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Author Manuscript
J Fluency Disord. Author manuscript; available in PMC 2015 September 01.

Published in final edited form as:
J Fluency Disord. 2014 September ; 0: 32–46. doi:10.1016/j.jfludis.2014.06.001.

PRESCHOOL SPEECH ARTICULATION AND NONWORD REPETITION ABILITIES MAY HELP PREDICT EVENTUAL RECOVERY OR PERSISTENCE OF STUTTERING

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Abstract

Purpose—In preschool children, we investigated whether expressive and receptive language, phonological, articulatory, and/or verbal working memory proficiencies aid in predicting eventual recovery or persistence of stuttering.

Methods—Participants included 65 children, including 25 children who do not stutter (CWNS) and 40 who stutter (CWS) recruited at age 3;9–5;8. At initial testing, participants were administered the Test of Auditory Comprehension of Language, 3rd edition (TACL-3), Structured Photographic Expressive Language Test, 3rd edition (SPELT-3), Bankson-Bernthal Test of Phonology-Consonant Inventory subtest (BBTOP-CI), Nonword Repetition Test (NRT; Dollaghan & Campbell, 1998), and Test of Auditory Perceptual Skills-Revised (TAPS-R) auditory number memory and auditory word memory subtests. Stuttering behaviors of CWS were assessed in subsequent years, forming groups whose stuttering eventually persisted (CWS-Per; n=19) or recovered (CWS-Rec; n=21). Proficiency scores in morphosyntactic skills, consonant production, verbal working memory for known words, and phonological working memory and speech production for novel nonwords obtained at the initial testing were analyzed for each group.

Results—CWS-Per were less proficient than CWNS and CWS-Rec in measures of consonant production (BBTOP-CI) and repetition of novel phonological sequences (NRT). In contrast, receptive language, expressive language, and verbal working memory abilities did not distinguish CWS-Rec from CWS-Per. Binary logistic regression analysis indicated that preschool BBTOP-CI scores and overall NRT proficiency significantly predicted future recovery status.

Conclusion—Results suggest that phonological and speech articulation abilities in the preschool years should be considered with other predictive factors as part of a comprehensive risk assessment for the development of chronic stuttering.

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Keywords

stuttering; persistence; recovery; articulation; nonword repetition

1. Introduction

Our understanding of fundamental characteristics of stuttering, including age of onset, incidence, prevalence, and recovery rates has improved dramatically in recent years (Yairi & Ambrose, 2013). We now recognize that onsets are on average slightly younger (33 months), incidences likely higher (~5–8%) and prevalence rates slightly lower (<1%) than previously thought (Yairi & Ambrose, 2013 for review). An extensive body of literature exists regarding the nature of stuttering from early childhood through adulthood (see Bloodstein & Bernstein Ratner, 2008; Yairi & Ambrose, 2005 for review), and many factors in the domains of speech motor control, language, and emotion/temperament have been hypothesized to play significant roles in stuttering (e.g., Conture & Walden, 2012; DeNil, 1999; Guitar, 2006; Smith, 1999; Smith & Kelly, 1997; Yairi & Ambrose, 2005). Many questions, however, still remain about what factors may help predict persistence or recovery in young children (Reilly, et al., 2009; Yairi & Ambrose, 2005, 2013). It has been suggested that recovery from stuttering versus persistence may constitute subtypes of the disorder (Yairi & Ambrose, 2013).

Estimates of recovery rates in young children who stutter (CWS) have varied, with reports as low as 36% and as high as 94% (e.g., Bloodstein & Bernstein Ratner, 2008; Mansson, 2000; Yairi & Ambrose, 2005; 2013). Yairi and Ambrose (2005) reported recovery rates for 2–5 year old CWS of approximately 65%. Clearly, the recovery rate depends in large part on the age at which the child is assessed, with much higher recovery rates for 2–3 year olds compared to older children. For example, recovery rates for 2–3 year olds have been documented to be in the 75–80% range, while rates for 4–5 year-olds are approximately 50% (Yairi & Ambrose, 2005).

1.1 Predictive Factors of Stuttering Outcome

The very fact that some children recover from stuttering while others do not raises some critical questions (Subramanian, Yairi, & Amir, 2003; Yairi & Ambrose, 2013). Clinically, it is very important to be able to predict from an early age which CWS will recover and which will continue stuttering (Watkins & Yairi, 1997; Yairi, Ambrose, Paden, & Throneburg, 1996). It is not financially nor practically feasible to treat every child who begins to stutter, yet early intervention has consistently been demonstrated to benefit the child, both by improving fluency strategies and providing emotional support (Subramanian, et al., 2003; Yairi & Ambrose, 2005). Furthermore, if a factor or combination of factors can accurately predict persistence of stuttering from an early age, intervention can be targeted to those most at risk (Yairi et al., 1996). In addition, differentiating children whose stuttering is likely to recover (CWS-Rec) from children whose stuttering is likely to persist (CWS-Per) bears significance for research. Including CWS-Rec with CWS-Per in a single “stuttering” experimental group may mask potential differences between groups and introduce confounding variables, which may subsequently lead to inaccurate experimental interpretations and conclusions about the nature of chronic developmental stuttering.

