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Behavioral and Cognitive-Affective Features of Stuttering in Preschool-Age Children: Regression and Exploratory Cluster Analyses

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Abstract

Purpose: The purpose of this study was to investigate associations among behavioral and cognitive-affective features of stuttering in preschool-age children who stutter, and the extent to which participants may or may not cluster together based on multiple indices of stuttering.

Methods: Participants were 296 preschool-age children who stutter (mean age 47.9 months). Correlation and regression analyses, as well as k-means cluster analyses were conducted between and among several indices of stuttering: frequency of stuttering- and non-stuttering-like disfluencies (SLDs and NSLDs), ratios of repetitions and prolongations/blocks out of total number of SLDs, associated nonspeech behaviors, duration of stuttering events, KiddyCAT scores (Vanryckeghem & Grutten, 2007), and a TOCS parent-rated scale (Gillam et al., 2009).

Results: For preschool-age children who stutter, most indices of overt stuttering behaviors were intercorrelated (e.g., more SLDs were associated with higher ratio of repetitions). Self-reported KiddyCAT scores (Vanryckeghem & Grutten, 2007) were largely not significantly associated with stuttering. Cluster analyses yielded two participant groupings: a larger group with less prominent stuttering features and a smaller group with more prominent features.

Conclusions: This study contributes to an increasingly comprehensive and nuanced understanding of the heterogeneous features of stuttering and their development in preschool-age children. Findings show strong intercorrelations between measures of stuttering behaviors, but

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more tenuous relationships between behaviors and cognitive-affective reactions to stuttering. Exploration of clusters of characteristics within this population revealed potential opportunities for future research.

Keywords

stuttering; cognitive-affective; preschool; regression; cluster

1. Introduction

Developmental stuttering may manifest with a range of cognitive-affective responses (e.g., Tichenor & Yaruss, 2018) as well as overt speech and nonspeech behaviors that are heterogeneous in nature and variable across contexts (Johnson et al., 2009; Yaruss, 1997). Although contemporary researchers have developed models to account for the diversity of symptoms associated with stuttering (e.g., Smith & Weber, 2017), many questions remain about the relations between and among different behavioral, cognitive, and affective manifestations across the lifespan of a person who stutters. Moreover, important differences among individuals or groups of people who stutter may be obscured by focusing on individual measures that are potentially limited in their ability to characterize the experience of stuttering. As a preliminary step to further understand clinical measures of various features of stuttering, the present study aims to: 1) investigate relations among several measures of behavioral and cognitive-affective features of stuttering, and 2) explore the extent to which children who stutter may or may not cluster together based on multiple indices of stuttering.

1.1 Common Measures of Features of Stuttering and Potential Limitations

There are several indices of stuttering that are commonly used in clinical and research settings. Perhaps the most common clinical measures of stuttering are listener-oriented indices of stuttering behaviors, such as frequency of stuttering-like disfluencies (SLDs, i.e., sound/syllable repetitions, sound prolongations, and monosyllabic whole-word repetitions; see Conture, 2001) calculated based on words or syllables, or an instrument of stuttering severity such as the Stuttering Severity Instrument, currently in its fourth edition (SSI; Riley & Bakker, 2009). Many other measures in addition to frequency of SLDs have been identified as potentially meaningful dimensions of overt stuttering behaviors, including frequency of typical or non-stuttering-like disfluencies (NSLDs, i.e., revisions, multi-word repetitions, interjections), total overall speech disfluencies (SLDs plus NSLDs), mean duration of stuttering events, frequency of associated nonspeech behaviors (also known as physical concomitants or physical secondaries), and scores from subjective rating scales by caregivers or clinicians, among other metrics (Ambrose & Yairi, 1999; Boey, 2008; Conture, 2001; Karimi et al., 2014; Kraft et al., 2019; LaSalle & Conture, 1995; Preus, 1981; Prins & Lohr, 1972; Sawyer et al., 2008; Schwartz & Conture, 1988; Tumanova et al., 2014).

The SSI, as an example, produces a total severity score from component sub-scores for stuttering frequency, average duration of stuttering events, and associated nonspeech behaviors (Riley & Bakker, 2009). Although it may be useful to have a single severity score that takes into account multiple facets of stuttering behavior, there are also potential limitations with the ability of this approach to characterize the multi-faceted experience of stuttering. Notably, combined severity scores may fail to capture meaningful differences among various combinations of stuttering characteristics. Consider that two individuals with identical scores on the SSI could present quite differently regarding overt stuttering behaviors: one child may present with a high number of syllable repetitions and low physical tension, and another child may present with infrequent but tense silent blocks. In this case, the SSI's severity score would be inadequate to differentiate between two clinically distinct presentations of stuttering, and would moreover provide no insight into the internal, cognitive-affective characteristics that may also differ in these children who stutter.

Despite these inherent limitations, individual indices such as stuttering frequency and the SSI may yet represent clinically or statistically meaningful dimensions of stuttering. Recent studies by Singer and colleagues, for example, found persistence of preschool stuttering to be associated with higher stuttering frequency (Singer et al., 2020a) and higher SSI scores (Singer et al., 2022). And a recent study by Walsh et al. (2020) found the "weighted SLD," a composite index derived from measures of stuttering type, frequency, and mean repetitions per stuttered syllable, to strongly predict persistence of stuttering in 4- and 5-year-olds. Thus, while these measures may not characterize the comprehensive experience of stuttering, particularly the cognitive-affective features, they do appear to be important (e.g., for estimating risk of persistence) in research and clinical practice.

Cognitive-affective reactions to stuttering, such as negative communication attitudes or covert avoidance of communication situations, are increasingly recognized as consequential features of stuttering, even in very young children (Ezrati-Vinacour et al., 2001; Langevin et al., 2009; Tichenor & Yaruss, 2018). There are few established and valid measures of the cognitive-affective features of stuttering, particularly for preschool-age children (Guttormsen et al., 2015). The Communication Attitude Test for Preschool and Kindergarten Children Who Stutter (KiddyCAT; Vanryckeghem & Grutten, 2007) may be one such measure, as it directly reflects the responses of children and has been shown to measure attitudes related to speech difficulty (Clark et al., 2012). Moreover, the KiddyCAT is straightforward to administer, with 12 yes/no questions (Vanryckeghem & Grutten, 2007), and has been consistently shown to differentiate groups of children who do and do not stutter (e.g., Clark et al., 2012; Vanryckeghem et al., 2015). However, the KiddyCAT is essentially limited to evaluating a single underlying construct (i.e., difficulty talking), with minimal context for evaluating different speaking situations or more nuanced cognitive-affective responses to the experience of stuttering (Clark et al., 2012). Test-retest reliability has been reported as strong (e.g., Vanryckeghem et al., 2015).

