional activity in brain regions associated with stuttering normalise when people who stutter speak rhythmically.

The powerful fluency-inducing properties of rhythmic speech have resulted in the use over decades of this speech pattern to instate fluency in behavioural treatments for adults who stutter (Bloodstein & Bernstein Ratner, 2008; Ingham, 1984; Packman et al., 2000). This was especially the case in the early part of the twentieth century. However, rhythmic speech induces fluency in all ages, and there have been recent studies using STS to induce fluency in treatments for young children who stutter (Andrews et al., 2012; Andrews et al., 2016; Trajkovski, Andrews, O'Brian, Onslow, & Packman, 2006; Trajkovski et al., 2011, 2009).

The mechanisms underpinning the fluency-enhancing effects of rhythmic speech are not well understood. Ingham (1984) summarised a number of hypotheses, including the distraction hypothesis, the rhythm effect hypothesis, the speech-rate hypothesis, the predictability hypothesis and the modified vocalisation hypothesis. However, these hypotheses had not been supported and so research into the mechanism underpinning the rhythm effect continued.

Recent studies suggest further hypotheses, namely that during rhythmic speech, adults who stutter achieve fluency by increasing vowel duration and reducing percentage of short phonation intervals (Davidow, 2014; Davidow et al., 2009; Davidow, Bothe, & Ye, 2011; Ingham et al., 2012; Stager, Denman, & Ludlow, 1997). A number of researchers have also suggested that linguistic stress contrasts are reduced during rhythmic speech (Andrews & Harris, 1964; Packman et al., 1997; Starkweather, 1987; Wingate, 1981, 1976). For example, Packman and colleagues (1997) showed that the variability of vowel duration decreased during STS in both adults who stutter and fluent adults. The finding of this effect for the fluent participants as well as the stuttering participants can be seen to support the proposal that STS reduces syllabic stress contrasts across utterances. This reduction in the variability of stress means that syllables are more similar in duration, loudness and/or pitch across an utterance. This provided empirical support for the development of the variability model of stuttering (Packman et al., 2000; Packman, Onslow, Richard, & van Doorn, 1996) and the subsequent P&A three-factor model of the cause of moments of stuttering (Packman, 2012; Packman & Attanasio, 2017). According to the P&A model, stuttering is triggered by the task demands of varying linguistic stress during speech production in those with compromised speech motor control. This is a logical deduction from findings that stuttering typically reduces significantly when a person who stutters reduces stress contrasts when speaking. The P&A model proposes that children start to stutter at around 2–3 years of age because this is the time in speech/language development that they start to use variable syllabic stress.

In summary, modifying speech rhythm to resemble a syllable-timed pattern typically induces fluency in people who stutter from early childhood. To date, however, the majority of the studies of rhythmic speech have been conducted in English, which is a stress-timed language. As far as we are aware, little is known about the effects of rhythmic speech on stuttering in languages from a different rhythmic class. The current study is the first to investigate the effects on stuttering of speaking rhythmically in Cantonese, which is a syllable-timed language. This study is part of a programme of research into the nature of stuttering among Cantonese speakers (see Law et al., 2017, 2018).

Language rhythm

Language rhythm is on a continuum, with stressed-timed on one end and syllable-timed on the other (Dauer, 1983; Roach, 1982). Traditionally, the differences between stress-timed and syllable-timed languages are thought to be related to the timing of syllabic stress and syllable duration. It was thought that stress-timed languages have equal or near-equal duration between the occurrences of syllabic stress and conversely in syllable-timed language, the duration of syllables is roughly the same (Abercrombie, 1967). However, a number of researchers refuted these assumptions empirically (Dauer, 1983; Grabe & Low, 2002; Roach, 1982). Rather, it was found that stress-timed and syllable-timed languages differ in terms of syllable structure, vowel duration and stress. Dauer (1983) and Roach (1982) summarised several key differences between syllable-timed and stress-timed languages. Stress-timed languages, such as English, have a greater variety of syllable structure compared to syllable-timed languages, such as French and Spanish. In French and Spanish, syllables are predominantly open and over half the syllables have a simple consonant–vowel structure whereas in English, there is more variation in syllable structure. Further, reduction in vowel duration in unstressed syllables is greater in stress-timed languages. For example, in English, a high proportion of vowels in unstressed syllables is reduced to schwa, whereas in syllable-timed languages, vowels in unstressed syllables are not regularly reduced, at least to this extent. Another key difference is that stress-timed languages have more rules relating to the occurrence of stress and, in the realisation of stress, have more complex and variable use of syllable duration, pitch contour, loudness and quality. For example, differences in syllable duration in stressed and unstressed syllables are greater in English than in Spanish. These together provide the perception of the rhythmic differences between stressed-timed and syllable-timed languages.

Cantonese is from the Sino-Tibetan language family. It is spoken by over 72 million people in the south-eastern region of China, Hong Kong, Macao and Southeast Asia, and many immigrants from these regions around the world (Simons & Fenning, 2017). Cantonese is a tone language with six contrastive lexical tones. That is, changing the fundament frequency of a syllable will change the meaning of the syllable. Cantonese is also a syllable-timed language. In contrast to other syllable-timed languages, such as Italian and French, Cantonese does not have lexical stress. That is, each syllable in Cantonese carries largely the same amount of stress or emphasis. This is why Cantonese is considered one of the languages with the most syllable-timed rhythm (Mok, 2009).

Aim of this study

Throughout this paper, the term *rhythmic speech* refers to the known fluency-enhancing speech pattern that involves speaking each syllable to a regular beat, as in STS. This terminology is intended to avoid possible confusion between the terms *STS* and *syllable-timed language*.

The aim of this study is to investigate the effects of rhythmic speech on stuttering in Cantonese, a syllable-timed language. Since Cantonese is considered to be highly rhythmic in nature, it would be logical to suppose that stuttering should not occur in Cantonese. However, this is not the case, and the prevalence of stuttering in Cantonese is not known. An explanation for this inconsistency may be, then, that Cantonese is less rhythmic than STS. It is important to investigate whether rhythmic speech has an ameliorative effect on stuttering in Cantonese and, if it does, whether the effect is equivalent to—or possibly even greater than—its effects in English, as reported in the literature (Andrews et al., 1982; Davidow et al., 2009; Ingham et al., 2009, 2012; Martin & Haroldson, 1979; Packman et al., 2001, 1997).