1.1.1 Nonlinguistic Factors as Possible Predictors—To date, only limited research has specifically examined factors that relate to eventual recovery from developmental stuttering (Ambrose, Cox, & Yairi, 1997; Reilly et al., 2009; Yairi & Ambrose, 2005). Because many more females than males recover from stuttering, with a resulting ratio of 4–5 adult males who stutter for every female, sex may be considered as helpful in predicting stuttering outcome (Yairi & Ambrose, 2005; Reilly et al., 2009). Family history has also been shown to play a role in determining stuttering outcome, as genetic research has indicated that CWS whose family members (especially immediate female family members) exhibited persistent stuttering were also more likely to persist (Ambrose et al., 1997; Kidd, Heimbuch & Records, 1981). The age of onset (older onset more likely to persist), and years since stuttering onset (longer period of stuttering more likely to persist) may also have some predictive value (see Yairi & Ambrose, 2005 for review).

1.1.2 Linguistic Aspects as Possible Predictors

Receptive and Expressive Language: Because the onset of stuttering typically occurs during the preschool years, a period also marked by a rapid expansion of linguistic skills (e.g., Bloodstein & Bernstein Ratner, 2008; Wagovich, Hall, & Clifford, 2009; Watkins & Yairi, 1997; Yairi & Ambrose, 2005), researchers have long discussed a potential link between stuttering and language development. Multiple studies have shown that disfluency is exacerbated during production of syntactically complex utterances (e.g., Bernstein Ratner & Sih, 1987; Gaines, Runyan, & Meyers, 1991; Logan & Conture, 1995; Weiss & Zebrowski, 1992; Yaruss, 1999; Zackheim & Conture, 2003). Furthermore, some researchers have shown that CWS perform more poorly than CWNS on measures of language and articulation abilities (Anderson & Conture, 2000; Bernstein Ratner & Silverman, 2000; Ntourou, Conture, & Lipsey, 2011). Additional research suggests that language abilities of CWS show greater "linguistic dissociations" or mismatches in abilities across, such as in receptive and expressive proficiencies (Anderson, Pellowski, & Conture, 2005; Coulter, Anderson, & Conture, 2009). Recent findings from a meta-analysis study of language abilities in CWS suggest that some language abilities of CWS may be reduced relative to CWNS and should be taken into account as playing a potential role in the development of stuttering (Ntourou et al., 2011). It has also been suggested that a 'mismatch' between utterance length and complexity and the language proficiency of a CWS, for example as measured by MLU, may play a role in the number of speech disfluencies (Zackheim & Conture, 2003). It should be noted however, that differences in language abilities in CWS are not characterized by frank language deficits (See Nippold, 2002 for review).

Moreover, language proficiency has been implicated in predicting the eventual course of stuttering. Evaluation of language skills according to standardized testing has shown evidence of differential receptive and expressive language skills in CWS-Rec and CWS-Per. Yairi et al. (1996) assessed receptive and expressive language development using the Preschool Language Scale (PLS; Zimmerman, Steiner, & Pond, 1979) at the first study visit (near stuttering onset) and one year later. CWS-Per scored significantly lower than CWS-Rec on expressive and receptive language portions at both time periods. However, nearly all scores were within the normal range, suggesting that subtle language differences may be present between CWS-Rec and CWS-Per, but these differences do not necessarily indicate language impairment (Yairi et al., 1996).

Analyses of language samples, however, have not revealed differences in expressive language for CWS-Per. Yairi et al. (1996) and Watkins, Yairi, & Ambrose (1999) reported similar expressive language skills among CWS-Per and CWS-Rec from analyses of language samples obtained near time of stuttering onset. However, Watkins & Yairi (1997) found differences between CWS-Per and CWS-Rec; CWS-Per demonstrated greater variability among measurements of mean length of utterance (MLU), number of different words (NDW), and number of total words (NTW), though performance still fell within the normal range for their age. Although no single measure of language skills was found to directly predict stuttering recovery, the authors suggest the observed variability in language production measures indicated a possible underlying difference in language development between children who eventually recovered and those whose stuttering persisted (Watkins & Yairi, 1997; Watkins et al., 1999).