1.2 Relationships Between Behavioral and Cognitive-Affective Features of Stuttering

Importantly, and perhaps counterintuitively, many studies have failed to find statistically significant relationships between an individual's cognitive-affective responses to stuttering and their overt stuttering behaviors yet some of those conclusions may be due to small sample sizes (Blumgart et al., 2012; Groner et al., 2016; Mulcahy et al., 2008; Werle et al., 2021; Winters & Byrd, 2021). For example, Mulcahy et al. (2008) considered anxiety and communication attitudes of adolescents who stutter, assessed in part by the OASES, and found no significant correlations with frequency of stuttering (n = 18, r = .25). Beilby et al. (2012) also performed correlational analyses between stuttering frequency and OASES scores in a sample of adolescents who stutter and found a statistically significant correlation between stuttering frequency and the "General Information" section of the OASES (n = 45, r = .45). Blumgart et al. (2012) reported a parallel, yet smaller association in a sample of adults who stutter (n = 200, r = .23). Beilby and colleagues (2012) also identified "moderate" positive correlations between stuttering frequency and the other OASES subsections for adults who stutter that did not reach significance following Bonferroni correction (n = 45, r ranging from .32 to .34). Notably, Beilby et al. (2012) did find slightly stronger and statistically significant correlations between stuttering frequency and scores in all sections of the OASES for children who stutter age 8-11 (n = 50, r ranging from .42 to .53). Few studies have assessed the relation between cognitive-affective and behavioral features of stuttering in very young children. Groner et al. (2016), as well as Winters and Byrd (2021), found no significant relationships between KiddyCAT scores and stuttering frequency in preschool-age children who stutter, although KiddyCAT scores have been shown to differ between children who stutter and children who do not stutter overall (Clark et al., 2012; Vanryckeghem & Grutten, 2007). In summary, there is conflicting evidence regarding whether or not behavioral and cognitive-affective manifestations of stuttering are correlated in adults, adolescents, or preschoolers. Additional research is needed to further characterize the associations between behavioral and cognitive-affective indices of stuttering across the lifespan.

1.3 Purpose

Thus, while there is a substantial body of literature describing differences between children who do and do not stutter using a variety of measures (see Bloodstein et al., 2021; Conture, 2001), there is less insight into the relationships among different features of stuttering within the population of children who stutter. For example, it is unclear whether or not certain types of stuttering may be more associated with nonspeech behaviors than others, or whether a subset of overt behavioral variables might predict more negative affective responses, or if there may be clusters of children within the population of children with differing stuttering characteristics. Illuminating these issues could have an important bearing on clinical practice by facilitating speech-language pathologists' ability to interpret behavioral and cognitive-affective measures and, in turn, develop individualized treatment plans within a fundamentally heterogeneous population.

Therefore, the aim of the present study is to better understand relationships among several features of stuttering in a large group of preschool-age children who stutter. Specifically, this study was guided by the following research questions:

1. To what extent are different indices of overt stuttering behaviors associated with one another in preschool-age children who stutter?
2. For preschool-age children who stutter, does overt stuttering behavior correlate with indices of the cognitive-affective manifestations of stuttering?
3. Do preschool-age children who stutter tend to cluster into different groups based on multiple indices of behavioral and cognitive-affective features of stuttering?

2. Methods

In this cross-sectional study, we systematically investigated correlations among features of stuttering in preschool-age children who stutter. Features of interest included overt stuttering behaviors and cognitive-affective manifestations associated with stuttering. Participant data were collected at Vanderbilt University Medical Center from 2000-2021 as part of ongoing large-scale investigations of linguistic and emotional contributions to developmental stuttering (e.g., Anderson et al., 2005; Johnson et al., 2009; Jones et al., 2017; Millager et al., 2014; Pellowski & Conture, 2002; Singer et al., 2020b; Tumanova et al., 2014).

2.1 Participants

Children (participants) and their parents were recruited via advertisements in a free, monthly parenting magazine available in Middle Tennessee, via advertisement e-mails sent to Vanderbilt University and Vanderbilt University Medical Center employees, via referral to the pediatric clinic at the Vanderbilt Bill Wilkerson Hearing and Speech Center, pediatrician referral, and other recruitment methods (e.g., distribution of fliers and brochures and word of mouth). Informed consent by caregivers and verbal assent by children were obtained prior to data collection and enrolled participants were compensated. Study procedures were approved by the Vanderbilt University Institutional Review Board.

2.1.1. Inclusion and Exclusion Criteria—Participants included in this study were identified as children who stutter by meeting at least one of the following criteria: either a minimum of 3% SLDs (i.e., sound/syllable repetitions, sound prolongations, silent blocks, and monosyllabic whole-word repetitions) in a 300-word sample, or a score of 11 or greater on the SSI. We opted to use either of those criteria to be inclusive of all children displaying characteristics consistent with developmental stuttering; our sample included $n = 10$ participants with fewer than 3% SLDs but scored 11 or higher on the SSI, and $n = 16$ participants with less than 11 on the SSI and greater than 3% SLDs. Note that self- or parent-reported status was not consistently available for all participants in the current study. As recently supported by Tumanova et al.'s (2014) study of a large sample of children who do and do not stutter, a threshold of 3% stuttered disfluencies has historically provided suitable diagnostic criteria for classifying stuttering in young children (see Ambrose & Yairi, 1999; Conture, 2001). The alternative inclusion criterion of an SSI score of 11 or greater (e.g., at least "mild" according to this instrument) allowed for inclusion of participants who did not meet the threshold of 3% stuttered syllables yet demonstrated behaviors that are nevertheless significantly associated with stuttering, such as duration of stuttering and associated nonspeech behaviors (e.g., Conture, 2001).

Participants' speech-language and hearing abilities were assessed using standardized measures. Potential participants were excluded if they scored below one standard deviation less than the mean on any of the following: (a) Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007), (b) Expressive Vocabulary Test (EVT; Williams, 2007), (c) the receptive and expressive subtests of the Test of Early Language Development (TELD; Hresko et al., 1999), or (d) the "Sounds in Words" subtest of the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 2000). Per longstanding study protocols, participants were also excluded if they failed to pass a binaural pure-tone hearing screening, or if they were reported by their caregiver to have a history of known co-existing concerns (e.g. neurological, developmental, or speech-language) that might preclude their ability to participate appropriately in all experimental tasks.

Ages of participants were limited to younger than 6 years (72 months) consistent with preschool stuttering ages as summarized by Bloodstein and Ratner (2008). Finally, to meet the requirements of our analytic plan (see below), participants were excluded if they did not have valid and complete disfluency or SSI data, or if any of the participant's data were found to be overtly erroneous or corrupted. In total, 31 additional participants were excluded: 11 were older than 72 months; 11 were missing valid SSI scores; 7 included erroneous disfluency data; and 2 with exclusionary medical or developmental concerns.

2.1.2. Participants Included in Study—A sample of 296 monolingual, English-speaking, preschool-age children who stutter met the inclusion criteria for our study. As shown along with other demographic characteristics summaries in Table 1, our sample included 78 girls and 218 boys with a combined mean age of 47.87 months (SD = 9.05, range = 30-71 months). Given the lengthy span of data collection, newly published assessment tools, and evolving research protocols and priorities, not all participants completed the KiddyCAT (published in 2006) or the TOCS questionnaires (published in 2009). Within the total sample of 296 participants, 203 completed the KiddyCAT, 113 completed the TOCS, and 86 participants completed both measures (Table 1, Figure 1).