Methods

Participants

Nineteen native Cantonese-speaking adults who stutter participated in this study. They were recruited through the mass mailing list of the Chinese University of Hong Kong, the speech therapy clinic at that university and advertisements from four local district councils in Hong Kong. Participants were 15 men and 4 women and they were accepted into the study in the order they contacted the researchers. Their mean age was 23 years, ranging from 18 to 33 years. All participants reported that they stuttered and reported no history of neurological disorders. A Cantonese-speaking speech-language pathologist (SLP) with over 10 years of experience with stuttering assessment and management confirmed the presence of stuttering for all participants. Of the 19 participants, 5 had previously received treatment for stuttering but none had received treatment incorporating rhythmic speech. A summary of participant characteristics is presented in Table 1.

Procedure

All recordings were made in a quiet room using a high-definition video camera (Panasonic HDC-DS9) and a digital audio recorder (Sony ICD-PX312). The video camera was placed on a tripod positioned 2 m directly in front of the participants and recorded head and upper body images. The audio recorder was placed 30 cm from the speaker's mouth. The speech samples were collected while participants engaged in conversation with a SLP. Two conversational speech samples were collected from each participant, under two conditions: *Control* and

Table 1. The characteristics of the participants, including age in years, sex, percentage syllables stuttered (%SS) and history of stuttering treatment.

Participant	Ages	Sex	%SS	History of stuttering treatment
1	20	Male	4.4	Yes
2	33	Male	1.6	No
3	30	Male	6.5	No
4	21	Male	2.6	No
5	19	Male	4.1	Yes
6	26	Female	22.6	Yes
7	18	Male	2.9	No
8	20	Female	2.6	Yes
9	20	Male	8.6	No
10	20	Male	3.5	No
11	28	Male	11.6	No
12	23	Male	4.1	No
13	22	Female	12.7	No
14	23	Male	1.8	No
15	22	Male	3.5	No
16	18	Male	4.2	Yes
17	30	Female	1.5	No
18	23	Male	8.5	No
19	23	Male	4.7	No
Mean	23			

Rhythm. A total of 20 questions were used to stimulate conversation for the 2 conditions, with 10 questions per condition. The questions were presented to the participants in a random order and related to everyday topics including hobbies, family, friends, leisure activities, food, daily routine and pets. Each speech sample lasted for approximately 10 min, comprising approximately 1000 syllables. For each speech sample, the first 300 syllables were excluded and the following 600 syllables were used for analysis.

Immediately prior to the *Control* condition, participants were instructed to speak in their usual manner, including speech rate, pitch, loudness and clarity. After the *Control* condition, the participants were taught to use rhythmic speech by a SLP. Metronome software (My Metronome App version 1.1) was used to train participants to speak with STS at a rate of 100 beats per minute. The SLP first demonstrated STS to participants in a reading task and the participants were then instructed to read the same passage in their usual pitch, loudness and clarity while matching each syllable to the beat of the metronome. When the SLP considered that the participants were using rhythmic speech in the reading practice task appropriately, they practised STS in monologue and then in conversation. For this, the rate of the metronome was gradually increased until participants indicated that it was at a comfortable rate for them to continue using rhythmic speech. The total practice time was approximately 15 min and all participants were using STS satisfactorily by the end of the 15 min.

A 5-min break was scheduled between the practice time and the start of the *Rhythm* condition. Prior to this condition, participants were instructed to speak in rhythmic speech using their usual pitch, loudness and clarity. During this condition, the metronome signal was delivered with an earpiece monaurally. This was to prevent a possible masking effect, which is another fluency-inducing condition. Participants were instructed to adjust the rate and intensity of the metronome to a level that they felt was comfortable for them to engage in the conversation while still being able to receive the stimulus to maintain STS. The *Control* speech condition always preceded the *Rhythm* condition to prevent any possible carry-over effect of rhythmic speech into natural speech.

Stuttering identification and rating

Stuttering moments were identified using a perceptual definition (Bloodstein & Bernstein Ratner, 2008). Two native Cantonese-speaking SLPs experienced in working with stuttering measured the video-recorded speech samples for percentage syllables stuttered (%SS), a widely used measure of stuttering severity. Stuttering instances were identified in the video samples, and %SS was calculated by dividing the number of stuttering instances by the total number of syllables in the sample and multiplying by 100. The first SLP measured the %SS in all of the videos. For intra-rater reliability, 20% of the videos were randomly selected and measured again by the first SLP, 1 week following the initial rating. The second SLP independently measured 20% of the speech samples, selected randomly, for inter-rater reliability. Reliability measures were conducted using intraclass correlation (ICC). Intra-rater reliability was calculated with ICC (3,1) as 0.98, and the inter-rater reliability was calculated using ICC (2,1) as 0.89. Both ICC values indicated excellent reliability (Portney & Watkins, 2000).

Rhythmicity rating

A perceptual rhythmicity scale was designed to evaluate the participants' degree of rhythmicity in their *Rhythm* condition samples. This was a 5-point scale (1 = not rhythmic at all, 5 = extremely rhythmic) based on the perception of the raters. All rhythmic speech samples were rated on the rhythmicity scale. To minimise the effect of language familiarity, two non-Cantonese speakers who were independent to the current study were recruited to rate all the rhythmic speech samples independently. The samples were randomly presented to the raters. Inter-rater reliability was calculated using ICC (2,1) as 0.91, which indicated excellent reliability (Portney & Watkins, 2000).

Speech rate

Changes of speech rate have been shown to have an effect on stuttering (Guitar, 2014; Tasko, McClean, & Runyan, 2007; van Lieshout, Hulstijin, & Peters, 2004). It has also been suggested as a possible confounder of the effect of rhythmic speech (Davidow, 2014). The speech rate of the participants in both the *Control* and *Rhythm* condition was measured to ensure that any changes in speech fluency during the latter were independent of changes in speech rate. Speech rate in this study was measured by articulation rate, a more precise measure that reflects exactly how fast a person talks (Ingham & Riley, 1998; Packman et al., 2000). Articulation rate is the measure of perceptually fluent speech across speaking time (Ingham & Riley, 1998). In this study, articulation rate is measured by the number of perceptually fluent syllables across phonation time.

The first 2 min of the audio speech samples were excluded and the following 2-min segments were extracted for analysis. Only perceptually stutter-free speech segments were included. Stuttering moments, segments that contained the clinician's speech and silent gaps of 250 ms or longer were excluded from analyses (Chon, Sawyer, & Ambrose, 2012; Hall, Amir, & Yairi, 1999; Tumanova, Zebrowski, Throneburg, & Kulak Kayikci, 2011). Articulation rate was calculated using Praat (Boersma & Weenink, 2017) and a software script that automatically detects syllable nuclei (de Jong & Wempe, 2009). This script has shown to provide a reliable measure for articulation rate (de Jong & Wempe, 2009).