Phonological Aspects: It has been reported that children who stutter have a higher rate of phonological disorders relative to the general population (Paden, Yairi, & Ambrose, 1999; Yaruss, Lasalle, & Conture, 1998), suggesting that a relationship between phonological skills and stuttering may exist. For example, Louko, Edwards, and Conture (1990) observed a less mature pattern of phonological processes in speech samples of CWS than CWNS when groups were matched for age. On the other hand, Nippold (2002) reviewed 15 studies that addressed a possible interaction between stuttering and phonology and did not find strong support for the claim that poor phonological skills are a factor in the etiology of stuttering.

Despite conflicting data regarding the prevalence of concomitant phonological difficulties and stuttering, phonological skills have been implicated in predicting transient or persistent stuttering. Yairi et al. (1996) demonstrated that the sequence of phonological development progresses normally in CWS, but that CWS-Per tended to develop at a slower rate than controls and CWS-Rec. Paden and Yairi (1996) examined phonological abilities in more detail, and found that CWS-Per had a significantly greater percent of phonological errors on the Assessment of Phonological Processes-Revised (APP-R; Hodson, 1986) than matched controls, whereas CWS-Rec did not differ from the control group. The authors emphasize, though, that while differences between persisting and recovered groups were apparent, phonological abilities varied widely within all groups. In addition, phonological abilities of CWS-Per were within normal limits, indicating that persistent stuttering is not necessarily correlated with overt phonological impairment. Paden and Yairi (1996) concluded that phonology may play a role in predicting eventual recovery or persistence, but should be considered in combination with other factors.

Studies designed to probe phonological processing skills in CWS have utilized nonword repetition tasks (NRTs) (Anderson, Wagovich, & Hall, 2006; Hakim & Bernstein Ratner, 2004; Seery, Watkins, Ambrose, & Throneburg, 2006; Smith, Goffman, Sasisekaran, & Weber-Fox, 2012; Weber-Fox, Spruill, Spencer, & Smith, 2008). Nonword repetition tasks are well documented to successfully identify children with specific language impairment (e.g., Deevy, Weil, Leonard, & Goffman, 2010; Dollaghan & Campbell, 1998; Shriberg et al., 2009). It is hypothesized that NRTs uniquely assesses phonological working memory by requiring the listener to store the phonemes heard, retrieve them from memory, and produce the nonsense word (Gathercole & Baddeley, 1990). More recent research has emphasized the complexity of this seemingly simple task. Not only does nonword repetition enlist phonological memory skills, but it also recruits auditory processing, phonological representation and analysis, and speech motor planning and execution (Gathercole, 2006; Rispens & Baker, 2012). New findings in typically developing school-age children revealed that oromotor control for novel, sequential non-linguistic movements predicted a significant portion of the variance (24%) in performance of a standard nonword repetition task (Krishnan et al., 2013).

The results of studies using NRT to distinguish CWS from CWNS have been mixed. In a preliminary study of children ages 4 to 8 years old, Hakim and Bernstein Ratner (2004) observed less accurate performances of children who stutter, as compared to their normal controls. Anderson et al. (2006) investigated nonword repetition abilities in children ages 3;0 to 5;2. In this study, both CWS and CWNS achieved scores within the normal range on standardized tests of expressive and receptive vocabulary and language, but differed significantly on 2- and 3-syllable nonwords in the Children's Test of Nonword Repetition (CNRep; Gathercole & Baddeley, 1996). In analyzing correlations between CNRep and standardized test scores, no significant correlations were observed between nonword repetition and any of the language tests for normally fluent children; however 3- and 5-syllable, as well as overall nonword repetition were significantly correlated with Goldman-Fristoe Test of Articulation, 2nd edition, (GFTA-2; Goldman & Fristoe, 2000) scores in children who stutter (Anderson et al., 2006). This finding suggested that a difference in nonword repetition skills exists in children who stutter compared to normally fluent peers, even when language skills are within normal limits (Anderson et al., 2006).

In contrast, other experimenters have found no evidence of compromised nonword repetition abilities in CWS without concomitant frank language disorders. Weber-Fox et al. (2008) and Seery et al. (2006) reported no differences in nonword repetition performance between older school-age CWS and CWNS. Additionally, Smith et al. (2012) did not find significant differences in NRT abilities in preschool CWS and CWNS who had language abilities within normal limits. In the same study, CWS who also had a phonological delay performed more poorly on the nonword repetition task than those with normal phonological skills, and CWS with a concomitant language delay performed more poorly than all other groups. Smith et al.'s study in 4–5 year old children included a rigorous testing battery, and groups were matched for socio-economic status, whereas previous studies included less stringent matching criteria between CWS and CWNS. It should be noted, in the Smith et al. study, the preschool CWS group included those children who would eventually persist in stuttering and those who would recover, as information regarding the course of their stuttering was unavailable at the time.

