The complexity of stuttering behavior in adults and adolescents: Relationship to age, severity, mental health, impact of stuttering, and behavioral treatment outcome.

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Abstract

Purpose: This study investigated the complexity of stuttering behavior. It described and classified the complexity of stuttering behavior in relation to age, behavioral treatment outcomes, stuttering severity, anxiety-related mental health, impact of stuttering, and gender.

Method: For this study, a taxonomy was developed—LBDL-C7—which was based on the Lidcombe Behavioral Data Language of stuttering. It was used by five experienced judges to analyze the complexity of stuttering behavior for 84 adults and adolescents before and after speech restructuring treatment. Data were 3,100 stuttering moments, which were analyzed with nominal logistic regression.

Results: The complexity of stuttering behavior appears not to change as a result of treatment, but it does appear to change with advancing age. Complexity of stuttering behavior was found to be independently associated with clinician stuttering severity scores but not with percentage of syllables stuttered or self-reported stuttering severity. Complexity of stuttering behavior was not associated with gender, anxiety, or impact of stuttering.

Conclusions: Clinical and research applications of these findings are discussed.

Introduction

Stuttering

The cause of stuttering is not yet fully understood, despite decades of research and theorizing (see Packman & Attanasio, 2017). However, much recent research indicates that it is a disorder with genetic involvement (see Frigerio-Domingues and Drayna, 2017; Kraft and Yairi, 2011), underpinned by impaired neural processing in the areas of the brain associated with spoken language (see Chang et al., 2019; Etchell et al., 2018). Stuttering typically starts during the early preschool years, with a cumulative incidence of 11.2% by 4 years of age, according to an Australian community prospective study (Reilly et al., 2013). Many children recover naturally within a few years, and around 1–2% continue to stutter throughout life (see Bloodstein et al., 2021).

The speech behaviors of early stuttering

Typically, the speech behaviors of stuttering onset involve *repetitions* of words or parts of words (Ambrose & Yairi, 1999; Bloodstein & Grossman, 1981; Reilly et al., 2009; Yairi & Lewis, 1984). The child may then start to stretch out speech sounds (commonly called *prolongations*) and speech may stop altogether (commonly referred to as *blocks*). Signs of struggle can develop as the child attempts to say a word. Thus, it is generally thought that, although moments of stuttering can be behaviorally quite simple at onset, over time, they typically become more complex, often comprising several of the above behaviors concurrently. For example, Onslow (1995) describes a moment of stuttering produced by a 4-year old, illustrated with waveform and spectrogram (see Figure 1), which shows the complexity of the stuttering behavior at the start of the word “well” in the utterance “Well I like” (spoken with an Australian accent). It comprises five repetitions of the first part of the word (/wea/), prolongation

of the vowel in one of the repetitions, and aberrant periods of silence between the repetitions. However, beyond the broad information that repetitions characterize stuttering at onset, with subsequent development of other behaviors, no information is available about the behavioral transition from early stuttering to persistent stuttering later in life.

INSERT FIGURE 1 AROUND HERE

Taxonomies of stuttering behavior

Stuttering-Like Disfluencies

Stemming from Johnson's original taxonomy (Johnson & Associates, 1959), a number of variants have developed for early stuttering (Einarsdóttir & Ingham, 2005). Currently, the most widely used taxonomy of early stuttering behaviors is the Stuttering-Like Disfluencies (SLD) taxonomy. SLDs comprise *part-word repetitions*, *single syllable word repetitions*, and *disrhythmic phonation* (see Yairi et al., 1996). Disfluencies that do not fit those descriptors are known as Other Disfluencies. This taxonomy was designed to help discriminate between stuttering and normal disfluency in preschool children. As the term "Stuttering-Like Disfluencies" indicates, disfluencies identified with the three descriptors are not necessarily stuttering; rather, three or more SLDs per 100 syllables are required in a child's speech to identify the child as stuttering. The complexity of stuttering in preschoolers who stutter has been investigated, using combinations of SLD and Other Disfluencies descriptors to identify clusters of disfluencies in one or more adjacent words (Ambrose & Yairi, 1999; Hubbard & Yairi, 1988; Logan & LaSalle, 1999; Sawyer & Yairi, 2010). This procedure has also been used with adults (Robb et al., 2009).

The SLD taxonomy has been used to establish information about the developmental course of early stuttering. Yairi et al. (1996) used the SLD taxonomy with a cohort of 32 preschoolers who stuttered and 32 control children to determine any indicators of whether natural recovery would occur and whether it would occur early or late in stuttering development. However, no definitive findings emerged. With 47 preschool children who stuttered, Walsh et al. (2020) used an algorithm based on the SLD taxonomy to explore whether recovery could be predicted when the childen were 6–9 years old. They reported an 83% correct recovery prediction based on a certain cutoff algorithm score.

The Lidcombe Behavioral Data Language

The Lidcombe Behavioral Data Language (LBDL) (Packman & Onslow, 1998; Teesson et al., 2003) was developed to overcome limitations of extant behavioral descriptors: they are imprecise and do not capture the complexity of stuttering moments (Onslow, 1995; Onslow et al., 1992). The LBDL was developed to provide an operational behavioral taxonomy of stuttering moments. It is not a method for identifying stuttering, but it is a taxonomy of behaviors that have, a priori, been identified perceptually as stuttering. The LBDL has been shown to have acceptable reliability when used by speech-language pathologists (SLPs) who have experience working with those who stutter (Teesson et al., 2003).