2.2. Procedures

During each participant visit, one examiner conducted a parent interview while another examiner conducted an unstructured free play session with the respective child that included a subsequent administration of standardized speech-language tests. During the parent interview, information about family demographics, relevant medical/developmental history, and concerns about children's speech-language abilities were collected. When possible, parents also completed the TOCS Observational Rating Scales (Gillam et al., 2009) during that interview session. During the child free play session, the examiner conducted an in situ disfluency count consisting of the first 300 words of an unstructured conversation with the participant. Examiner-child interactions were audio-video recorded for subsequent scoring and analyses. In the subsequent speech and language assessment session, tests were administered in the following order: GFTA, PPVT, EVT, and TELD. Following these standardized tests and when possible, the KiddyCAT was administered as well as the hearing screening.

2.3. Assessment of Features of Stuttering and Covariates

2.3.1. Overt Stuttering Behaviors—Following a review of significant features of stuttering (Conture, 2001; Schwartz & Conture, 1988; Tumanova et al., 2011, 2014), we identified several distinct indices of overt stuttering behaviors for use in this study: frequency of SLDs, frequency of NSLDs, ratios of repetitions and prolongations/blocks out of total number of SLDs, associated nonspeech behaviors, and duration of stuttering events.

Operational definitions and descriptions of how values were generated for each behavior are included below.

2.3.1.1. Frequency of Speech Disfluencies.: SLDs include sound/syllable repetitions, monosyllabic whole word repetitions, audible sound prolongations, and tense pauses or blocks (Conture, 2001; Tumanova et al., 2014). NSLDs include disfluencies that are more commonly found in all speakers regardless of stuttering classification, and include revisions, multi-syllabic word and phrase repetitions, and interjections (Conture, 2001; Johnson et al., 2009; Tumanova et al., 2014). We used the proportion of stuttered disfluencies out of the 300-word sample for frequency of SLDs and the proportion of non-stuttering-like disfluencies out of the 300-word sample for frequency of NSLDs.

2.3.1.2. Ratio of SLD Types.: To represent the relative frequency of specific types of stuttering we grouped types of SLDs into two ratio measures: (a) the *ratio of repetitions*, quantified as the total number of part- and whole-word repetitions out of the total number of SLDs, and (b) the *ratio of prolongations/blocks*, quantified as the total number of prolongations and blocks out of the total number of SLDs. Although part- and single syllable whole-word repetitions are often counted as separate types of stuttering, we grouped them together as within-word repetitions of single syllables. Prolongations and blocks may also be considered perceptually distinct types of stuttering, but we opted to group them together for increased coder reliability, parallel to prior researchers' use of the umbrella "dysrhythmic phonations" category (e.g., Schwartz & Conture, 1988; Yairi et al., 1993).

2.3.1.3. Associated Nonspeech Behaviors.: The Physical Concomitants sub-score of the SSI was used to measure the degree of associated nonspeech behaviors. The Physical Concomitants sub-score is generated by summing scores from four general areas of physical behaviors as judged by an experimenter familiar with stuttering (i.e., distracting sounds, facial grimaces, head movements, and movements of the extremities; Riley & Bakker, 2009). The Physical Concomitants score is a continuous scale on which a higher value indicates more nonspeech behaviors associated with stuttering.

2.3.1.4. Duration of Stuttering Events.: We assessed duration using the Duration sub-score of the SSI. A duration score is generated by averaging the "three longest stuttering events" taken from the 300-word speech sample and converting the average time to a numeric score between 2 and 18 via a table included in the SSI (Riley & Bakker, 2009). A higher duration score indicates longer stuttering events.

2.3.2. Cognitive-Affective Features of Stuttering—Covert or internal manifestations of stuttering may be important dimensions of preschool stuttering and may be independent of overt stuttering behaviors (e.g., Beilby et al., 2012; Winters & Byrd, 2021). Our study included two indices proposed to evaluate those covert manifestations: cognitive-affective features of stuttering and caregiver-reported reactive aspects to stuttering.

2.3.2.1. Cognitive-Affective Features of Stuttering.: The KiddyCAT assesses speaking attitudes, particularly with regard to whether speaking is difficult or not (Clark et al., 2012;

Vanryckeghem & Grutten, 2007). The KiddyCAT is scored by counting a child's responses to the twelve yes(1)/no(0) items, with higher scores denoting more negative speech attitudes.

2.3.2.2. Reactions to Stuttering.: The TOCS assessment battery includes a measure entitled: Disfluency-Related Consequences Rating Scale. The TOCS Disfluency-Related Consequences Rating Scale is comprised of nine questions, answered by a parent or other caregiver, each with Likert responses ranging from 0-3 (i.e., Never, Rarely, Sometimes, Always; Gillam et al., 2009). The questions probe for cognitive-affective responses to stuttering (e.g., how often does a child "become embarrassed about his or her ability to speak fluently") as well as for behaviors that can be construed as reactions to stuttering (e.g., how often does a child "seem to become tense when called on to speak"). All items probe for the perceived consequences of stuttering to the child who stutters, except for a single item that is focused on an emotionally triggering action on the part of other children (how often does a child "get rejected by other children…"). A total score is generated by summing Likert responses for each item, yielding a total between 0 and 27.

Notably, the TOCS observational rating scales were not explicitly designed to measure cognitive-affective features of stuttering but rather to probe for "stuttering and related behaviors…beyond the immediate assessment context" (Gillam et al., 2009, p. 8). However, Tumanova et al. (2018) recently demonstrated that children with higher scores on the TOCS Disfluency-Related Consequences Rating Scale (i.e., children who were more reactive to stuttering) tended to have shorter mean lengths of utterances. The authors suggested that the shorter lengths of utterances may have been indicative of efforts by some children who stutter to avoid or minimize stuttering by way of truncated speech. In the context of a paucity of tools for assessing children's thoughts and feelings about stuttering, we elected to include this TOCS Disfluency-Related Consequences Rating Scale as an index of cognitive-affective reactions to stuttering.

2.3.3. Covariates—In general, the course of stuttering is impacted by both age and time since stuttering onset. For instance, older children with longer times since onset are more likely to exhibit persistent stuttering into school-age years and adulthood (see Bloodstein et al., 2021; Singer et al., 2020a, 2022). Moreover, Groner et al. (2016) found that children with longer times since onset had lower KiddyCAT scores, although this finding was not replicated in a recent study by Winters and Byrd (2021). To control for potential age- and time-related effects on developmental stuttering, age and time since onset were included as covariates in all key study analyses.

2.4. Statistical Analyses

Analyses were conducted using analytic software R version 4.0.3 (R Core Team, 2020) and *SPSS Statistics* version 18.0 (SPSS Inc., 2009). The primary R package used was *psych* (Revelle, 2022); additional packages used for data management and cluster analyses are described below.

Several participants ($n = 49$) were missing data for time since onset of stuttering. After a manual review of these cases, the missing data values were determined to be missing at random and were subsequently imputed using the iterative R package *missForest* (Stekhoven & Buehlmann, 2012).

The intent of the present study was to conduct a preliminary, exploratory examination of relationships among and between indices of the manifestations of stuttering for which effect sizes and relationships have been relatively under-investigated. Thus, this was not an 'hypothesis testing' study for which reasonable effect sizes for statistical powering were available and did not correct for multiple comparisons given our diminished focus on p-values. In accordance with our research purpose, the focus of our evaluations and interpretations of our findings were on effect sizes (i.e., standardized regression coefficients).