Statistical analyses

All statistical analyses were conducted using IBM SPSS version 22©. Descriptive statistics were used to display the %SS and articulation rate of both conditions, and the difference in %SS and articulation rate between the two conditions. A Wilcoxon signed-rank test was used to examine the difference in %SS between the two conditions. A paired *t*-test was used to examine the difference in articulation rate between the two conditions. Prefatory to regression analyses, Pearson and Spearman correlations were conducted to explore the relationship among the percentage of change in %SS, and the degree of rhythmicity and percentage of change in articulation rate. Non-parametric tests were used for data that had non-normal distribution. Follow-up analyses on the participants who were able to perform rhythmic speech and those who were not able to perform rhythmic speech were conducted using independent samples *t*-tests.

Ethics

The Human Ethics Committee of The University of Sydney (2014/835) and the Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Committee (CRE-2012.164) granted ethics approval for this study.

Results

Percentage %SS

Figure 1 displays the %SS scores for both speech conditions for all 19 participants. The median %SS for the *Control* condition was 4.1 (range 1.6–22.6%SS). The median %SS for the *Rhythm* condition was 2.3 (range 0.6–12.0%SS). Medians are given because the data are skewed. Although participants showed varying responses to rhythmic speech, reduction in stuttering in the *Rhythm* condition was statistically significant, $Z = -3.22$, $p < 0.01$, with a large effect size, $r = -0.52$. The percentage stuttering reduction in terms of %SS for all participants ranged from −96.5% to 89.8%, with a mean of 43.2%.

Articulation rate

The articulation rate for all participants for both conditions is presented in Figure 2. The mean articulation rate for the *Control* condition was 5.2 syllables per second, ranging from 4.1 to 6.0 syllables per second. The mean articulation rate for the *Rhythm* condition was 4.8 syllables per second, ranging from 4.1 to 5.5 syllables per second. The majority of the participants reduced their articulation rate during the *Rhythm* condition. This reduction was statistically significant, $t(18) = 5.80$, $p < 0.01$, with a large effect size, $d = 1.33$. The percentage articulation rate reduction for all participants ranged from −3.1% to 18.6%, with a mean of 8.19%.

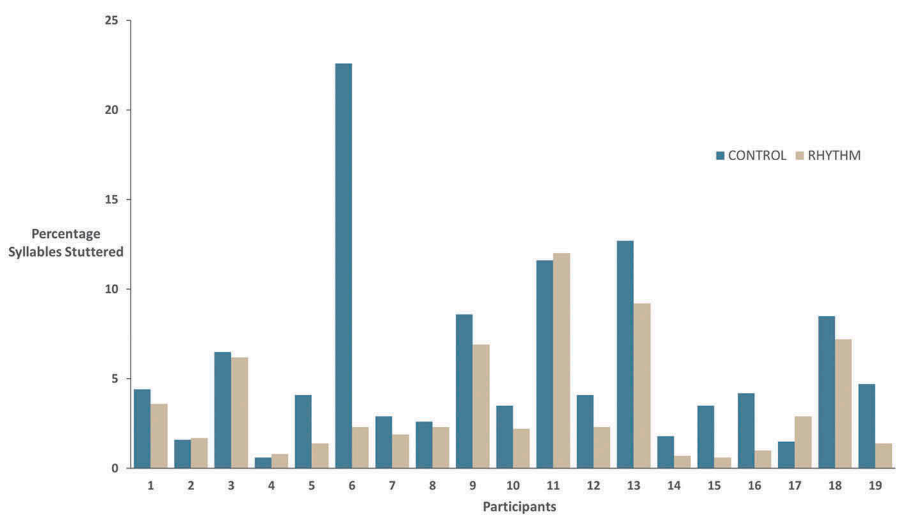

Figure 1. The percentage syllables stuttered (%SS) of the participants in both *Control* and *Rhythm* conditions.

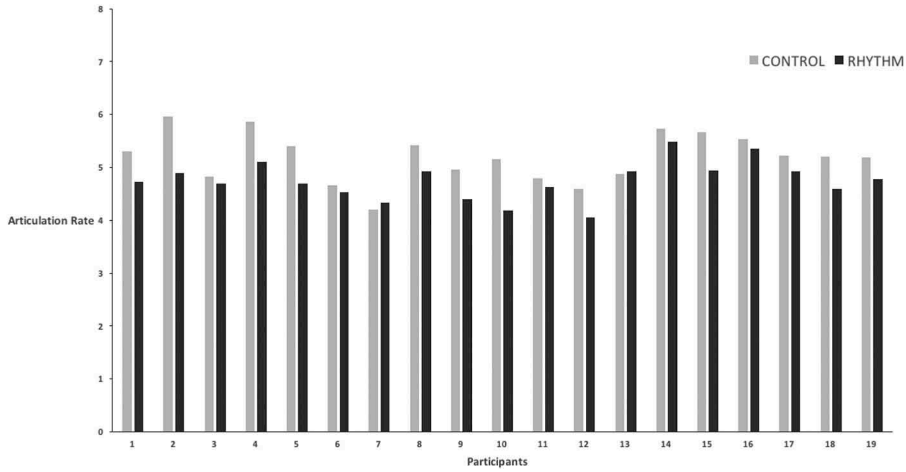

Figure 2. The articulation rate measured in syllables per second of the participants in both *Control* and *Rhythm* conditions.

Rhythmicity

The mean rhythmicity scores of the participants ranged from 1.0 to 5.0. This indicated that some participants were considered to be using extremely rhythmic speech and some did not speak in a rhythmic manner (Figure 3). Table 2 details the mean rhythmicity rating of each participant. The spectrograms in Figure 4 illustrate an utterance produced by a participant speaking with a high degree of rhythmicity and an utterance produced by a participant speaking with a low degree of rhythmicity. An utterance with more uniform syllable duration indicates higher degree of rhythmicity; 10 of the 19 participants obtained a mean rhythmicity score of 3.0 or above, indicating that they were able to speak in a rhythmic manner. Of the nine participants who had a low degree of rhythmicity during rhythmic speech condition, three received a mean score of 1.0, which indicated that they were not speaking rhythmically, despite the training provided.

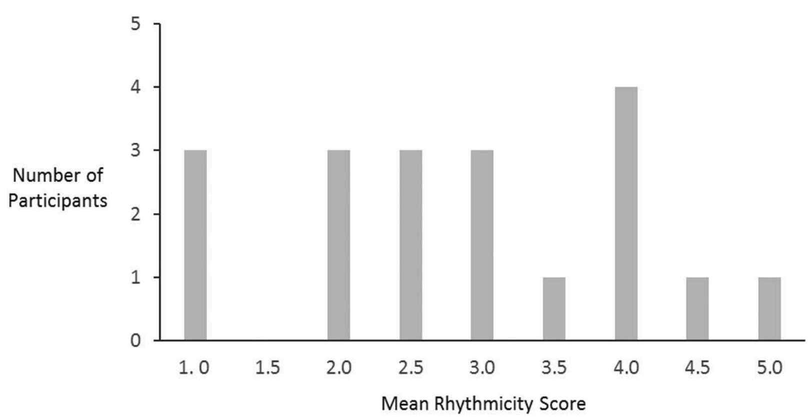

Figure 3. The distribution of the mean rhythmicity scores.