The LBDL comprises three categories with seven descriptors, as illustrated in Figure 2. *Repeated movements* (commonly referred to as “repetitions”) comprise either repetition of an entire syllable (*syllable repetition*), part of a syllable (*incomplete syllable repetition*) or more than one syllable (*multisyllable unit repetition*). Repeated movements can occur for short or long periods. With *fixed postures*, the usual movements of articulators, such as mouth, jaw, and lips, cease. Fixed postures can be brief or can last for as long as half a minute. Fixed postures *with*

audible airflow are commonly referred to as "prolongations" and involve articulatory and laryngeal sounds, which may involve phonation or voiceless consonants such as /s/ and /f/. Fixed postures *without audible airflow*—no sound—are commonly referred to as "blocks." *Superfluous behaviors* do not contribute to the intended verbal communication. Superfluous behaviors that are verbal are described elsewhere as "interjections" (Johnson & Associates, 1959). Examples are "well, you know, you see …" and "oh well, um, yes, um …" Superfluous behaviors that are non-verbal are potentially the most socially distracting behaviors of the disorder, involving grimacing, breath holding, inspiratory airflow, eyebrow movement, and lip compression.

INSERT FIGURE 2 AROUND HERE

More than one descriptor can be applied to any moment of stuttering and so can convey the behavioral complexity of stuttering. To illustrate, in the complex stuttering moment presented by Onslow (1995) (see Figure 1), three of the seven LBDL descriptors can be applied: *incomplete-syllable repetition*, *fixed posture with audible airflow*, and *fixed posture without audible airflow*. The seventh descriptor, *non-verbal superfluous behavior*, could not be applied because the moment of stuttering was taken from an audio-only recording. The aim of the present study is to explore the behavioral complexity of individual moments of stuttering using the LBDL, as in the above example. This procedure differs from the studies reported earlier that used SLDs and Other Disfluencies to explore the complexity of stuttering in preschoolers and adults. First, those studies identified *clusters* of disfluencies across syllables and words and,

second, SLDs are not necessarily stuttered disfluencies. As stated, the LBDL is only used to describe a disfluency already determined to be a moment of stuttering.

The LBDL has been used in several studies of stuttering (Blomgren et al., 2014; Hasseltine et al., 2016; Law et al., 2017; Lim et al., 2008; MacMillan et al., 2014; O'Brian, Packman, Onslow, & O'Brian, 2004). The LBDL has also been used to describe dysfluencies in other speech disorders, namely Parkinson's disease (Goberman et al., 2010) and apraxia (Bailey et al., 2017).

The potential clinical importance of observable stuttering behaviors

The behaviors of stuttering may differentially interfere with communication, and there is some suggestion of this during the preschool years. In the Langevin et al. (2009) study, four preschoolers with stuttering were video-recorded playing with peers in the preschool setting. It was found that they were more likely to suffer social penalty if stuttering behaviors such as *fixed postures* impaired getting their meaning across, as opposed to the simpler repetitious type of stuttering, which did not impair communication to such an extent.

If any such social penalties pertain to the disorder later in life, it would not be surprising if the complex behaviors of stuttering and the subsequent reduction in communicative effectiveness were associated with adverse effects of the disorder: (a) Mental health—particularly social anxiety disorder (Blumgart et al., 2010; Craig et al., 2003; Iverach et al., 2009, 2017; Stein et al., 1996), (b) impaired quality of life (Craig, 2010; Beilby et al., 2012; Franic et al., 2012; Koedoot et al., 2011); and (c) impaired educational, social, and vocational attainment (Blumgart et al., 2010; Bricker-Katz et al., 2013; Klein & Hood, 2004; Klompas & Ross, 2004; McAllister et al., 2012; O'Brian et al., 2011). Considering that stuttering is commonly associated with social anxiety, it is plausible that stuttering behaviors that are more likely to impede the

flow of speech substantively and draw attention to speech, such as *fixed postures* and *superfluous behaviors,* may lead to social anxiety more than *repeated movements*, which generally are simpler events. The Langevin et al. (2009) study mentioned above confirms this possibility. The same reasoning could be applied to the impact of stuttering, considering its likely connection to social anxiety. Further, substantive disruptions to the flow of speech arising from time-consuming *fixed postures* may have an impact from a practical perspective alone. Indeed, available data suggest that the verbal output of those who stutter is around a third less than their peers (Johnson, 1961; Spencer et al., 2009). Additionally, any such differential impact of stuttering behaviors may pertain to educational and vocational outcomes. Beyond that, two reports involving large cohorts (Gerlach et al., 2018; McAllister et al. 2012), introduced a complicating variable of gender into this issue; vocational status was lower for women than for men.