Only one previous study examined nonword repetition in relation to stuttering persistence and recovery (Chon & Ambrose, 2007). In this preliminary study, 10–13 year-old CWS whose stuttering had persisted and those who had recovered from stuttering did not differ in percent of phonemes correct, suggesting that nonword repetition abilities do not differentiate recovered and persistent stuttering in older, school-age children. However, the persistent group contained only five participants; results may differ with a larger sample size. To date there have been no prospective studies of NRT proficiency and eventual recovery or persistence of stuttering.

1.2 The Current Focus

As reviewed above, the empirical evidence concerning the role of linguistic factors in stuttering is mixed. We would argue that such mixed results from studies comparing groups of CWS and CWNS are predictable, given that CWS are an extremely heterogeneous population. Many researchers (Smith, 1999; Van Riper, 1992) have proposed that the factors that contribute to the onset and development of chronic stuttering vary across individuals, and thus, a given language skill may be a strong factor in one child's etiological history, but not in another's. A different experimental strategy, one that has not been widely used to date, seems warranted in the attempt to uncover etiological factors near the onset of stuttering. Using a prospective design, as in the current study, we can assess proficiencies in target areas in a cohort of CWS in the preschool years, and then determine which, if any, of the factors are predictive of persistent stuttering. The present focus is on the question of whether language, phonological, and articulation proficiencies play a role in the eventual recovery or persistence of stuttering. We investigated the relationships between standardized clinical assessments of expressive and receptive language, phonological, articulation, and verbal working memory proficiencies and the eventual persistence or recovery in children diagnosed as stuttering in the preschool years. We included behavioral testing designed specifically to assess morphological and syntactic components of receptive and expressive language proficiency, phonological and articulation abilities for familiar words in picture naming, verbal working memory for familiar words, and the processes involved in nonword repetition, including auditory perception, phonological representation and analysis, phonological working memory, speech motor planning and execution. By utilizing a comprehensive assessment of a range of linguistic, phonological, articulation and verbal working memory skills, our goal is to elucidate the potential relationship between these abilities and persistence or recovery of stuttering.

2. Method

2.1 Participants

Sixty-five children aged 3;9 to 5;8 (years; months) at initial visit were included in this study. Forty of these participants were diagnosed as stuttering at recruitment (CWS), while twenty-five participants did not stutter (CWNS), and were included as a control group. All participants were part of a larger longitudinal study that included two data collection sites: Purdue University and the University of Iowa.

All participants demonstrated normal hearing on a hearing screening at 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz at 20 dB HL. All children had normal or corrected to normal vision, spoke English as their primary language, and had no history of neurological problems according to parent report. Three CWS were placed on medication for attention-deficit hyperactivity disorder at a later point in time, but were not taking medication at time of initial testing.

During their initial visit, participants were evaluated by a speech-language pathologist. In this study, children were diagnosed as children who stutter (CWS) if they met the following diagnostic criteria established by Yairi and Ambrose (1999): The child: (1) was regarded by his/her parents as having a stuttering problem; (2) was regarded by a project speech-language pathologist as having a stuttering problem; (3) was rated by either a parent or the project speech-language pathologist as having a stuttering severity of 2 or higher on an eight point scale (0=normal to 7=very severe); and (4) exhibited at least three stuttering-like disfluencies (SLDs) per 100 syllables of spontaneous speech obtained during two language samples. For the purpose of this study, SLDs included part-word repetition, monosyllabic word repetition, and disrhythmic phonation (sound prolongations, silent blocks, broken words, and other within-word interruptions that disturb the continuity of words). The severity of stuttering was calculated for each child using the weighted stuttering-like disfluencies (SLD) formula developed by Yairi and Ambrose (1999). This formula places the highest weight on disrhythmic phonations.

2.2 Formation of Groups for Comparison

For this report, each CWS was followed for 12–48 months (mean=37.75, *SD* =12.44) after the first study visit and until age 5;7–9;10 (median age 7;11; 25th percentile= 6;10 and 75th percentile=8;7). According to Yairi and Ambrose (2005), recovery rates of children decrease as age increases; that is, the longer the child is classified as stuttering, the less likely he or she is to recover. Age at the latest study visit and recovery status for all CWS are reported in Table 1. Two spontaneous speech samples, as well as clinician and parent ratings were obtained at each annual visit, and the participants' fluency was reassessed. Based on previous literature (Yairi & Ambrose, 2005), it was predicted that approximately half of the children who exhibited stuttering at initial visit (ages 3;9–5;8) would recover and approximately half would persist, and the 21/40 (52.5%) who recovered in our sample is well in line with this prediction.