2.4.1. Interrater Reliability—Across the lengthy span of data collection, differing configurations of laboratory assistants (k = 13) conducted disfluency counts on a total of n = 45 randomly selected children who do and do not stutter. To characterize overall interrater reliability for those data, we calculated intraclass correlation coefficients (ICCs) and 95% confidence intervals (CIs) for disfluency count data using the singlerater, absolute agreement, one-way random effects model (Koo & Li, 2016). For evaluating the quality of our interrater reliability, we used the standard of less than .50 to be poor, .50 to .75 to be moderate, .75 to .90 to be good, and above .90 to be excellent (Koo & Li, 2016). Overall agreement between coders was excellent for both SLDs and for repetitions (respectively ICC = .94, 95% CI [.92, .97]; ICC = .93, 95% CI [.90, .96]). For NSLDs, overall agreement was good, ICC = .77, 95% CI [.70, .85] and for prolongations/blocks, agreement was in the moderate range, ICC = .70, 95% CI [.61, .80].

2.4.2. Associations Among Indices of Overt Stuttering Behaviors—Our first research question was: to what degree are different indices of overt stuttering behaviors associated with one another in preschool-age children who stutter? We included six different indices of overt stuttering behaviors in our study (i.e., frequency of SLDs, frequency of NSLDs, ratio of repetitions, ratio of prolongations/blocks, SSI Duration sub-score, and SSI Physical Concomitants sub-score). We used partial correlation models to assess the strength of the relationship between each pair of behaviors while controlling for age and time since onset of stuttering in each model. Approximately normal distributions are an assumption of partial correlation, and stuttering behaviors are often skewed in distribution without further transformation (for example, see Tumanova et al., 2014). We were able to transform our data distributions to normal using square root or log transformations; furthermore, we confirmed that there were no non-linear components to the relationships and no significant influential outlying values were apparent. *SPSS Statistics* version 18.0 software (SPSS Inc., 2009) was used to conduct those transformations, evaluations, and correlations analyses.

2.4.4. Relations Between Overt Behavioral Indices and Cognitive-Affective Manifestations of Stuttering—Our second research question was: for preschool-age children who stutter, does overt stuttering behavior correlate with indices of the cognitive-affective manifestations of stuttering? Correlations and multiple regression models were used to address this question. The KiddyCAT scores were the dependent variable in one set of analyses, the TOCS Disfluency-Related Consequences Ratings Scale scores were the dependent variable in the other set. Each set included all six indices of overt stuttering behavior as independent variables, and age and time since onset as covariates. For each dependent variable, we reported both the bivariate (correlation) and the multivariate (regression) results in terms of standardized *beta* coefficients, bias-corrected 95% confidence intervals, and corresponding *p*-values.

In these analyses we used the same data—transformed to normal distribution—that we used for the partial correlations above, as well as transformed (square root) TOCS scores. Our distribution of KiddyCAT scores was normally distributed. Furthermore, we confirmed that the additional assumptions for multiple regression were met (lack of multicollinearity, homoscedasticity and normal distribution of residuals).

2.4.5. Cluster Analysis with Behavioral and Cognitive-Affective Indices of Stuttering—

Our third research question was: do preschool-age children who stutter tend to cluster in different groups based on overt behavioral and cognitive-affective indices of stuttering? To address this question, we conducted an unsupervised k-means clustering analysis using the *cluster* package in R (Maechler et al., 2021). K-means clustering was selected as a relatively straightforward and commonly-used method for subdividing a sample into *k* groups such that objects within each group are maximally alike and objects between groups are maximally different (Boehmke, 2017; Kaufman & Rousseeuw, 2009). Because the ideal number of clusters (*k*) was not known in advance, analyses for $k =$ 2 through $k = 10$ were calculated and compared. To select the best fit for our data, we then used the "silhouette approach," which compares cluster results to optimize greatest similarity between within-cluster objects and greatest distance between cluster means overall (Boehmke, 2017; Kaufman & Rousseeuw, 2009).

We included all variables of interest in the cluster analysis: frequency of SLDs, frequency of NSLDs, ratio of repetitions and ratio of prolongations/blocks out of total number of SLDs, associated nonspeech behaviors, duration of stuttering events, KiddyCAT scores, and TOCS Disfluency-Related Consequences Rating Scale scores, as well as age and time since onset of stuttering. To conform to the assumptions of a k-means cluster analysis, data must be continuous and standardized with equal variances (Boehmke, 2017; Kaufman & Rousseeuw, 2009). We treated standardized SSI, KiddyCAT, and TOCS scores as continuous data even though they are not strictly interval scales. We interpreted the resultant clusters using within-cluster means and visual inspection of graphs.

3. Results

3.1. Relationships Among Indices of Overt Stuttering Behaviors

Results (*beta* standardized correlation coefficients and bias-corrected 95% confidence intervals) from partial correlations among the six overt stuttering behaviors, controlling for age and time since onset of stuttering, are reported in Table 2. Except for the correlations between frequency of NSLDs with the two SSI sub-scores and ratio of repetitions with SSI Physical Concomitants sub-score, all of the associations were statistically significant ($p <$ .01). The three strongest positive associations were between frequency of SLDs and SSI Duration sub-score ($\beta = .57$, 95% CI [.48, .65]); frequency of SLDs and ratio of repetitions (β = .44, 95% CI [.32, .56]); and frequency of SLDs and ratio of prolongations/blocks (β = .43, 95% CI [.31, .54]). Conversely, the strongest inverse associations were between frequency of NSLDs and ratio of repetitions (β = −.54, 95% CI [−.64, −.44]) and between ratio of prolongations/blocks and ratio of repetitions (β = −.25, 95% CI [−.35, −.14]). See Table 2 for full results.

3.2. Associations of Overt Behavioral Indices with Cognitive-Affective Manifestations of Stuttering

As described above, due to missing data, we had a sample of 203 children with KiddyCAT scores and 113 with TOCS data. Within the smaller sample of children with TOCS data, the ratio of repetitions variable was overly collinear with other variables in the model. Therefore, that variable was not included in the regression model for TOCS data.

Results of the bivariate and multivariate associations of each of the indices of overt stuttering with the KiddyCAT scores, controlling for age and time since onset, are shown in Table 3. KiddyCAT scores had strong inverse relationships to age (β = −.28, 95% CI [−.41, −.15]) and time since onset (β = −.20, 95% CI [−.32, −.07]). Of behavioral indices of stuttering, higher physical concomitants were most strongly associated with higher KiddyCAT scores in preschool-age children who stutter (β = .15, 95% CI [.02, .28]). A multivariate model that included all six measures of overt stuttering, as well as age and time since onset, was statistically significant (R = .37, p < .001) yet no single measure of overt stuttering demonstrated a statistically significant association with the KiddyCAT scores (see Table 3).

Results from the bivariate and multivariate associations between stuttering behaviors and TOCS Disfluency-Related Consequences Rating Scale scores, including age and time since onset, are shown in Table 4. Frequency of SLDs, ratio of prolongations and blocks, SSI duration sub-score, and SSI physical concomitants sub-score each had a statistically significant bivariate association with the TOCS scores (p < .05). The strongest positive association was observed for frequency of SLDs (β = .28, 95% CI [.12, .44]). A multivariate model that included the five overt stuttering measures, age, and time since onset was statistically significant (R = .37, p = .003). No single overt stuttering measure, however, demonstrated a uniquely statistically significant effect in the full model, p > .05 (see Table 4).