Stuttering treatment and the complexity of stuttering behavior

Despite the potential clinical importance of the topic, little is known about the complexity of stuttering behavior for persistent stuttering. Only limited data are available from three studies about this matter. In a nonclinical study, Law et al. (2017) studied 24 adult Cantonese speaking participants who stuttered, and, using the LBDL, they categorized participant stuttering moments as either simple or complex. Simple stuttering moments were those that could be described with only one of the LBDL behavioral descriptors, and complex stuttering moments were those that could be described with more than one of the LBDL descriptors. Law et al. reported that around half the stuttering moments were simple and half were complex, and that complexity status correlated with severity measured with percentage of syllables stuttered. In another nonclinical study, Mulcahy et al. (2008) studied 19 adolescents who stuttered and 18 controls, and reported

no association between measures of anxiety or quality of life and stutter type: “a repetition (collapsing across word and part-word repetitions), or a prolongation/block” p. 311).

In a clinical study, Ingham and Andrews (1971) compared post-treatment speech from an early version of speech restructuring treatment with syllable-timed speech. “Speech restructuring treatment” refers broadly to training clients “to use a new speech pattern to reduce stuttering while sounding as natural as possible” (Onslow & Menzies, 2010, p. 101). The treatment generally begins with a slowed speech rate using continuous vocalization, and is gradually shaped towards stutter-free speech that sounds reasonably natural. In contrast, syllable-timed speech is a simpler treatment process. Ingham and Andrews reported that speech restructuring treatment involved residual stuttering involving “sound and syllable repetitions” (p. 283). In contrast, syllable-timed speech involved residual stuttering associated with “blocks, prolongations, interjections and effortful omissions of a syllable” (p. 283).

The present study

In summary, the behaviors of persistent stuttering are potentially of clinical importance. They may be associated with mental health and impact of the disorder, and they may be associated with limited vocational outcome, potentially with gender effects. Stuttering behaviors may change with advancing age and with behavioral treatment. Yet, the preceding review shows that little is known about those matters. Consequently, the present study was designed to answer the following questions about the complexity of stuttering behavior with adolescents and adults, exploring variables that emerged during the preceding review: (a) Does it change with age? (b) Does it change after behavioral treatment? (c) Does it relate to anxiety-related mental health and impact of stuttering? (d) What is the influence of gender? Considering the likely influence of

stuttering severity on these variables, the study was designed to incorporate the potential influence of: (e) Stuttering severity.

Method

The study was approved by the Human Ethics Committee of The University of Sydney (03-2006/3/8772).

The LBDL Complexity-7 taxonomy

The LBDL Complexity-7 (LBDL-C7) taxonomy was designed for this study and comprises seven stuttering complexity types, based on all possible combinations of the three LBDL categories (repeated movements, fixed postures, and superfluous behaviors). This was devised to provide a comprehensive behavioral description of the complexity of any moment of stuttering.

The complexity types for the LBDL-C7 are shown in Table 1. The three broad LBDL behavioral categories are represented by the letters R (repeated movements), F (fixed postures), and S (superfluous behaviors). To illustrate, a stuttering moment might be classified as a repeated movement only (C7-R) or as a repeated movement with superfluous behavior (C7-RS).

INSERT TABLE 1 AROUND HERE

Participants

The study cohort comprised 84 adolescents and adults who were stuttering and assessed before and after a behavioral treatment program. There were 17 females and 67 males, who were treated previously for stuttering as part of a clinical trial (Cream et al., 2010). Of these, there were 61 adults (ages 18–74 years) and 23 adolescents (ages 12–17 years). Age information was available for 80 participants: mean age 26.9 years (*SD* 12.0 years, range 11–74 years). All

participants received an intensive group speech restructuring program at one of six specialist stuttering clinics in Australia or New Zealand. The treatments varied slightly between sites, but were loosely based on procedures described by either Block et al. (2005) or O'Brian et al. (2003). Each program involved an intensive week, which ran for approximately 8 hours per day for five consecutive days, followed by weekly 90-minute follow-up sessions for seven weeks. During the intensive week, all participants learned a speech restructuring pattern in a slow and unnatural manner, also known as prolonged speech, derived from the methods of Goldiamond (1965). The treatment programs varied slightly across sites, but the concepts and duration remained consistent. All contained the following components: (a) learning a variation of prolonged speech in a slow and exaggerated manner, (b) shaping this speech into stutter-free natural-sounding speech, (c) practicing this speech in a range of everyday speaking environments, and (d) developing problem-solving strategies for the maintenance of fluency gains (Cream et al., 2010, pp. 889–890).

Speech samples

During the Cream et al. (2010) trial, a 10-minute video recording was made of each participant speaking immediately before and immediately after the intensive treatment week. The videos were a head and shoulders shot of the participant conversing with an off-camera person within a clinic environment. There were 168 recordings in total, but for technical reasons, only 147 of the 168 videos could be used in the study. The first 5 minutes of each recording was used for analysis. This approach was selected in preference to a certain number of syllables because time is easier to operationalize than syllable counts.

Procedure

This section describes how the 147 videos from the Cream et al. (2010) trial were used to develop a corpus of stuttering moments for analysis.

The five judges

Judges were five SLPs experienced with assessment and treatment of adults and children who stutter. All had either previously worked, or were currently working, in clinical or research settings with stuttering. Their experience with stuttering clients ranged from 2–7 years.