2.3 Criteria for Recovery of Children who Stutter

A CWS participant was classified as recovered if the following criteria were met: (1) the project speech-language pathologist judged that the child did not exhibit stuttering; (2) the project speech-language pathologist rated stuttering severity as less than 2 (on an eight point scale); (3) parent judged that the child did not exhibit stuttering; (4) parent rated stuttering severity as less than 2; and (5) stuttering-like disfluencies occurred fewer than 3 per 100 syllables in the spontaneous language samples. The participants who demonstrated these criteria for recovery were included in one experimental group (CWS-Rec, n=21), while those who exhibited persistence in stuttering were included in a second experimental group (CWS-Per n=19).

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2.4 Nonlinguistic Factors: Inclusionary and Matching Criteria

It is well known that nonlinguistic factors such as nonverbal reasoning, age, and socioeconomic status (SES) can affect language skills (Hoff-Ginsberg, 1998). Therefore, the group means for CWNS, CWS-Rec and CWS-Per were matched closely for age at first assessment, nonverbal reasoning abilities, as indexed by the Columbia Mental Maturity Scale (CMMS; Burgemeister, Blum, & Lorge, 1972), and SES, estimate based on the mother's highest level of education (Hollingshead, 1975). The ranges, group means, and standard errors for each of these measures are reported in Table 2. ANOVA results indicated that groups did not differ in age, $F(2, 62) = 2.43$, $p = .10$, SES, $F(2, 62) = 1.31$, $p = .28$, or scores on the Columbia Mental Maturity Scale (CMMS), $F(2, 62) = .38$, $p = .68$. Furthermore, all participants included in this study demonstrated CMMS scores within normal limits, thus eliminating any possible confound of reduced nonverbal reasoning skills.

2.5 Test Battery

A standardized testing battery was administered to each of the participants during their initial study year. The five proficiency measures in the current study include: (1) The *Test of Auditory Comprehension of Language, 3rd edition* (TACL-3; Carrow-Woolfolk, 1999) to assess receptive language, specifically, the comprehension of vocabulary, morphology, and syntax; (2) The *Structured Photographic Expressive Language Test*, 3rd edition (SPELT-3; Dawson, Stout, & Eyer, 2003) to assess expressive language abilities, specifically morphological and syntactic components of a child's expressive language; (3) The *Bankson-Bernthal Test of Phonology, Consonant Inventory subtest* (BBTOP-CI; Bankson & Bernthal, 1990) to assess the participants' phonological and articulation abilities; (4) The Dollaghan and Campbell nonword repetition test (NRT; Dollaghan & Campbell, 1998), which uses unfamiliar nonwords to assess the complex interplay between auditory perception, phonological representation and analysis, phonological working memory, speech motor planning and execution for novel phonemic sequences. In this test, participants are required to repeat nonsense words of increasing length (1–4 syllables), as presented via an audio recording. As reported by Shriberg, and colleagues (2009), phonological and articulation deficits may lead to lower nonword repetition accuracy scores. In the current study, if a child demonstrated a phonological error on the BBTOP-CI, the phoneme was not scored as incorrect on the NRT; thus, NRT score was not dependent on the child's articulation abilities. (5) The Auditory Number and the Auditory Word Memory subtests of the *Test of Auditory Perceptual Skills—Revised* (TAPS-R; Gardner, 1985) were included. The auditory number memory subtest requires the child to repeat number sequences of increasing length spoken by the experimenter. Similarly, the auditory word memory subtest is designed to assess auditory memory and sequencing skills by having the child repeat a real-word sequence of increasing length, as spoken by the experimenter. Performance on the TAPS-R subtests was included in the current study as an index of verbal memory for real words coupled with demands of overt speech.

Importantly, as part of the criteria for participation in the larger longitudinal study, and in order to eliminate possible confounding variables, all CWNS demonstrated receptive language, expressive language, and articulation abilities within normal limits. However, CWS participants were not excluded based on language or articulation skills. Thus, no

CWNS participants exhibited impaired language or articulation skills, but twenty-two CWS with language or articulation skills below normal limits were included. This is a key point to keep in mind when comparing the findings for the CWNS and CWS participants because differences between groups may be attributed to differences in inclusionary criteria differences. Nevertheless, the findings for the CWNS are presented to provide a comparison group of typically developing peers who are matched for age, gender, CMMS scores, and SES.