3.3. Cluster Analyses

We conducted two rounds of k-means cluster analyses. The first analysis included all participants with valid KiddyCAT responses (n = 203) to assess clusters derived from frequency of SLDs, frequency of NSLDs, ratio of repetitions, ratio of prolongations/blocks, associated nonspeech behaviors, duration of stuttering events, and KiddyCAT scores, as well as age and time since onset. A second analysis was conducted with a subset of participants (n = 86) with complete and valid TOCS Disfluency-Related Consequences Rating Scale and KiddyCAT data, thereby adding the TOCS data to our cluster analysis.

Results from the cluster analyses of both samples of data revealed best fit for k = 2 clusters of children who stutter, such that k = 2 accounted for the least overlap of participants within groups compared with k = 3 through 10. Average silhouette width was used as a measure of cluster fit, ranging from −1 to 1, with averages closer to 1 having points that are closer to the cluster mean (Kaufman & Rousseeuw, 2009). At $k = 2$ clusters, our analyses resulted in average silhouette widths equal to 0.289 ($n = 203$ subset) and 0.236 ($n = 86$ subset); these values are indicative of discrete but widely dispersed clusters.

As shown in Table 5, both sample cluster solutions indicated a larger *n* cluster with relatively less severe stuttering features and a smaller *n* cluster with more severe stuttering features (see Table 5). Based on within-cluster means and post hoc *t*-tests between clusters ($p < 0.01$), compared to participants placed into cluster 1, participants in cluster 2 were characterized by higher frequency of SLDs, higher ratio of prolongations and blocks, higher SSI Duration sub-scores, and higher SSI Physical Concomitants sub-scores. Within the larger sample that included values for ratio of repetitions, on average the participants in cluster 2 had a lower ratio than did those in cluster 1. Within the sample with both TOCS and KiddyCat scores, participants clustered into cluster 2 tended to have higher TOCS and KiddyCat values than did the participants in cluster 1 ($p < .01$, Table 5).

As an example to visualize our cluster results for the $n = 86$ subset, Figure 2 exhibits a plot of clusters with an overlay of frequency of SLDs and SSI duration sub-scores. That plot reveals participants in cluster 1 more tightly clustered around less severe scores for both variables than those in cluster 2, with substantial overlap between clusters when only two variables are plotted together.

4. Discussion

Stuttering is characterized by several behavioral and cognitive-affective features that are heterogeneous between individuals, and the relationships among and between these features have been relatively unexplored. To explore possible relationships between features of stuttering, we applied regression and exploratory cluster analyses to nested subsets of a large group of preschool-age children who stutter ($n = 296$). We found that, to a great extent, measurable aspects of stuttering behaviors were correlated with one another in young children who stutter. Conversely, communication attitudes as measured by the KiddyCAT were broadly not significantly correlated with other indices of stuttering behaviors. Considered together in exploratory k-means cluster analyses, results indicate that most preschool-age children have relatively milder presentations across features of stuttering, while a smaller cluster of children present with more severe presentations in terms of both behavior and cognitive-affective impact of stuttering.

4.1. Overt Stuttering Behaviors Were Broadly Intercorrelated in Preschool-Age Children

Our pairwise partial correlation analyses of behavioral features of stuttering revealed that frequency of SLDs was positively correlated with other stuttering measures (ratio of repetitions, ratio of prolongations and blocks, SSI sub-score for Duration, and SSI sub-score for Physical Concomitants). Conversely, there was a negative correlation between frequency of SLDs and NSLDs. In other words, more stuttering overall tends to correspond with more repetitions, more blocks, longer moments of stuttering, a greater presence of physical concomitant behaviors, and fewer non-stuttering disfluencies. Notably, relative frequency of repetitions was not significantly correlated with SSI Physical Concomitants sub-scores, while frequency of prolongations and blocks were associated with physical concomitants. NSLDs were also shown to have no significant association with SSI Duration or Physical Concomitants sub-scores, which is an expected result given that SSI sub-scores were putatively calculated based on instances of stuttering. Previous studies have largely emphasized differences among clinical measures, such as frequency of SLDs, between groups of children who do and do not stutter (Ambrose & Yairi, 1999; Tumanova et al., 2014), but few have underscored relations between a broader range of stuttering behaviors within a large group of children who stutter. Taken together with our cluster analysis results, we may characterize stuttering behaviors as largely intercorrelated in preschool-aged children. Further clinical implications are discussed below.

4.2. Nonspeech Behaviors and Communication Attitudes in Preschool-Age Children

Bivariate correlation analyses indicated that increased physical concomitants were associated with increased KiddyCAT scores. However, although a multivariate regression analysis indicated that stuttering behaviors, along with age and time since onset, were significantly predictive overall of KiddyCAT scores, none of the individual stuttering behaviors were significant in that model. The three largest effects from the multivariate model, none of which were statistically significant, indicated a positive association between the SSI Physical Concomitants sub-score and the KiddyCAT scores as well as a negative association between both frequency of NSLDs and ratio of repetitions and the KiddyCAT scores.

Winters and Byrd (2021) recently conducted similar multiple regression analyses between SSI sub-scores and KiddyCAT scores for a group of $n = 49$ preschool-age children who stutter, finding no statistically significant relationships. On one hand, the findings from the present study diverge from those of Winters and Byrd (2021) in that the present study found bivariate associations between the KiddyCAT scores and physical concomitants and that the overall multivariate model was predictive of KiddyCAT scores. On the other hand, the present findings that indicated nonsignificant correlations between KiddyCAT scores and other behavioral measures of stuttering are similar to those of Winters and Byrd (2021). It is notable that our participants were, on average, 8 months younger than those recruited by Winters and Byrd (2021). As we have reported (see Table 3) and has been reported in other studies (Groner et al., 2016), lower scores on the KiddyCAT are significantly associated with greater age for preschool-age children who stutter. It is possible that any potential association between stuttering behaviors and cognitive-affective features of stuttering in young children is particularly sensitive to the effects of age during this developmental period and could also be related to other third-order variables. Considering the present study and past work in this area, one avenue for future research may be a longitudinal exploration on how the nature of the relationship between negative attitudes about stuttering and stuttering behaviors evolves over time.

A noteworthy barrier to understanding cognitive-affective features of stuttering in preschool-age children is a relative paucity of valid methods for measuring this aspect of stuttering. To our knowledge, the KiddyCAT is the only norm-referenced, self-reported measure of communication attitudes for preschool-age stuttering that is widely available and thought to be psychometrically valid (Clark et al., 2012; Vanryckeghem & Grutten, 2007), although a preschool-age version of the OASES is in development (Tichenor et al., 2022). Given this limitation, we included the Disfluency-Related Consequences Rating Scale from the TOCS (Gillam et al., 2009) as another feasible measure of the cognitive-affective features of stuttering, acknowledging that it is based on parents' observations rather than the direct reports of children. We found that behavioral measures of stuttering (except for frequency of NSLDs), controlling for age and time since onset, were collectively correlated with TOCS Disfluency-Related Consequences scores for our subset of 113 participants with complete TOCS response sets. Bivariate regression analyses of individual behavioral features of stuttering and TOCS rating scale scores revealed that nearly each of our selected measures of stuttering behaviors were positively correlated with TOCS rating scale scores, while frequency of NSLDs was negatively correlated with TOCS rating scale scores. In other words, participants with greater frequency of stuttering, more prolongations/blocks, longer average instances of stuttering, and more prominent associated physical behaviors were all more likely to be rated by their parents as also having more negative reactions and consequences to their stuttering. It is unclear whether this finding is due to parents perceiving more prominent stuttering behaviors as having a greater negative impact on children, to parents reflecting their own underlying concerns or views of stuttering behaviors, or to some other combination of factors.