Step One: LBDL training of the five SLP judges

The five SLP judges all received LBDL training using an instructional package (Teesson et al., 2003). This package consists of a written description of the taxonomy, and written examples of each of the three categories and seven descriptors. It also contains 18 video examples of stuttering moments, which demonstrate the different types of stuttering. The judges worked through the training package as a group. Then, as a group, they watched a further 10 video samples (unrelated to this study) and used the LBDL to classify stuttering moments. Each sample was discussed until the group as a whole agreed on the classification of each of these samples. At the conclusion of the training, there was general agreement between the SLPs about how to classify stuttering moments using the LBDL taxonomy.

Step Two: Clinician severity ratings for the video samples

Each of the five judges individually watched the same 18 randomly chosen 5-minute samples from the 147 samples used in the Cream et al. (2010) trial and assigned a severity rating to each using a 9-point scale, where 1 = *no stuttering* and 9 = *extremely severe stuttering* (O'Brian, Packman, & Onslow, 2004; O'Brian et al., 2003). The mean severity rating, calculated

for all 18 samples, for each of the five judges was 4.1, 4.3, 4.7, 5.1, and 5.3. The judge with the median severity rating was assigned the task of listening to the remaining 129 samples and assigning a severity rating to each sample. This judge was chosen to increase the likelihood that scores for the remaining samples would be representative of the group.

Step Three: Measurement of percentage of syllables stuttered (%SS) from the video samples

Each of the five judges then re-listened to the 18 randomly chosen 5-minute samples from the 147 samples used in the Cream et al. (2010) trial, counted the number of syllables in each sample, and identified and marked each stuttering moment on a transcript. The mean %SS scores for the 18 samples, calculated for each judge, was 4.5, 4.6., 5.5, 6.2 and 7.2. The judge who counted the lowest number of stuttering moments—a different judge from the one who assigned severity ratings—was assigned the task of listening to the remaining 129 samples to measure %SS. In contrast to Step Two, for %SS, in order to select a judge likely to be representative of the group, the judge with the lowest number of stuttering moments was chosen. This increased the likelihood that stuttering moments identified would be agreed by all judges to be a stuttering moment. The judge marked stuttering moments on a transcript, from which %SS scores were obtained.

Step Four: Classification of stuttering moments

Each of the five judges was randomly assigned a different 1-minute segment of each of the 147 five-minute samples from the Cream et al. (2010) trial. Each judge then classified all the identified stuttering moments in the samples. Stuttering moments were classified using the three main categories of the LBDL classification system: repeated movements, fixed postures, superfluous behaviors. These stuttering moments could be classified as any one, or a

combination, of the three LBDL categories of stuttering. After completing this task, the 147 five-minute samples from the Cream et al. trial had all identified stuttering moments classified according to the LBDL, along with a SLP severity rating and a %SS.

Step Five: Categorization of stuttering moments

All identified stuttering moments from the Cream et al. (2010) samples were allocated to one of the seven LBDL-C7 types, as shown in Table 1.

Data analyses

Our analyses were regression modelling with the LBDL-C7 types as the dependent variable and nine explanatory variables. Univariable modelling established variables suitable for entering into a multivariable model.

Nominal logistic regression

Our analysis was nominal logistic regression, which is an extension of binary logistic regression where the dependent variable has more than two categories. We investigated associations between LBDL-C7 types (see Table 1) and potential explanatory variables (see below). All potential explanatory variables were assessed for association with LBDL-C7 type pre-treatment. However, we also investigated whether changes in stuttering severity and/or frequency from immediately before to after the intensive treatment were associated with changes in LBDL-C7 type. C7-R (repeated movement only) was used as the reference category for the analyses, and robust variances were specified to take account of repeated measures of individual participants included in the analyses. We log-transformed %SS prior to analysis to remove positive skew; hence, preventing extreme values having an undue influence on results. Univariable modelling established variables suitable for entering into a multivariable model

based on a p value of < 0.05. For multivariable modelling, a cut-off Bonferroni adjusted p value of 0.006 was used to determine statistical significance. This allowed for the exploratory testing of nine potential explanatory variables.

Potential explanatory variables

For the nominal logistical regression, there were nine potential explanatory variables available from the Cream et al. (2010) trial for answering the research questions established in the Introduction. The first two were [1] *Age* and [2] *Gender*. The variables [3] *Clinician Stuttering Severity* (see above) and [4] *%SS* (see above) were available immediately before and after the intensive treatment week, and before and after treatment values were entered into the nominal logistic regression. The variable [5] *Self-Reported Stuttering Severity* was collected during the Cream et al. (2010) trial. Immediately before and after completing the intensive treatment week, participants documented a typical stuttering severity rating for each of eight standard speaking situations: talking with a family member, talking with a familiar person who was not a family member, talking in a group of people, talking with a stranger, talking with an authority figure, talking on the phone, ordering food or drink, and giving name and address. Ratings were made on the 9-point scale described above (see *Step Two: Clinician severity ratings for the video samples*, above). The mean rating for all eight situations for each participant was used in the analyses.

The remaining explanatory variables were psychological data collected in the Cream et al. (2010) trial: [6] *OASES,* [7] *Number of Mental Health Disorders* (adults only), [8] *Anxiety* (adolescents only), and [9] *Depression* (adolescents only). Participants completed a battery of standard psychological tests before beginning treatment. These variables are explained below.