2.6 Data Analysis

The clinical proficiencies described above were compared for the CWNS, CWS who eventually persisted in stuttering (CWS-Per), and CWS who eventually recovered (CWS-Rec). Group means were analyzed using ANOVAs to detect possible group differences. Furthermore, in order to estimate the degree to which these factors influenced future recovery status of CWS, a binary logistic regression analysis was performed utilizing SPELT-3, TACL-3, BBTOP-CI, TAPS-R, and NRT Overall scores of CWS-Rec and CWS-Per as independent variables (SPSS; IBM Corp, 2011). Since NRT Overall scores was calculated as a total percentage of phonemes correct across 1-, 2-, 3-, and 4-syllable nonwords, scores for these individual syllable lengths were not included in the analysis. Significance values were set at $p < .05$ for all analyses. In addition, based on previous reports (Yairi & Ambrose, 1999) we considered whether recovery or persistence of stuttering was linked to sex. Finally, severity of stuttering of the CWS-Rec and CWS-Per groups were compared to determine any group differences, although previous reports indicate severity is not predictive of recovery or persistence (Yairi & Ambrose, 2005).

3. Results

3.1 Receptive Language

CWNS, CWS-Rec, and CWS-Per displayed similar receptive language abilities as measured by the TACL-3, F (2, 62) =1.39, p=.26 (see Table 3 for TACL-3 scores). In comparing these scores to the CWNS, both CWS-Rec and CWS-Per demonstrated group mean receptive language abilities similar to their normally fluent peers. One participant in the CWS-Per group achieved a standard score of 76, which is 1–2 standard deviations below the normative mean; all other participants demonstrated abilities within the average range.

3.2 Expressive Language

Expressive language abilities as indexed by the SPELT-3 differed among experimental groups, F (2, 62) = 8.53, $p < .01$. Post-hoc Tukey test revealed that SPELT-3 scores were similar for the CWS-Rec and CWS-Per groups, but were significantly different between CWNS and CWS-Rec, as well as CWNS and CWS-Per (see Table 3 for SPELT-3 scores). These observed group differences between CWNS and CWS are likely because only CWNS participants with SPELT-3 scores within the normal range were included in the study, whereas CWS participants with scores within and below the normal range were included. The group mean scores were within normal limits for all experimental groups; however, it should be noted that eight participants (4 CWS-Rec and 4 CWS-Per) had standard scores below the average range.

3.3 Articulation Proficiency

Measures of articulation abilities, as indexed by the BBTOP-CI, also differed among groups, $F(2, 62) = 14.84$, $p < .01$. In contrast to measures of expressive language skills, though, measures of articulation abilities differed between CWS-Rec and CWS-Per, as well as CWNS and CWS-Per, but no differences were found between CWNS and CWS-Rec (See Table 3 for BBTOP-CI scores). Again, because only CWNS participants with BBTOP-CI scores within the normal range were included in the study, whereas CWS participants with scores within and below the normal range were included, the observed group differences between CWNS and CWS-Per may not be representative of the general population. However, given that the inclusion criteria were identical for the CWS who eventually recovered and those whose stuttering persisted, the differences in the BBTOP-CI scores for these two groups do suggest poorer articulation abilities for the CWS whose stuttering would persist.

Notably, of the 19 CWS-Per participants, nine displayed delayed phonological/articulation skills, as represented by a score greater than one SD below the normative mean on the BBTOP-CI, whereas only four of 21 CWS-Rec participants exhibited delayed phonology on this measure. In other words, of the 13 children who demonstrated phonological abilities below the average range at their initial visit, nine (69%) persisted and four (31%) recovered.

3.4 Nonword Repetition Proficiency

In a repeated measures ANOVA including the four nonword syllable lengths, the percent of phonemes correct on the Dollaghan and Campbell (1998) nonword repetition task indicated higher NRT abilities for the CWNS, compared to CWS-Per, $p = .04$, as well as for CWS-Rec compared to the CWS-Per, $p = .01$ (see Table 4 for NRT scores). No differences were observed between CWNS and CWS-Rec, $p = .70$. As expected, accuracy in NRT decreased with increasing numbers of syllables, $F(1, 62) = 24.79$, $p < .01$; however, there was no interaction between group and nonword length, $F(2, 62) < 1$ (Figure 1). In addition, a one-way ANOVA and Tukey post-hoc test was performed on the *overall* NRT score, also revealing higher NRT scores for CWNS compared to CWS-Per, $F(1, 38) = 4.94$, $p = 0.03$ (Figure 1). NRT scores of individual participants are shown in Figure 2. As can be seen in Figure 2, overlap in NRT performance for the CWS-Rec and CWS-Per groups was higher for the 3-syllable condition with only two of the 19 CWS-Per scores falling below the range of scores for the CWS-Rec. In contrast, for the 4-syllable condition, seven of the 19 CWS-Per fell below the range of the CWS-Rec. These findings suggest that the longer, more complex novel nonword utterances were better at distinguishing the children who would eventually recover (CWS-Rec) from those whose stuttering persisted (CWS-Per).