4.3. Features of Preschool-Age Stuttering May Suggest Higher-Severity and Lower-Severity Clusters

Our k-means cluster analyses consistently organized research participants into two broad groups: a larger group of children with less prominent or severe features of stuttering, and a smaller group of children with more prominent or severe features of stuttering. Given the close or overlapping nature of the clusters derived in our analyses, we are cautious to avoid interpreting these clusters as functionally distinct phenotypes of stuttering; however, the reasonably strong grouping of data in both subsets of participants warrants further consideration. Findings underscore the fact that more severe presentations of stuttering (18-38% of our participants) are not as common as less severe presentations (62-82% of our participants), reflecting the right-skewed distributions of many stuttering features in young children who stutter (Tumanova et al., 2014).

Our two-cluster finding can be said to resemble the clusters for young children who stutter previously hypothesized by Schwartz and Conture (1988), who reduced an initial five-cluster finding into two broad groups that were largely differentiated by predominant type of stutter, repetitions versus prolongations/blocks. For our largest data set ($n = 203$), repetitions were the only behavioral measure of stuttering to be found, on average, more prominent in the otherwise less severe cluster #1. Conversely, prolongations and blocks were significantly more prominent for our cluster #2. Schwartz and Conture (1988) in turn discussed a resemblance of their findings to early theories of stuttering by Froeschels (1943) suggesting "clonic" and "tonic" subtypes among people who stutter. It is an ongoing question as to why most young children who stutter present with repetitions and an overall less severe presentation, while a small group of others present with sustained tension and more prominent stuttering features.

To view our findings through a recent framework for characterizing features of stuttering, it may be that participants in cluster #2 are more likely to demonstrate or further develop struggle and avoidance behaviors related to stuttering. This concept was recently summarized by Tichenor and colleagues (2022):

> Repeatedly experiencing difficulty speaking (Perkins, 1990; Tichenor & Yaruss, 2019b) is, for many people, associated with the development of fear, shame, embarrassment, and other negative reactions concerning speech or communication. These feelings become habitual, anticipated, and reinforced by repeated speech difficulties, and as a result, a person may learn to avoid, push, or struggle in an attempt to cope with the sensation (or anticipation) of being stuck or unable to communicate as they wish. (p. 14)

On average for our $n = 86$ dataset, participants in cluster #2 demonstrated more prominent stuttering behaviors, including greater frequencies of prolongations/blocks and physical concomitants, as well as more negative communication attitudes. We therefore speculate that this group may represent children who are most likely at the start of a process of learning to “avoid, push, or struggle” as a response to stuttering, although further study is needed to support this speculation.

4.4. Clinical Implications

Prior to this study, we were uncertain as to how frequency of stuttering alone should be valued in the clinical characterization of stuttering for individual children who stutter, given the heterogeneous nature of stuttering behaviors. However, our results support the notion that, for preschool-age children, frequency of stuttering may be a reasonable measure upon which to judge overall severity of stuttering behaviors. Per correlation results (as reported in Table 2), frequency of stuttering returned among the strongest associations with other behavioral features of stuttering.

In a seminal longitudinal study by Yairi and colleagues (1993), which evaluated a group of 16 preschoolers who were observed within a few weeks of the onset of stuttering, children with persistent stuttering showed no significant behavioral differences compared with those whose stuttering had resolved by a six-month follow-up. However, as mentioned in the Introduction above, stuttering frequency and related measures have more recently been shown to be predictive of persistent stuttering in young children with greater times since onset (Singer et al., 2020a, 2022; Walsh et al., 2020). In each of these cited studies, severity of stuttering was measured differently: frequency of SLDs (Singer et al., 2020a), overall SSI score (Singer et al., 2022), and weighted SLD score (Walsh et al., 2020). Despite these differences and a need to further understand the nature of persistent stuttering, assessing stuttering frequency (or highly related measures) may be particularly useful for prognosis and characterization of stuttering for preschool-age children who have been stuttering for a period of several months, taken in context with other individual characteristics and history.

Do our *k*-means cluster findings point to any clinical implications? Given the high degree of correlation among variables, there may be more concern or urgency to address stuttering in children who present with characteristics resembling cluster #2 findings, with these children exhibiting more prominent and potentially distracting stuttering behaviors as well as reporting more negative communication attitudes—all of which may negatively impact overall communication or quality of life. Many clinical researchers have speculated that differing presentations of stuttering in young children may suggest distinct clinical pathways or "decision streams" for clinicians to consider (e.g., Ambrose et al., 2015; Zebrowski, 1997), however more research is needed to understand whether these clusters—driven primarily by stuttering behaviors—align with such pathways.

4.5. Limitations

As a tradeoff for the relatively large *n* of extant data in the current study, some of the measures we used did not represent the most precise measures of specific features of stuttering as possible. For example, we used sub-scores of the SSI to represent stuttering duration and associated non-speech behaviors, as opposed to mean duration of all instances of stuttering and behaviorally-coded indices of physical concomitants (cf. Schwartz & Conture, 1988). Similarly, the TOCS Disfluency-Related Consequences Rating Scale was not designed to directly assess children's cognitive-affective responses to stuttering, although we speculatively explored it based on the possibility that it may be related to these responses. And other potentially significant indices, such as weighted SLD (Walsh et al., 2020), were not possible to include. Further, potentially salient demographic information was also not reported in the same way for all participants, such as race and ethnicity, further limiting our ability to broadly generalize our findings to the population.

There are several analytic limitations to the current study as well. Most significantly, we opted to omit correction for multiple comparisons for the purpose of exploring relationships between many variables and the application of an exploratory analytic technique. Failure to correct for multiple comparisons increases the likelihood of a Type I error (false positive) and should prompt caution in interpreting or overgeneralizing our findings.

4.6. Future Directions

Despite these limitations, our findings point to many important follow-up questions for future researchers to explore. As mentioned above, the relationship between the behavioral and cognitive-affective features of stuttering remains unclear and may involve age or time since onset as mediating factors (Winters & Byrd, 2021). And if attitudes and emotions related to stuttering are not associated with stuttering behaviors in young children, what other factors might be influencing them? One factor worth considering might be temperament and emotional factors such as affectivity and effortful control, for which differences have been found between children who do and do not stutter (see Jones et al., 2014). If a child's temperamental characteristics impact their emotional reactions and ability to self-regulate to stressful stimuli, it is reasonable to suppose that temperamental characteristics might play a role in the development of negative attitudes and emotions related to stuttering. Emerging support for this notion was recently reported by Tichenor and colleagues (2022), who found significant correlations between a parent-reported measure of temperament and cognitive-affective features of stuttering in preschool-age children who stutter. More work is needed to contextualize the relationship between cognitive-affective features of stuttering and temperament as children grow and develop over time.