Participants completed an age-appropriate Overall Assessment of the Speaker's Experience of Stuttering (OASES) questionnaire (Yaruss et al., 2006; Yaruss & Quesal, 2006) before and after the intensive treatment week. Participants who were 7–12 years old completed the OASES-S, participants who were 13–17 years old completed the OASES-T, and adults completed the OASES-A. The OASES is a self-report questionnaire that measures the impact of stuttering designed to reflect the World Health Organization's International Classification of Functioning, Disability, and Health framework. For the present analyses, the overall score was the variable [6] *OASES.*

The adults completed the *Composite International Diagnostic Interview (CIDI-Auto-2.1)* (World Health Organization, 1997). This was done alone in a clinic room at the research center where their assessment was undertaken. The CIDI-Auto-2.1 is a standardized, computerized, self-administered interview designed to assess mental health disorders according to the criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)* (American Psychiatric Association, 2000) and the *ICD-10: Classification of Mental and Behavioural Disorders* (World Health Organization, 1993). On completion, the CIDI generates a score for the total number and type of mental health disorders for each participant. For the present analyses, total number of mental health disorders was the variable: [7] *Number of Mental Health Disorders.*

The adolescent participants completed the Revised Children's Manifest Anxiety Scale (Reynolds & Richmond, 2000)[1] at home without the assistance of a parent. The Revised

[1] Participants in the present study completed the Revised Children's Manifest Anxiety Scale (RCMAS) prior to release of the RCMAS-2 (Reynolds & Richmond, 2008).

Children's Manifest Anxiety Scale measures anxiety in children for respondents 6–19 years of age. It is a 37-item self-report test that contains "*yes*/*no*" statements about how respondents think and feel about themselves. It produces scores for a number of subscales, as well as a total anxiety score. For the present analyses, the total anxiety score was used as the variable: [8] *Anxiety.*

The adolescent participants completed the Children's Depression Inventory (Kovacs, 1992) at home without the assistance of a parent. The Children's Depression Inventory measures the cognitive, affective, and behavioral signs of depression for respondents 7–17 years. It is a 27-item self-report test. Respondents choose one of three statements (scored 0–2) for each item according to how much they have experienced each depressive symptom during the previous two weeks. For the present analyses, the Total Depression Score was used as the variable: [9] *Depression.*

Results

Descriptive statistics

From the speech samples, 3,100 stuttering moments were used for analysis from 147 speech samples: A total of 81 samples from before and 66 samples from after the intensive treatment week. Mean percentage syllables stuttered was 6.5 immediately before the intensive treatment, and 1.4 immediately after the intensive treatment. Other descriptive statistics for the explanatory variables are presented in Table 2. Some of the explanatory variables were missing for some participants. Missing variables were handled with listwise deletion. The numbers of observations that were available for each of the explanatory variables are presented in Table 2.

INSERT TABLE 2 AROUND HERE

Around half (54.7%) of the stuttering moments contained a repeated movement, around half (49.8%) contained a superfluous behavior, and around two thirds (65.2%) contained a fixed posture. (These figures add to more than 100% because stuttering moments commonly involve more than one of those three categories.) The most infrequently occurring LBDL-C7 type was C7-S (superfluous behaviors only), the most frequently occurring was C7-FS (fixed postures and superfluous behaviors), and the median occurring was C7-RFS (repeated movements, fixed postures, and superfluous behaviors). These data are presented in Figure 3.

INSERT FIGURE 3 AROUND HERE

Univariable logistic regression

Statistically significant results in univariable analysis

There is evidence that LBDL-C7 type may be associated with: Clinician Stuttering Severity ($F_{6,74} = 9.43$, $p < .0001$), %SS ($F_{6,73} = 4.43$, $p = .0007$), Age ($F_{6,69} = 3.13$, $p = .009$), and Gender ($F_{6,74} = 2.57$, $p = .026$); *OASES* scores ($F_{6,72} = 2.35$, $p = .039$). Hence, these variables were included in multivariable analysis.

Nonsignificant results in univariable analysis

There was insufficient evidence that the distribution of LBDL-C7 type changed from immediately before to after the intensive treatment week ($F_{6,77} = 0.67$, $p = .68$).

There was insufficient evidence to show that LBDL-C7 type is associated with the following variables: Self-Reported Stuttering Severity ($F_{6,72} = 2.21$, $p = .052$), Number of Mental

Health Disorders ($F_{6,50} = 1.99$, $p = .084$, Anxiety ($F_{6,15} = 0.53$, $p = .78$), and Depression ($F_{6,15} = 0.90$, $p = .52$).

Multivariable logistic regression

Multivariable analysis suggests Age and Clinician Stuttering Severity have independent associations with LBDL-C7 type. However, %SS, Gender, and OASES were not statistically significant in the multivariable modelling; hence, they were removed from the final model. Details of the final multivariable model with significant results are presented in Tables 3 and 4.

INSERT TABLES 3 AND 4 AROUND HERE

Discussion

The purpose of this study was to explore variables pertinent to the complexity of stuttering behavior with adolescents and adults. The study was based on a corpus of 3,100 stuttering moments from 84 adolescents and adults, gathered before and after participation in a behavioral treatment program, and has yielded information of value not only for clinicians who work with individuals with persistent stuttering but also for researchers. The findings are discussed according to the nominal logistical regression results.