In order to more closely examine nonword repetition proficiency in relation to stuttering without the influence of concomitant language or phonological impairments, analyses were also conducted for only the CWS-Rec and CWS-Per who scored within normal limits on SPELT-3, TACL-3, and BBTOP-CI. The resulting CWS-Rec group included 15 participants, and the CWS-Per group included 9 participants. As shown in Figure 3, mean group scores were similar for 1- and 2-syllable nonwords, but CWS-Per performed less accurately than CWS-Rec on 3-and 4-syllable nonwords. A repeated measures ANOVA was performed on NRT scores of 1-, 2-, 3-, and 4-syllable lengths for only these subjects without comorbid impairments, revealing a statistically significant group difference, $F(1, 38) = 4.47$, $p = .04$. Again, as expected, NRT accuracy decreased as nonword length increased, $F(1, 38) = 14.55$, $p < .01$. A one-way ANOVA was conducted for overall nonword accuracy, $F(2, 62) = 3.27$, $p = .05$, which indicated a significant difference in overall NRT scores between CWS who would eventually recover and those who would persist.

3.5 Auditory Perception and Verbal Working Memory for Known Words

Scores on the TAPS-R Auditory Number Memory subtest, $F(2, 62) = 5.75$, $p < .01$ and the Auditory Word Memory subtest, $F(2, 62) = 6.86$, $p < .01$, differed among groups. According to a Tukey post-hoc analysis, CWNS scored significantly lower than CWS-Rec on the Auditory Number Memory subtest, $p < .01$, but did not differ significantly from CWS-Per, $p = .10$ (see Table 5 for TAPS-R subtest scores). CWS-Per and CWS-Rec did not differ, p = .54.

On the Auditory Word Memory subtest, CWNS scored significantly *higher* than CWS-Rec and CWS-Per, p < .01. However, CWS-Rec and CWS-Per did not differ, $p = .99$. It should be noted that 3 CWS-Rec participants, ages 3;9, 3;10, and 3;11 at the time of testing, were below the minimum age of 4;0 for standardized scoring of the TAPS-R auditory memory subtests. Because they demonstrated abilities within the normal range for 4;0, despite their young age, they were retained for this analysis.

3.6 Sex

Of the 11 female participants included in this study, seven (64%) eventually recovered from stuttering, while only four (36%) persisted. In contrast, the ratio of recovery versus persistence among male participants was nearly equal; of 29 males, 14 (48%) recovered and 15 (52%) persisted. These differences in the patterns of recovery and persistence for males and females however did not reach statistical significance, Chi-Square =0.76, $p = .39$.

3.7 Stuttering Severity

The weighted stuttering severity score for the CWS-Rec was 8.03 (SE=1.81) and 11.87 (SE=1.95) for the CWS-Per. The difference in the scores for the two groups was not significant, $F(1, 38) = 2.08$, $p = .16$.

3.8 Predicting Recovery or Persistence

Binary logistic multiple regression analysis was conducted to identify which language, phonological, and working memory test scores would best predict eventual recovery status of CWS. Results indicated that the BBTOP-CI and NRT Overall scores should be included in the model, $p = .01$ and $p = .05$, respectively (Table 6).

Given that CWS-Per performed less accurately on both the BBTOP-CI and NRT scores, we explored how closely performance on these measures was correlated. Correlational analysis revealed that the CWS-Rec (r=.54, p=.01) and CWS-Per (r=.55, p=.01) participants' scores obtained on the BBTOP-CI were correlated with their overall nonword repetition accuracy. BBTOP-CI scores of CWNS were not correlated with NRT scores. The significant correlations accounted for approximately 29–30% of the variances in overall NRT scores for CWS-Rec and CWS-Per.

Additionally, we evaluated multicollinearity of the predictor variables using variance inflation factors (VIFs). The largest VIF was < 3, indicating that multicollinearity is not impacting the estimated standard error markedly (Kutner, Nachtsheim, & Neter, 2004).

4. Discussion

4.1 Aims & Summary of Findings

The objective of this prospective study was to investigate the potential relationships among preschool CWS's clinical measures of linguistic, phonological, novel nonword speech production, and auditory memory and the eventual course of their stuttering—recovery or persistence. Results indicate that the clinical assessments with the strongest predictive value for eventual stuttering status were the measure of consonant production abilities for familiar words in picture naming (BBTOP-CI scores) and the processes mediating nonword repetition (NRT), which include auditory perception, phonological representation and analysis, phonological working memory, speech motor planning and execution for novel phonemic sequences. In contrast, receptive and expressive language abilities (TACL-3 and SPELT-3, respectively), as well as verbal working memory for real words and numbers (TAPS-R) did not differentiate the CWS who would eventually recover from those who would persist. Binary logistic regression analysis revealed that the significant predictors of eventual stuttering recovery or persistence were BBTOP-CI and NRT Overall scores. The current findings provide a first step in determining how standardized clinical tests, beyond the typical measures of stuttering, may be helpful in predicting a 3;9–5;8 year old child's risk for developing persistent stuttering. These results indicate that preschool articulation abilities should be part of a comprehensive assessment for determining risk of chronic stuttering.