Table 2. The mean rhythmicity rating and per cent of stuttering reduction in *Rhythm* condition.

Participant	Mean rhythmicity rating	Per cent of stuttering reduction
1	1	18.8
2	2.5	−2.6
3	3	5.7
4	4	70.9
5	3	65.1
6	4	89.8
7	2.5	34.2
8	1	13.2
9	2	19.8
10	3.5	37.9
11	1	−3.4
12	4	43.6
13	2	27.8
14	4	64.2
15	4.5	81.9
16	3	76.0
17	2.5	−96.5
18	2	15.2
19	5	69.3

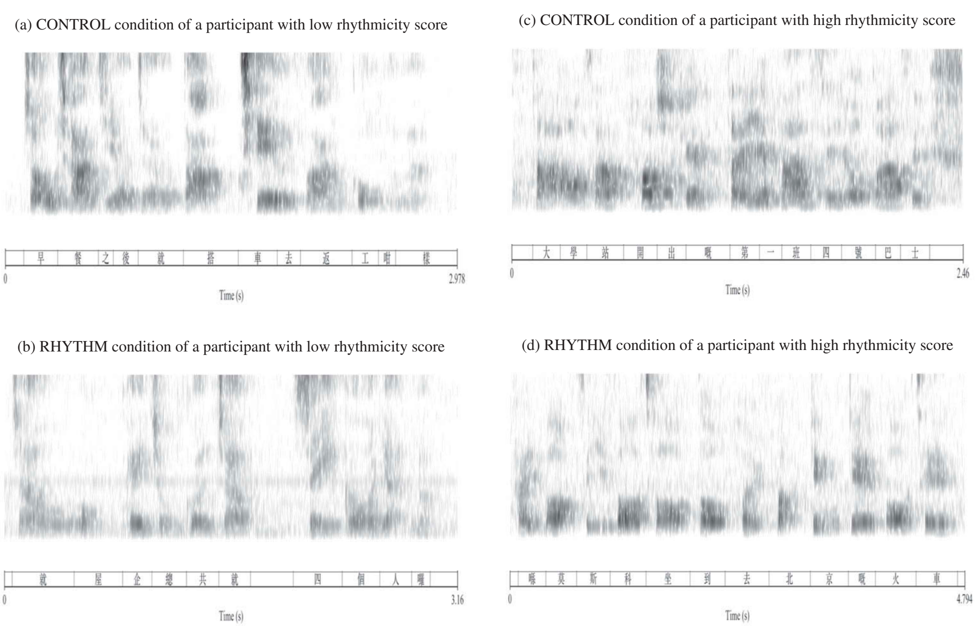

Figure 4. Spectrograms of utterances by a participant with low rhythmicity score and a participant with high rhythmicity score in both *Control* and *Rhythm* conditions.

(a) *Control* condition of a participant with low rhythmicity score
(b) *Rhythm* condition of a participant with low rhythmicity score
(c) *Control* condition of a participant with high rhythmicity score
(d) *Rhythm* condition of a participant with high rhythmicity score

Relationships among reduction in stuttering, reduction in articulation rate and degree of rhythmicity in the RHYTHM condition

Correlations among variables were conducted with and without the inclusion of an outlier; for one participant, %SS during the rhythmic speech condition was almost double during the natural speech condition, which is unusual.

There was a strong positive correlation between the percentage stuttering reduction and rhythmicity score, $r = 0.75$, $p < 0.01$, with a $R^2 = 0.56$. Without the outlier, the strong positive correlation remains with $r = 0.78$, $p < 0.01$ and a $R^2 = 0.61$. This indicated that the more rhythmic the participants were during the *Rhythm* condition, the more they reduced their stuttering.

Results of the correlation between percentage stuttering reduction and percentage articulation rate reduction showed that the stuttering reduction during rhythmic speech condition was independent to the reduction of articulation rate, $r = 0.04$, $p = 0.88$. Without the outlier, $r = -0.06$, $p = 0.83$.

There was also no relationship between reduction of articulation rate and the degree of rhythmicity during rhythmic speech condition. The correlation between the two variables is $r = 0.18$, $p = 0.45$ and $r = 0.19$, $p = 0.46$, with and without the outlier, respectively.

A regression analysis was anticipated to investigate the individual contribution to stuttering reduction due to the changes in articulation rate and degree of rhythmicity. However, since only one variable, the degree of rhythmicity, met the criteria for further analysis, the above simple correlations were sufficient.

Stratified analyses: high-rhythmicity and low-rhythmicity group

Follow-up analyses were conducted to examine whether there was a difference in stuttering reduction and articulation rate reduction between those who spoke with a high degree of rhythmicity and those who spoke with a low degree of rhythmicity. Ten participants were placed into the high-rhythmicity group (rhythmicity score of 3.0 or above) and nine were placed into the low-rhythmicity group (rhythmicity score of 1.0–2.0).

The mean percentage of reduction in %SS for the high-rhythmicity group was 60.4% (range 5.7–89.8%); for the low-rhythmicity group, it was 3.0% (range −96.5–34.2%) (see Figure 5). The high-rhythmicity group had a significantly greater reduction in stuttering when compared to the low-rhythmicity group, $t(17) = -3.85$, $p < 0.01$, $d = 1.75$, with a large effect size.

The mean percentage of reduction in articulation rate for the high-rhythmicity group was 9.0% (range 2.7–18.6%) and for the low-rhythmicity group was 7.3% (range −3.1–18.1%) (Figure 6). The difference of articulation rate reduction between the two groups was not statistically significant, $t(17) = -0.61$, $p = 0.55$.