Is the complexity of stuttering behavior influenced by gender or age?

There was univariable evidence associating complexity of stuttering behavior with gender, but this is not considered meaningful as no significant associations were found with multivariable modelling. With multivariable modelling, age showed independent association with LBDL-C7 type. This indicates that, with advancing decades from adolescence through

adulthood, there is a significant odds ratio of 1.21 associated with the appearance of repeated movements, fixed postures, and superfluous behaviors. This information suggests that, for any individual, the trajectory of stuttering complexity is not necessarily stable from adolescence onwards. This result confirms the suggestion from studies of early stuttering that such an effect might occur, as noted in the Introduction.

Does the complexity of stuttering behavior change after behavioral treatment?

Quantitative aspects of speech restructuring treatment effects are well known, with many clinical trials showing a post-treatment reduction of stuttering severity (for an overview, see Onslow, 2021). The present results appear to be the first to explore aspects of the complexity of stuttering behavior in relation to this treatment effect. While participants' %SS scores showed a pre- to post-treatment reduction of 78.5%, there was no significant change in the type of stuttering in response to treatment. There was no evidence of an association between the change in %SS and a change in the complexity of stuttering behavior. This result seems robust, with similar null results for Clinician Stuttering Severity and Self-Reported Stuttering Severity.

How does the complexity of stuttering behavior relate to stuttering severity, anxiety related disorders, and impact of stuttering?

There are some interesting findings in relation to the first part of this question, namely the relationship between the complexity of stuttering behavior and measures of stuttering severity.

No significant association was found with multivariable modelling between complexity of stuttering behavior type and %SS. This is in contrast to the Law et al. (2017) study, conducted with Cantonese speakers, in which a relationship was reported between complexity of stuttering behavior and %SS. This can be explained by the fact that in the Law et al. study a stuttering

441 moment was reported only as either complex or not. Conceivably, the effect may also have been
442 related to linguistic or cultural aspects of the Cantonese language.

443 However, with multivariable modelling there was a significant relationship between all
444 behavioral stuttering types and Clinician Stuttering Severity. This difference can be explained by
445 the fact that the complexity of stuttering moments is likely to influence the measure of Clinician
446 Stuttering Severity but not the measure of %SS. In other words, compared to %SS, which is
447 simply a measure of frequency of stuttering, Clinician Stuttering Severity includes additional
448 information about the complexity of stuttering behavior as perceived by the observer. This
449 finding might be interpreted as an indicator of the limitations of %SS as a clinical measure to add
450 to its many limitations as a research measure (O'Brian et al., 2020). This in effect mirrors a
451 similar recommendation for management of early stuttering (Bridgman et al., 2011) subsequent
452 to findings of a study comparing %SS and parent severity ratings as measures of early stuttering
453 (Onslow et al., 2018).

454 Surprisingly, however, there was no association between complexity of stuttering
455 behavior and Self-Reported Stuttering Severity. This finding is of particular interest in the
456 context of the concurrent evidence found for an association between complexity of stuttering
457 behavior and Clinician Stuttering Severity, reported above. In quantitative terms, there is
458 evidence of an association between %SS and Self-Reported Stuttering Severity (O'Brian et al.,
459 2020); but, again, that association does not seem to hold for the present analysis of observable
460 stuttering behaviors. Collectively, these data suggest that, while listeners base their stuttering
461 severity judgments on overall stuttering behavior, including complexity of stuttering behavior,
462 adolescents and adults do not. Rather, these data suggest that, when assessing the severity of
463 their stuttering, adolescents and adult focus predominantly on how they experience their

stuttering rather than on its behavioral manifestations. In fact, they may not even be aware of how their stuttering manifests behaviorally.

Regarding the second part of this research question, anxiety disorders and anxiety related disorders are common in those with persistent stuttering who present for speech treatment (Craig, & Tran, 2014; Iverach et al., 2009; Iverach, Jones, et al., 2010; Iverach, O'Brian, et al. (2010); Iverach et al., 2011; Tran et al., 2011). In particular, social anxiety relates to the fear of negative evaluation by others, and it is intuitive to predict that the presence of such mental health disorders would relate to the complexity of stuttering behavior. For example, it would be logical to predict that the LBDL-C7 type C7-R, which involves only repeated movements, would be potentially far less socially distracting than type C7-RFS, which comprises repeated movements, fixed postures, and superfluous behaviors. Hence, some connection with such categories and mental health would be anticipated in the present participants, who had presented for and participated in a behavioral treatment program for their stuttering.

However, the present results showed this not to be the case, with no evidence of any association between any of the seven LBDL-C7 complexity types and Number of Mental Health Disorders, Anxiety, or Depression. This was the case even though around a third of the corpus of stuttering events studied contained a potentially socially distracting superfluous behavior (see Figure 2). Based on this result, there is no reason to expect that a person with behaviorally complex stuttering moments involving repeated movements, fixed postures, and superfluous behaviors would be any more likely to have a mental health diagnosis than a person with less complex stuttering behavior.