The current study has also introduced k-means cluster analysis as a feasible tool for considering a wide range of relevant measures and indices exhibited by children who stutter. Another plausible next research step might be to include a broader range of variables in a cluster model, to account for factors that have been shown to vary with stuttering severity and/or long-term stuttering outcomes, such as family history of stuttering, speech-language skills, emotional regulation skills, and temperament characteristics (Jones et al., 2017; Kraft et al., 2019; Singer et al., 2020a, 2022). Finally, it may be important to evaluate clusters with respect to longitudinal outcomes such as persistence versus recovery of stuttering.

4.7. Conclusions

This large-scale correlational study of cross-sectional data highlights the many intercorrelations among behavioral features of stuttering as well as the more limited associations between behavioral and cognitive-affective features of stuttering for preschool-age children who stutter. Considered with previous investigations of stuttering across the lifespan (e.g., Eggers et al., 2021; Tichenor et al., 2022), our findings contribute to an increasingly comprehensive and nuanced understanding of the heterogenous features of stuttering and their development.

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Highlights

- For preschool-age children who stutter…
- Most measures of stuttering behaviors were intercorrelated
- Self-reported communication attitudes were largely not significantly associated with stuttering behaviors
- Reactions to stuttering (per caregiver report) were associated with stuttering behaviors
- Cluster analyses broadly grouped children by severity of stuttering features

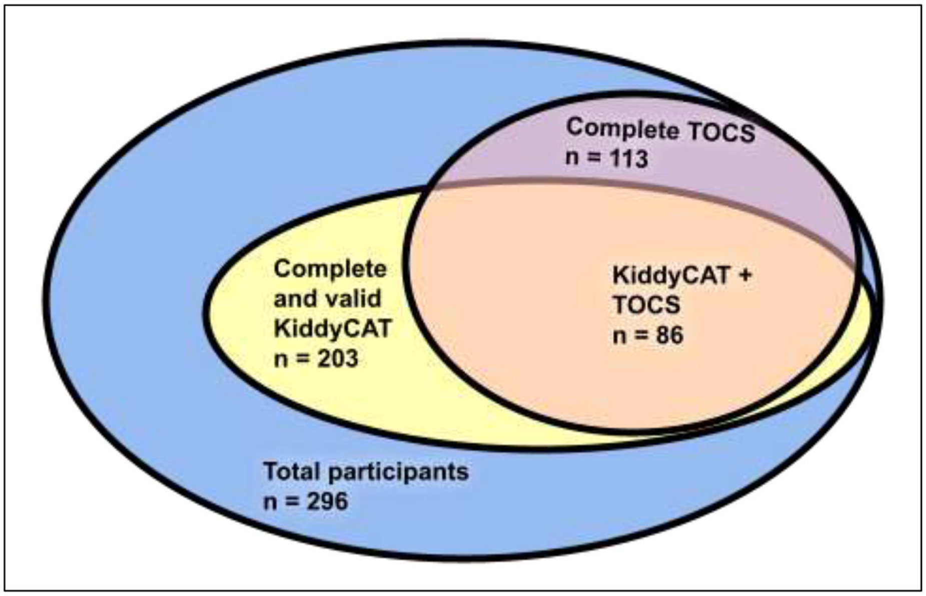

Figure 1. Construction of Participant Subsets

Note. SLD = stuttering-like disfluencies; SSI = Stuttering Severity Instrument; TOCS = Test of Childhood Stuttering.

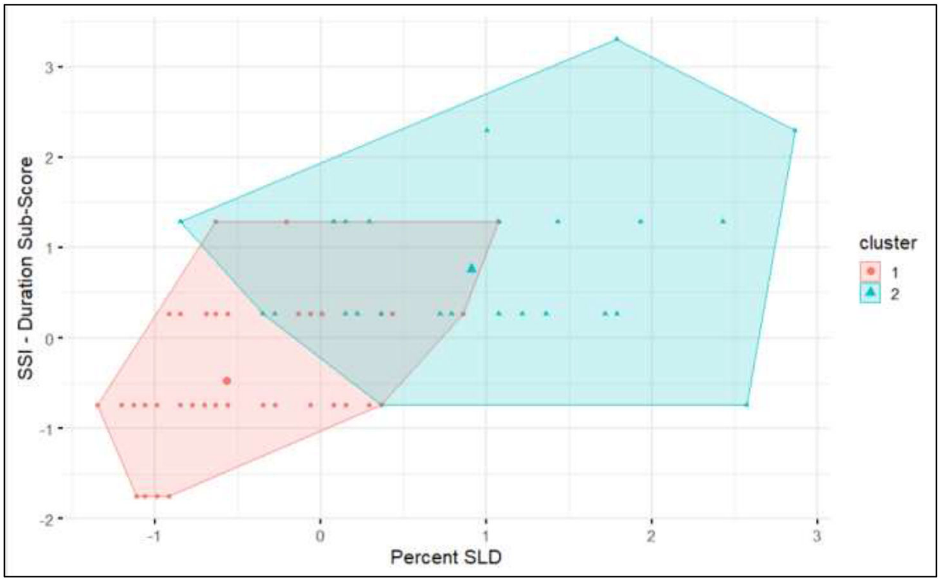

Figure 2. K-Means Cluster Plot by Percent SLDs and SSI Duration Sub-score

Note. k = 2. SLD = stuttering-like disfluency. SSI = Stuttering Severity Instrument. Data includes *n* = 86 participants with complete KiddyCAT and TOCS Disfluency-Related Consequences Rating Scale data.

Table 1

Participant Characteristics of Sample and Subsets

Variable	***Full dataset (n = 296)***	***Valid KiddyCAT data (n = 203)***	***Complete TOCS data (n = 113)***	***Complete KiddyCAT and TOCS (n = 86)***
Mean chronological age in months (SD)	47.87 (9.05)	48.26 (8.88)	47.25 (8.80)	48.02 (9.05)
Median time since onset of stuttering in months (IQR)	12.28 (11.15)	12.64 (12.48)	12.25 (12.86)	12.41 (11.73)
Parent-reported gender				
Percent female	26.3%	28.6%	23.9%	24.4%
Percent male	73.6%	71.4%	76.1%	75.6%
Parent-reported race				
Percent Asian	1.4%	<1.0%	1.8%	0%
Percent Black or African American	15.5%	15.3%	13.3%	12.8%
Percent White	54.7%	58.6%	39.8%	43.0%
Percent reporting more than one race	2.7%	2.0%	2.7%	2.3%
Percent missing or unreported	25.7%	23.6%	42.5%	41.9%
Parent-reported ethnicity				
Percent Hispanic	1.7%	2.0%	3.5%	3.5%
Percent non-Hispanic	71.3%	73.4%	54.0%	54.7%
Percent missing or unreported	27.0%	24.6%	42.5%	41.9%
Speech-language standard scores				
GFTA mean score (SD)	106.20 (11.54)	107.18 (11.64)	107.68 (11.08)	108.41 (10.78)
PPVT mean score (SD)	107.13 (14.49)	109.19 (13.67)	111.96 (13.72)	113.48 (12.47)
EVT mean score (SD)	110.32 (13.70)	110.98 (13.62)	113.65 (12.94)	114.40 (12.56)
TELD - Receptive Subtest mean score (SD)	111.20 (17.32)	112.49 (16.59)	118.46 (15.69)	119.91 (14.89)
TELD - Expressive Subtest mean score (SD)	105.42 (15.03)	107.07 (14.97)	110.01 (16.21)	111.70 (16.20)

Note. SD = standard deviation. IQR = interquartile range. GFTA = Goldman-Fristoe Test of Articulation. PPVT = Peabody Picture Vocabulary Test. EVT = Expressive Vocabulary Test. TELD = Test of Early Language Development. TOCS = Test of Childhood Stuttering.