Discussion

This is the first study to investigate the effects of rhythmic speech on stuttering in a syllable-timed language. Previous studies conducted in English have consistently demonstrated that when speakers adopt syllable-timed rhythmic speech, their stuttering will greatly reduce or even be eliminated (Andrews et al., 1982; Davidow et al., 2009; Ingham et al., 2009, 2012; Martin & Haroldson, 1979; Packman et al., 2001, 1997). The results of the present study with adult Cantonese speakers align with these findings to

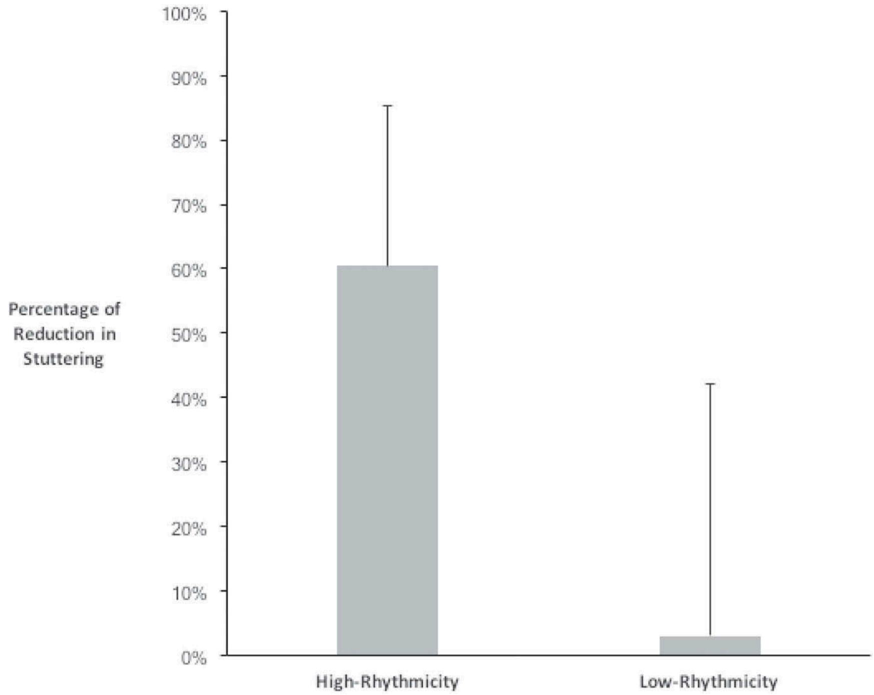

Figure 5. The mean percentage stuttering reduction of the high-rhythmicity and low-rhythmicity group in *Rhythm* condition.

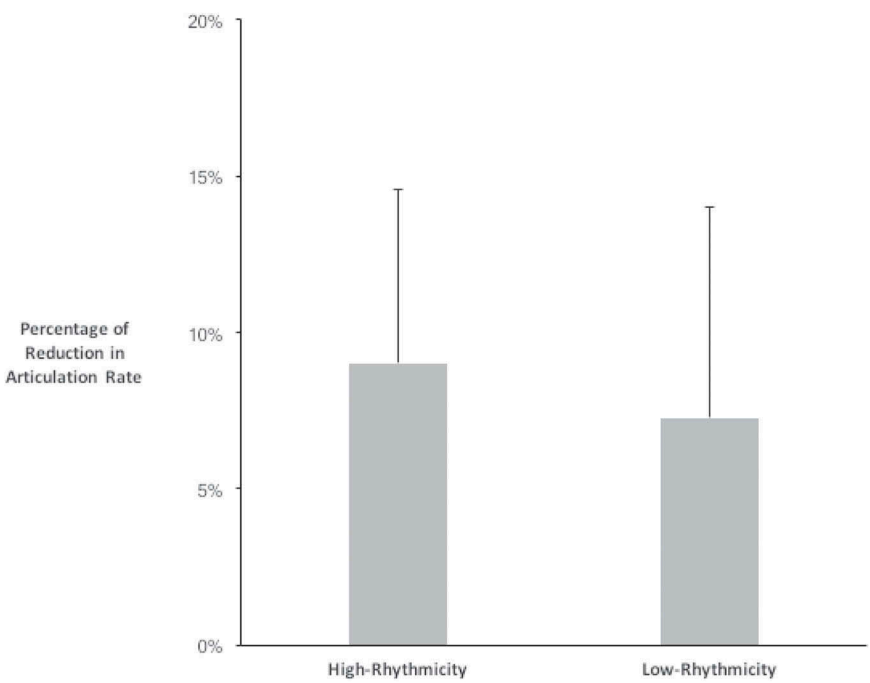

Figure 6. The mean percentage articulation rate reduction of the high-rhythmicity and low-rhythmicity group in *Rhythm* condition.

some extent; however, the reductions in stuttering were not nearly as great as those in these studies. Interestingly, the Cantonese speakers in this study appeared to have difficulty adopting the syllable-timed rhythmic speech pattern (STS) during the *Rhythm* condition, despite the highly syllable-timed nature of Cantonese.

Stuttering reduction with STS

The median %SS scores for the 19 participants reduced from 4.1 in the *Control* condition to 2.3 in the *Rhythm* condition, with the measures in the *Rhythm* condition ranging from 0.6%SS to 12.0%SS. The mean percentage reduction was 43.2% and, while this reduction is statistically significant, it is not nearly as great as those in previous studies in English. Importantly, none of the participants were stutter-free in this condition.

The first conclusion about this finding would be that STS is simply not as effective in reducing stuttering in Cantonese as it is in in other languages. However, this explanation does not ring true because it was apparent that most participants actually had difficulty adopting the rhythmic STS pattern. The 5-point rhythmicity scale developed for the study showed that only 10 of the 19 participants were judged to be speaking rhythmically (range 3–5), and, of those, only 2 participants were judged to be extremely rhythmic, with scores of 5. In other words, most participants were not able to acquire a high degree of rhythmicity.

To further explore the limited reductions in stuttering in the *Rhythm* condition, we found that rhythmicity was strongly and positively correlated with amount of stuttering reduction. In other words, the more rhythmic a participant's speech, the greater the reduction in stuttering was likely to be. When we further analysed the data by stratifying the participants into a high-rhythmicity group (scores 3–5) and a low-rhythmicity group (scores 1–2), the effects of rhythmic speech were still clear. The mean percentage stuttering reduction was 60.5% for the high-rhythmicity group at and only 3.0% for the low-rhythmicity group. This difference was statistically significant, with a large effect size. Hence, it appears that degree of rhythmicity was the major factor responsible for inducing fluency in our participants. In other words, rhythmic speech—to the extent that it was used—was effective in reducing stuttering. The association between degree of rhythmicity and stuttering severity is consistent with the P&A three-factor causal model of moments of stuttering (Packman & Attanasio, 2017).