There was evidence in univariable analyses that a construct potentially associated with mental health—impact of the disorder measured with the OASES—was connected to complexity

of stuttering behavior. However, that result was not clinically significant because it was not retained in multivariable analysis. Regardless of its indirect association with mental health, the suggestion of a connection between OASES scores and mental health in stuttering has occurred more strongly in other reports. Manning and Beck (2013) reported a connection between OASES scores and anxiety, with adults, and Iverach et al. (2017) reported such an effect with adolescents. Freud and Amir (2020) found an association between OASES scores and a measure of psychological resilience. Additionally, Ward et al. (2021) found an association between OASES scores and a measure of the thoughts and beliefs that sustain anxiety for those who stutter.

Overview of clinical and research applications

As indicated above, there are some important applications of the findings for clinicians and researchers. For clinicians, contrary to intuition, the present findings suggest that observable stuttering behaviors provide no clinical clue about the impact stuttering is having on the client: most importantly whether or not the client may be experiencing any clinically significant anxiety. This raises interesting issues about what influences the development of the self-image of adolescents and adults who stutter, as it is not apparent simply from the clinical complexity of their observable stuttering behavior.

The finding that complexity of stuttering behavior did not change after treatment is also of clinical interest because it can be used to inform clients that, although speech restructuring treatments are known to reduce the frequency of stuttering, no changes in the complexity of their stuttering behavior can be predicted. In other words, they may experience reduced stuttering frequency, but there is no reason to expect that the complexity of their stuttering will shift from one type of behavioral complexity to another.

The findings of (a) an association between complexity of stuttering behavior and Clinician Stuttering Severity and (b) no such relationship between complexity of stuttering behavior and either %SS or Self-Reported Stuttering Severity is salient for both clinicians and researchers. It suggests that when considering these measures, Clinician Stuttering Severity is a justifiable choice, whether working with people who stutter in the clinic or conducting research with them, including in clinical trials. Of the three measures, Clinician Stuttering Severity is the only one that captures the complexity of stuttering behaviors. It may be productive, however, for the clinician and client to discuss any differences between their respective severity ratings.

Although the LBDL-C7 behavioral taxonomy of stuttering generated useful clinical information about stuttering in the present report, considerable effort is required in administering it. In contrast to unitary stuttering measures, the effort associated with generating the present index is extensive, involving segregation and detailed multi-personnel analysis of stuttering moments (see *Procedure*). While the procedure would be unmanageable for clinical trials, clinicians could find the LBDL-C7 index of benefit for use with some individual clients as a way to informally document stuttering behaviors before and after treatment, or both. For example, a clinician may note in a client's file a clinical judgment that stuttering is type C7-R, comprising predominantly repeated movements, or type C7-RFS, comprising repeated movements, fixed postures, and superfluous behaviors (see Table 1). Or perhaps a file entry may indicate that a client's stuttering is type C7-FS, comprising no repeated movements but with fixed postures and superfluous behaviors.

Another potential limitation of this study is the extent to which the results from the speech restructuring treatment involved in the Cream et al. (2010) report is representative of speech restructuring treatments in general. Arguably, though, the programs administered at each

of the six Australian and New Zealand speech clinics are representative of this generic treatment procedure (see *Method*).

Conclusions

We conclude from this study that, for individuals, the trajectory of stuttering complexity is not necessarily stable from adolescence onwards. Regardless, there is no evidence from this study that behavioral treatment for stuttering alters the complexity of stuttering behavior, even though it reduces their severity. There was an association between complexity of stuttering behavior and clinician perception of stuttering severity. However, that association was not evident for self-reported stuttering severity. No evidence of an association was found between complexity of stuttering behavior and gender, impact of stuttering, anxiety, or depression.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing.

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Figure Captions

Figure 1. Waveform and spectrogram of a child stuttering while saying "well I like." (Image reproduced from Onslow (1995)).