Table 2

Results of Partial Correlations Among Indices of Overt Stuttering Behaviors in a Sample of Preschool-Age Children Who Stutter (n = 296)

	Frequency of NSLDs	Ratio of Repetitions	Ratio of Prolongations and Blocks	SSI Duration Sub-Score	SSI Physical Concomitants Sub-Score
Frequency of SLDs	− .16* (−.29, −.02)	.44** (.32, .56)	.43** (.31, .54)	.57** (.48, .65)	.32** (.19, .44)
Frequency of NSLDs		− .54** (−.64, −.44)	− .20** (−.32, −.08)	− .09 (−.20, .04)	− .10 (−.23, .03)
Ratio of Repetitions			− .25** (−.35, −.14)	.20** (.09, .30)	.03 (−.11, .15)
Ratio of Prolongations and Blocks				.32** (.22, .42)	.29** (.18, .39)
SSI Duration Sub-Score					.32** (.20, .43)

Note. Values in cells are *beta* (bias-corrected 95% confidence interval). Age and time since onset of stuttering included as covariates in all models.

** $p < .001$

* $p < .01$. SLD = stuttering-like disfluency. NSLD = non-stuttering-like disfluency. SSI = Stuttering Severity Instrument.

Table 3

*Results of Bivariate Correlation and Multivariate Regression Analyses Between Indices of Overt Stuttering Behaviors and KiddyCAT Scores Controlling for Age and Time Since Onset Among Preschool-Age Children Who Stutter (*n *= 203)*

	Bivariate [a]		**Multivariate [b]**	
	beta **(bias-corrected 95% C.I.)**	***p*** **-value**	***beta*** **(bias-corrected 95% C.I.)**	***p*** **-value**
Age	− .28 (−.41, −.15)	< .001	− .24 (−.37, −.10)	< .001
Time Since Onset	− .20 (−.32, −.07)	.004	− .13 (−.27, .02)	.104
Frequency of SLDs	.01 (−.14, .14)	.915	.07 (−.16, .30)	.545
Frequency of NSLDs	− .08 (−.23, .05)	.220	− .17 (−.36, −.01)	.061
Ratio of Repetitions	− .09 (−.21, .03)	.185	− .18 (−.39, .03)	.081
Ratio of Prolongations and Blocks	.10 (−.05, .24)	.198	− .05 (−.27, .16)	.670
SSI Duration Sub-Score	− .02 (−.15, .11)	.765	− .07 (−.26, .12)	.447
SSI Physical Concomitants Sub-Score	.15 (.02, .28)	.029	.14 (−.03, .31)	.131

Note.

[a] Associations of each behavior index controlled for age and time since onset.

[b] Multiple $R = .37$, $p < .001$. C.I. = confidence interval. SLD = stuttering-like disfluency. NSLD = non-stuttering-like disfluency. SSI = Stuttering Severity Instrument. KiddyCAT = The Communication Attitude Test for Preschool and Kindergarten Children Who Stutter.

Table 4

*Results of Bivariate Correlation and Multivariate Regression Analyses Between Indices of Overt Stuttering Behaviors and TOCS Scores Controlling for Age and Time Since Onset Among Preschool-Age Children Who Stutter (*n = *113)*

	Bivariate [a]		Multivariate [b]	
	beta **(bias-corrected 95% C.I.)**	***p*** **-value**	***beta*** **(bias-corrected 95% C.I.)**	***p*** **-value**
Age	.07 (−.13, .26)	.481	.05 (−.16, .27)	.669
Time Since Onset	.09 (−.11, .29)	.344	.08 (−.15, .31)	.479
Frequency of SLDs	.28 (.12, .44)	.003	.10 (−.09, .27)	.339
Frequency of NSLDs	− .20 (−.40, −.01)	.066	− .14 (−.35, .07)	.148
Ratio of Prolongations and Blocks	.25 (.05, .44)	.006	.12 (−.07, .34)	.215
SSI Duration Sub-Score	.28 (.08, .47)	.004	.11 (−.17, .36)	.397
SSI Physical Concomitants Sub-Score	.20 (.01, .37)	.023	.08 (−.10, .27)	.413

Note. Ratio of repetitions was not included in these analyses due to too much collinearity with the other measures in this smaller sample.

[a] Associations of each behavior index controlled for age and time since onset.

[b] Multiple $R = .37$, $p = .023$. C.I. = confidence interval. SLD = stuttering-like disfluency. NSLD = non-stuttering-like disfluency. SSI = Stuttering Severity Instrument. TOCS = Test of Childhood Stuttering.

Table 5

Comparison of Within-Cluster Means (and Standard Deviations) for Dependent Variables

		KC Data Only (n = 203)		KC and TOCS Data (n = 86)	
		Cluster 1 *n* = 167	**Cluster 2 *n* = 36**	**Cluster 1 *n* = 53**	**Cluster 2 *n* = 33**
Variables	**Age, months**	47.83 (8.88)	50.26 (8.88)	48.86 (8.96)	46.66 (9.14)
	Time Since Onset, months	13.45 (8.08)	17.95 (10.98)	15.85 (8.83)	11.84 (7.88)
	Frequency of SLDs	**0.08 (0.05)** *	**0.14 (0.08)** *	**0.06 (0.03)** *	**0.13 (0.04)** *
	Frequency of NSLDs	0.04 (0.02)	0.04 (0.03)	0.04 (0.02)	0.04 (0.03)
	Ratio of Repetitions	**0.56 (0.16)** *	**0.37 (0.17)** *	N/A	N/A
	Ratio of Prolongations and Blocks	**0.08 (0.09)** *	**0.38 (0.18)** *	**0.07 (0.07)** *	**0.24 (0.19)** *
	SSI Duration Sub-Score	**4.86 (1.92)** *	**7.17 (2.32)** *	**4.53 (1.48)** *	**6.97 (1.74)** *
	SSI Physical Concomitants Sub-Score	**0.83 (1.56)** *	**5.50 (4.09)** *	**0.55 (1.24)** *	**2.94 (2.28)** *
	KC Total Score	4.01 (2.81)	5.08 (2.87)	**2.81 (2.06)** *	**4.67 (2.69)** *
	TOCS Total Score	N/A	N/A	**3.43 (3.56)** *	**7.73 (4.39)** *

Note.

* and bold denotes statistically significant difference between clusters ($p < 0.01$). Results reflect results of k-means cluster analyses for K = 2 clusters. SLD = stuttering-like disfluency. NSLD = non-stuttering-like disfluency. SSI = Stuttering Severity Instrument. KC = KiddyCAT. TOCS = Test of Childhood Stuttering. N/A refers to removal of the ratio of repetitions data from the n = 86 subset model due to a violation of multicollinearity.