Rhythmic speech and the syllable-timed nature of Cantonese

A paradoxical finding of this study was that the Cantonese speakers had difficulty adopting a syllable-timed rhythmic speech pattern. Intuitively, it could be assumed that Cantonese speakers would find it easier than speakers of other languages to speak in syllable-timed rhythmic speech, given the syllable-timed nature of this language. However, this was not shown to be the case and, surprisingly, the proportion of participants who had difficulty adopting a syllable-timed rhythmic speech was much higher than that of previous studies. Previous studies reported that at least 75% of participants, regardless of whether they stuttered, were able to speak rhythmically (Davidow, 2014; Davidow et al., 2009, 2011; Ingham et al., 2009, 2012; Packman et al., 1997). In contrast, results of this study showed that, during the *Rhythm* condition, 47% of the participants were rated to have a low-degree of rhythmicity, and of those, three participants were unable to speak in rhythm at all.

It could be argued that the low success rate in using rhythmic speech could be due to poor instruction given prior to the *Rhythm* condition. However, previous studies have indicated that rhythmic speech requires minimal training, with participants taking only a few minutes to acquire the technique (Christenfeld, 1996; Packman et al., 2000). Approximately 15 min of demonstration and practice of rhythmic speech was provided to each participant in the present study which is consistent with the previous studies (Andrews et al., 1982; Davidow, 2014; Ingham et al., 2009, 2012; Packman et al., 1997; Toyomura et al., 2011) and a metronome signal was provided to the participants through an earpiece to facilitate their rhythmic speech production. Therefore, the difficulty in adopting a syllable-timed rhythmic speech in this study is unlikely to be related to poor instruction or training.

This leaves us with the more likely explanation that the difficulty adopting rhythmic speech pattern by participants in this study is related to the minimal difference between Cantonese and syllable-timed rhythmic speech. Previous studies in rhythmic speech were mainly conducted in English and, from a language rhythm perspective, when required to speak rhythmically, English speakers move from the stress-timed end of the language rhythm continuum to the highly syllabic speech pattern that is known to reduce stuttering. However, for Cantonese speakers, their normal speech is already close to that speech pattern. In other words, they are required to make only a small shift further along the syllable-timed continuum order to sound more rhythmic. This can be seen by comparing the spectrograms in Figure 4. There is slightly less variation in syllable duration in *Rhythm* condition (Figure 4(d)), when compared to the *Control* condition (Figure 4(a) and (c)). Therefore, it may be more difficult for Cantonese speakers to use STS because there is little contrast between that and their normal Cantonese.

Speech rate and rhythmic speech

It has been suggested that reductions in speech rate may contribute to the effects of rhythmic speech (Davidow, 2014; Packman et al., 2000). While previous studies have consistently shown that speech rate is not related to the effects of rhythmic speech (Andrews et al., 1982; Brady, 1969; Davidow, 2014; Davidow et al., 2011; Packman et al., 1997), it is still important to look for this possibility. Measures of articulation rate indeed showed a statistically significant reduction in speech rate in the *Rhythm* condition. This finding was not surprising and corroborated with previous studies (Andrews et al., 1982; Brady, 1969; Davidow et al., 2011; Packman et al., 1997). Since participants were taught to speak in a way that was different from their usual pattern, their articulation rate would be expected to reduce in order to consciously engage in this novel motor speech production.

Importantly, however, our results confirmed that articulation rate was independent of the effects of rhythmic speech. There were no correlations between articulation rate and either %SS or rhythmicity. Further, there was no difference in the reduction of articulation rate between those participants with a high rhythmicity and those with a low rhythmicity. It can be concluded, then, that articulation rate was not a factor in the reductions in stuttering in this study.

Clinical implications

The findings of this study have clinical implications, given that STS is used to induce fluency in some behavioural treatments for stuttering in both children and adults. The findings raise the issue of whether rhythmic speech should be recommended for

Cantonese-speaking adults who stutter. The results of this study provide a less than straightforward answer to this question. Despite a smaller reduction of stuttering in the present study, when compared to rhythm studies in English, rhythmic speech does appear to be effective to some extent in inducing fluency in Cantonese-speaking adults who stutter. Also, since the language rhythm in everyday speaking Cantonese and rhythmic speech is quite similar, treatment based on STS may result in more natural sounding speech and hence require less naturalness training.

Paradoxically, however, this similarity may hinder some Cantonese-speaking adults who stutter using STS to the extent needed to successfully control stuttering. It may be that a technique that has a greater contrast in rhythmicity, such as speech restructuring (prolonged speech, smooth speech), provides an easier target for them.

However, as clearly shown in this study, not only is speech rate not associated with the effects of rhythmic speech but it was also unrelated to degree of rhythmicity. Therefore, although slowing down is expected during rhythmic speech production when first introduced, it is not necessary to make speech rate a treatment target. Instead, people who stutter should perhaps be instructed to speak at their own rate while the main focus should be on maintaining a high-degree of rhythmicity.

Future research

Replication of the findings of this study with adults is needed before definite conclusions can be drawn about the effects of syllable-timed rhythmic speech on stuttering in Cantonese. It would also be critical to investigate the rhythm effect in Cantonese-speaking children who stutter. It is known from research in other languages that the early utterances of children tend to be quite evenly stressed, across syllables, before they develop more adult patterns of linguistic stress (Kehoe & Stoel-Gammon, 1997; Schwartz, Petinou, Goffman, Lazowski, & Cartusciello, 1996). It is also known that at onset in the preschool years, at least in English, stuttering typically takes the form of syllable repetitions. The effects of STS on stuttering in young Cantonese-speaking children, then, may differ from those in adults.

In the present study, rhythmicity was measured at a perceptual level. In future research, acoustic analyses could be used to compare the use of STS in Cantonese with other syllable-timed languages. Perceptual and acoustic analyses comparing STS in Cantonese and STS in stress-timed languages would also be of interest.

Future research could also examine whether Cantonese speakers who stutter exhibit differing degrees of rhythmicity when speaking normally and, if so, whether there is a relationship between degree of rhythmicity and stuttering severity. Furthermore, research could also explore whether stuttering varies in Cantonese speakers when speaking rhythmically across various tasks, such as reading, and across contexts, such as speaking in different situations in their natural environment. Finally, other variables that have been proposed to contribute to the rhythm effect, such as the duration of phonation intervals, could be measured during rhythmic speech in Cantonese speakers, to investigate their possible contribution to stuttering reduction.

From a clinical perspective, future research could further explore the acquisition rate of rhythmic speech in Cantonese or other syllable-timed language adults who stutter, to determine the feasibility of using rhythmic speech as treatment. Should rhythmic speech be determined as a viable clinical option, further research investigating the most effective way to instruct rhythmic speech as well as the optimal degree of rhythmicity that induces the greatest amount of fluency is warranted.

Further, considering that rhythmic speech has shown favourable treatment outcomes for early intervention in English, it may be possible that STS could also be applied to Cantonese-speaking children who stutter. However, careful outcome measures on speech naturalness will be required, given the similarities between syllable-timed rhythmic speech and Cantonese.