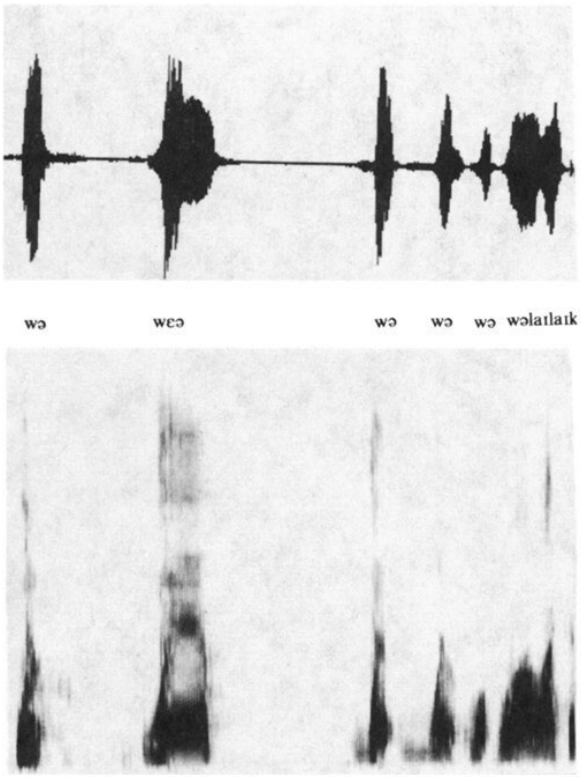
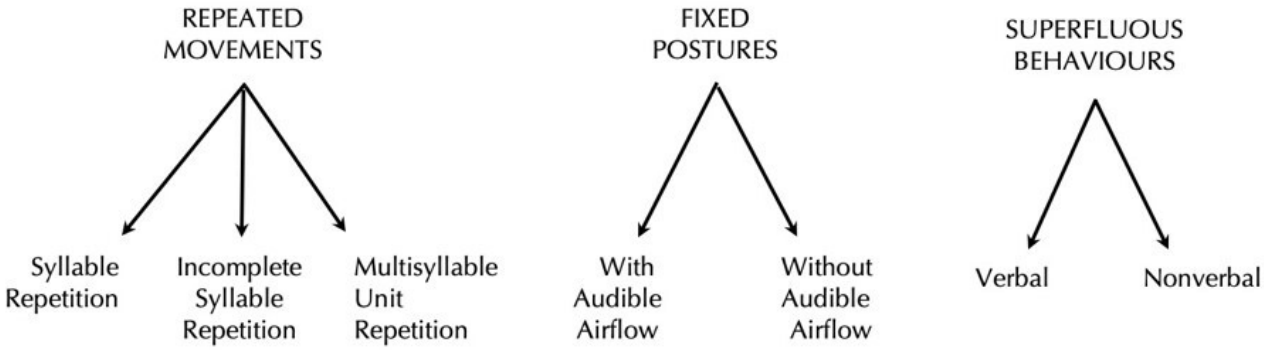
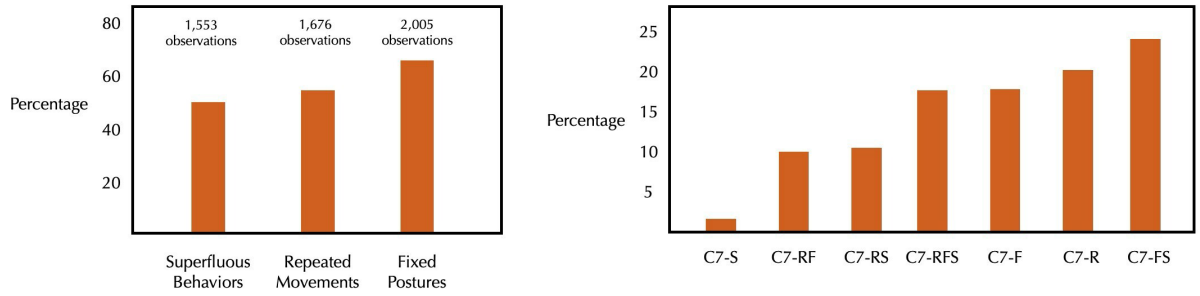


Figure 2. The three categories and seven descriptors of the LBDL.



795 Figure 3. Summary data for the 3,100 stuttering moments.



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798 Table1. The seven LBDL-C7 types.

799

	LBDL categories		
LBDL-C7 type	Repeated movements (R)	Fixed postures (F)	Superfluous behaviors (S)
C7-R	Yes	No	No
C7-F	No	Yes	No
C7-S	No	No	Yes
C7-RF	Yes	Yes	No
C7-RS	Yes	No	Yes
C7-FS	No	Yes	Yes
C7-RFS	Yes	Yes	Yes

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Table 2. Descriptive statistics for the data.

Variable		*n**	Mean	*SD*	Minimum	Maximum
Age		80	26.9	12.9	11	74
%SS	Pre	79	6.5	6.3	0.4	32.6
	Post	62	1.4	1.8	0.1	9.7
Clinician Stuttering Severity	Pre	81	5.6	2.0	2	9
	Post	64	2.4	1.5	1	8
Self-Reported Stuttering Severity	Pre	79	4.3	1.3	1.0	7.8
	Post	65	2.3	1.2	1.0	5.8
OASES	Pre	80	60.1	12.1	34.6	90.9
Number of Mental Health Disorders	Pre	67	2.6	2.7	0	9
Anxiety	Pre	21	7.8	5.2	0	17.0
Depression	Pre	21	5.0	3.1	1.0	13.0

* $N = 84$. Some participant scores were missing for each measure.

Table 3. Odds ratio estimates

Variable	LBDL-C7 type	Odds ratio	95% Confidence Limits	
Age (decades)	C7-F	1.112	0.90	1.36
Age (decades)	C7-S	1.010	0.68	1.48
Age (decades)	C7-RF	1.03	0.89	1.18
Age (decades)	C7-RS	1.07	0.85	1.34
Age (decades)	C7-FS	1.01	0.73	1.39
Age (decades)	C7-RFS	1.21	1.04	1.41
Clinician Stuttering Severity	C7-F	1.34	1.15	1.57
Clinician Stuttering Severity	C7-S	1.33	1.05	1.69
Clinician Stuttering Severity	C7-RF	1.39	1.24	1.56
Clinician Stuttering Severity	C7-RS	1.14	1.02	1.27
Clinician Stuttering Severity	C7-FS	1.51	1.25	1.82
Clinician Stuttering Severity	C7-RFS	1.50	1.33	1.70

Table 4. Details of the final multivariable model

Variable	*F*	Numerator *df*	Denominator *df*	*p*
Age (decades)	3.96	6	69	0.0018
Clinician Stuttering Severity	8.92	6	69	<.0001