Conclusion

This is the first study to investigate the effects of rhythmic speech on stuttering in a syllable-timed language and the first to demonstrate a relationship between the degree of rhythmicity and stuttering reduction. The results converge with previous findings conducted in English that rhythmic speech has ameliorative effects on stuttering in Cantonese. However, an intriguing and unexpected finding was that the results of this pioneering investigation provide preliminary evidence that effects of syllable-timed rhythmic speech may not be as apparent as they are in English, this warrants further investigation with more participants. These findings indicated that despite Cantonese being one of the most syllable-timed languages, its rhythmicity is apparently not as strong as the clinically employed rhythmic speech. An important conclusion to be drawn from this study is that the commonly accepted fluency-enhancing conditions may not be universally effective in reducing stuttering and may be influenced by the features of different languages.

Acknowledgements

The authors would also like to acknowledge and thank Chris Tse, Ginni Lam, Lam Hei Lok, Catherine Chan and David Chung for assisting with data transcription and preparation. The authors wish to thank Ms Annie Fu for her assistance with data analysis.

Declaration of interest

Financial Disclosures: Ann Packman, Mark Onslow, Carol To and Kathy Lee received funding from the Australian Research Council (Grant Code DP140100982) in support of the research described in this paper.

Non-Financial Disclosures: Thomas Law, Ann Packman, Mark Onslow, Carol To, Kathy Lee and Michael Tong have no relevant non-financial relationships to disclose in support of the research reported in this article.

Preliminary findings of this study were reported at the 10th Biennial Asia Pacific Conference on Speech, Language and Hearing, in Narita, in 2017.

Funding

This research was funded by the Australian Research Council [Grant Code DP140100982].

References

Abercrombie, D. (1967). *Elements of general phonetics*. Chicago, IL: Aldine.

Andrews, C., O'Brian, S., Harrison, E., Onslow, M., Packman, A., & Menzies, R. (2012). Syllable-timed speech treatment for school-age children who stutter: A phase I trial. *Language, Speech and Hearing Services in Schools*, *43*, 359–369. doi:10.1044/0161-1461(2012/11-0038)

Andrews, C., O'Brian, S., Onslow, M., Packman, A., Menzies, R., & Lowe, R. (2016). Phase II trial of a syllable-timed speech treatment for school-age children who stutter. *Journal of Fluency Disorders*, *48*, 44–55. doi:10.1016/j.jfludis.2016.06.001

Andrews, G., & Harris, M. (1964). *The syndrome of stuttering*. Oxford, London: William Heinemann Medical Books.

Andrews, G., Howie, P. M., Dosza, M., & Guitar, B. E. (1982). Stuttering: Speech pattern characteristics under fluency-inducing conditions. *Journal of Speech, Language, and Hearing Research*, *25*, 208–216. doi:10.1044/jshr.2502.208

Bloodstein, O., & Bernstein Ratner, N. (2008). *A handbook on stuttering* (6th ed.). Clifton Park, NY: Delmar.

Boersma, P., & Weenink, D. (2017). *Praat: Doing phonetics by computer* (Version 6.0.30). Retrieved from www.praat.org

Brady, J. P. (1969). Studies on the metronome effect on stuttering. *Behaviour Research and Therapy*, *7*, 197–204. doi:10.1016/0005-7967(69)90033-3

Chon, H., Sawyer, J., & Ambrose, N. G. (2012). Differences of articulation rate and utterance length in fluent and disfluent utterances of preschool children who stutter. *Journal of Communication Disorders*, *45*, 455–467. doi:10.1016/j.jcomdis.2012.08.003

Christenfeld, N. (1996). Effects of a metronome on the filled pauses of fluent speakers. *Journal of Speech, Language, and Hearing Research*, *39*, 1232–1238. doi:10.1044/jshr.3906.1232

Dauer, R. M. (1983). Stress-timing and syllable-timing reanalyzed. *Journal of Phonetics*, *11*(1), 51–62.

Davidow, J. H. (2014). Systematic studies of modified vocalization: The effect of speech rate on speech production measures during metronome-paced speech in persons who stutter. *International Journal of Language & Communication Disorders*, *49*, 100–112. doi:10.1111/1460-6984.12050

Davidow, J. H., Bothe, A. K., Andreatta, R. D., & Ye, J. (2009). Measurement of phonated intervals during four fluency-inducing conditions. *Journal of Speech, Language, and Hearing Research*, *52*, 188–205. doi:10.1044/1092-4388(2008/07-0040)

Davidow, J. H., Bothe, A. K., & Ye, J. (2011). Systematic studies of modified vocalization: Speech production changes during a variation of metronomic speech in persons who do and do not stutter. *Journal of Fluency Disorders*, *36*, 93–109. doi:10.1016/j.jfludis.2011.03.003

de Jong, N. H., & Wempe, T. (2009). Praat script to detect syllable nuclei and measure speech rate automatically. *Behavior Research Methods*, *41*, 385–390. doi:10.3758/BRM.41.2.385

Grabe, E., & Low, E. L. (2002). Durational variability in speech and the rhythm class hypothesis. *Laboratory Phonology*, *7*. Retrieved from http://wwwhomes.uni-bielefeld.de/~gibbon/AK-Phon/Rhythmus/Grabe/Grabe_Low-reformatted.pdf

Guitar, B. (2014). *Stuttering: An integrated approach to its nature and treatment* (4th ed.). Baltimore, MD: Lippincott Williams & Wilkins.

Hall, K. D., Amir, O., & Yairi, E. (1999). A longitudinal investigation of speaking rate in preschool children who stutter. *Journal of Speech, Language, and Hearing Research*, *42*, 1367–1377. doi:10.1044/jslhr.4206.1367

Ingham, J. C., & Riley, G. (1998). Guidelines for documentation of treatment efficacy for young children who stutter. *Journal of Speech, Language, and Hearing Research*, *41*, 753–770. doi:10.1044/jslhr.4104.753

Ingham, R. J., Bothe, A. K., Jang, E., Yates, L., Cotton, J., & Seybold, I. (2009). Measurement of speech effort during fluency-inducing conditions in adults who do and do not stutter. *Journal of Speech, Language, and Hearing Research*, *52*, 1286–1301. doi:10.1044/1092-4388(2009/08-0181)

Ingham, R. J., Bothe, A. K., Wang, Y., Purkhiser, K., & New, A. (2012). Phonation interval modification and speech performance quality during fluency-inducing conditions by adults

who stutter. *Journal of Communication Disorders*, *45*, 198–211. doi:10.1016/j.jcomdis.2012.01.004
Ingham, R. J. (1984). Rhythmic-stimulation procedures. In R. J. Ingham (Ed.), *Stuttering and behavior therapy: Current status and experimental foundations* (pp. 89–117). San Diego, CA: College-Hill Press.
Kehoe, M., & Stoel-Gammon, C. (1997). The acquisition of prosodic structure: An investigation of current accounts of children's prosodic development. *Language*, *73*(1), 113–144. doi:10.2307/416597
Law, T., Packman, A., Onslow, M., To, C. K.-S., Tong, M. C.-F., & Lee, K. Y.-S. (2017). The topography of stuttering in cantonese. *Folia Phoniatrica et Logopaedica*, *69*(3), 110–117.
Law, T., Packman, A., Onslow, M., To, C. K.-S., Tong, M. C.-F., & Lee, K. Y.-S. (2018). Lexical tone and stuttering in cantonese. *Clinical Linguistics & Phonetics*, *32*(4), 285–297. doi: 10.1080/02699206.2017.1359851
Martin, R., & Haroldson, S. K. (1979). Effects of five experimental treatments on stuttering. *Journal of Speech, Language, and Hearing Research*, *22*, 132–146. doi:10.1044/jshr.2201.132
Mok, P. P. K. (2009). On the syllable-timing of Cantonese and Beijing Mandarin. *Chinese Journal of Phonetics*, *2*, 148–154.
Packman, A. (2012). Theory and therapy in stuttering: A complex relationship. *Journal of Fluency Disorders*, *37*, 225–233. doi:10.1016/j.jfludis.2012.05.004
Packman, A., & Attanasio, J. S. (2017). *Theoretical Issues in Stuttering* (2 ed.). New York, NY: Routledge.
Packman, A., Hand, L., Cream, A., & Onslow, M. (2001). *An investigation of linguistic factors in the rhythm effect in stuttering*. Paper presented at the 4th International Speech Motor Conference, Speech motor control in normal and disordered speech, Nijmegen, The Netherlands.
Packman, A., Onslow, M., & Menzies, R. (2000). Novel speech patterns and the treatment of stuttering. *Disability and Rehabilitation*, *22*, 65–79. doi:10.1080/096382800297132
Packman, A., Onslow, M., Richard, F., & van Doorn, J. (1996). Syllabic stress and variability: A model of stuttering. *Clinical Linguistics and Phonetics*, *10*, 235–263. doi:10.3109/02699209608985174
Packman, A., Onslow, M., & van Doorn, J. (1997). Linguistic stress and the rhythm effect in stuttering. In W. Hulstijin, H. F. M. Peters, & P. H. H. M. van Lieshout (Eds.), *Speech production: Motor control, brain research, and fluency disorders* (pp. 473–478). Amsterdam, New York: Elsevier.
Portney, L. S., & Watkins, M. P. (2000). *Foundations of clinical research: Applications to practice* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.
Roach, P. (1982). On the distinction between 'stress-timed' and 'syllable-timed' languages. In D. Crystal (Ed.), *Linguistic controversies: Essays in linguistic theory and practice in honour of F.R. Palmer* (pp. 73–79). London, UK: Arnold.
Schwartz, R. G., Petinou, K., Goffman, L., Lazowski, G., & Cartusciello, C. (1996). Young children's production of syllable stress: An acoustic analysis. *The Journal of the Acoustical Society of America*, *99*, 3192–3200. doi:10.1121/1.414803
Simons, G. F., & Fenning, C. D. (2017). *Ethnologue: Languages of the world* (20th ed.). Dallas, Texas: SIL International. Retrieved from Online version http://www.ethnologue.com/
Stager, S. V., Denman, D. W., & Ludlow, C. L. (1997). Modifications in aerodynamic variables by persons who stutter under fluency-evoking conditions. *Journal of Speech, Languag,E and Hearing Research*, *40*, 832–847. doi:10.1044/jslhr.4004.832
Stager, S. V., Jeffries, K. J., & Braun, A. R. (2003). Common features of fluency-evoking conditions studied in stuttering subjects and controls: An H_2 ^{15}O PET study. *Journal of Fluency Disorders*, *28*, 319–336. doi:10.1016/j.jfludis.2003.08.004
Starkweather, C. W. (1987). *Fluency and stuttering*. Englewood Cliff, NJ: Prentice-Hall.
Tasko, S. M., McClean, M. D., & Runyan, C. M. (2007). Speech motor correlates of treatment-related changes in stuttering severity and speech naturalness. *Journal of Communication Disorders*, *40*, 42–65. doi:10.1016/j.jcomdis.2006.04.002
Toyomura, A., Fujii, T., & Kuriki, S. (2011). Effect of external auditory pacing on the neural activity of stuttering speakers. *NeuroImage*, *57*, 1507–1516. doi:10.1016/j.neuroimage.2011.05.039

Trajkovski, N., Andrews, C., O'Brian, S., Onslow, M., & Packman, A. (2006). Treating stuttering in a preschool child with syllable timed speech: A case report. *Behaviour Change*, *23*, 270–277. doi:10.1375/bech.23.4.270

Trajkovski, N., Andrews, C., Onslow, M., O'Brian, S., Packman, A., & Menzies, R. (2011). A Phase II trial of the Westmead Program: Syllable-timed speech treatment for preschool children who stutter. *International Journal of Speech-Language Pathology*, *13*, 500–509. doi:10.3109/17549507.2011.578660

Trajkovski, N., Andrews, C., Onslow, M., Packman, A., O'Brian, S., & Menzies, R. (2009). Using syllable-timed speech to treat preschool children who stutter: A multiple baseline experiment. *Journal of Fluency Disorders*, *34*, 1–10. doi:10.1016/j.jfludis.2009.01.001

Tumanova, V., Zebrowski, P. M., Throneburg, R. N., & Kulak Kayikci, M. E. (2011). Articulation rate and its relationship to disfluency type, duration, and temperament in preschool children who stutter. *Journal of Communication Disorders*, *44*, 116–129. doi:10.1016/j.jcomdis.2010.09.001

van Lieshout, P. H. H. M., Hulstijin, W., & Peters, H. F. M. (2004). Searching for the weak link in the speech production chain of people who stutter: A motor skill approach. In B. Maaseen, R. Kent, P. van Lieshout, & W. Hulstijin (Eds.), *Speech motor control in normal and disordered speech* (pp. 313–356). New York, NY: Oxford University Press.

Wingate, M. (1981). Sound and pattern in artificial fluency: Spectrographic evidence. *Journal of Fluency Disorders*, *6*, 95–118. doi:10.1016/0094-730X(81)90009-7

Wingate, M. E. (1976). *Stuttering: Theory and treatment*. New York, NY: Irvington.