4.2 Articulation Proficiency as a Factor for Predicting Recovery or Persistence

Compared to the CWNS and CWS-Rec groups, articulation proficiency in the CWS whose stuttering eventually persisted was reduced, and the results indicate that speech production abilities in the preschool years may be an indicator of future persistence of stuttering. These findings complement those of Paden et al. (1999), who reported that, when tested near stuttering onset, children whose stuttering would be persistent demonstrated poorer phonological abilities than children who would recover from stuttering. The current results are also consistent with previous evidence that stuttering and poor phonological skills co-occur for a significant proportion of children who stutter (Louko et al., 1990; Paden et al., 1999; Yaruss et al., 1998). Among the participants in the current study who displayed concomitant frank delays in consonant production skills at initial testing, a majority would persist in stuttering. Still, a few CWS-Rec also demonstrated frank deficits in phonological skills, and half of CWS-Per demonstrated age appropriate phonological skills. Therefore, while reduced phonological skills may contribute to greater risk of developing persistent stuttering, this cannot be interpreted as the sole, or even the major etiological factor contributing to early stuttering.

4.3 Proficiency in Perception and Production of Novel Phonological Sequences Help to Predict Stuttering Recovery or Persistence

Compared to the CWNS and CWS-Rec groups, the CWS-Per group exhibited reduced abilities in repetition of novel phonological sequences on the Dollaghan and Campbell (1998) nonword repetition task (NRT). These results extend those of Anderson et al. (2006), who observed significantly lower 2- and 3-syllable nonword repetition scores for CWS (ages 3–5 years) than their normally fluent peers. In the current study, CWS-Rec and CWS-Per NRT proficiency was found to be significantly different, and NRT Overall scores were predictive of recovery status. The observed group differences suggest a possible role for the many processes underlying nonword repetition, including auditory perception, phonological working memory, speech motor planning, and execution, which are required for production of novel phonemic sequences in distinguishing eventual recovery or persistence in stuttering. The current results differ, however, from those reported in a retrospective study by Chon and Ambrose (2007), which indicated no differences in nonword repetition abilities in persistent and recovered CWS. However, Chon and Ambrose studied nonword repetition in *school-age* children who had already recovered or were persisting, whereas the current study examined nonword repetition in children 3;9–5;8 years of age in a prospective study of eventual recovery or persistence. It is possible that as phonological working memory abilities continue to develop during childhood, the initial lags in proficiency for CWS who eventually persist may diminish over time. When taken together, these studies may indicate that the poorer nonword repetition performance of the CWS-Per exhibited in the preschool years is resolved by the time of assessment in later school-age years. To date, the current study is the first to examine nonword repetition abilities of preschool-age CWS in relation to future stuttering outcome.

Articulation abilities (as measured by the BBTOP-CI) and overall NRT score were significantly correlated for CWS-Rec (r = .54) and CWS-Per (r = .55) in the current study. These results are consistent with Anderson et al. (2006), who reported significant correlations between scores on the Goldman-Fristoe Test of Articulation, 2nd edition nonword repetition (CNRep) scores (r =.61) for CWS. The positive correlations in both studies suggest that stronger articulation/speech execution abilities are associated with better NRT performance. However, the variances in significant correlations between NRT performances articulation abilities in the current (29–30%) and Anderson et al. (37%) studies reveal that much of the variances in performances are unaccounted for. It is likely that the unaccounted variances were related to the different demands of the articulation tasks (GFTA and BBTOP-CI) and NRT tasks. While both tasks tap into phonological, speech motor planning and execution proficiency, the articulation task assesses these skills for familiar words in naming pictures, whereas the NRT requires the combined processes of auditory perception, phonological representation and analysis, phonological working memory, speech motor planning and execution for novel phonemic sequences. The results of the current study extend the findings of Anderson et al. (2006) to examining these relationships in the context of how well nonword repetition and articulation proficiencies may predict future stuttering outcome.

Both groups of CWS demonstrated normal verbal working memory abilities for real words, as indexed by the Test of Auditory-Perceptual Skills—Revised (TAPS-R; Gardner, 1985), number and word memory subtests, and verbal working memory was *not* predictive of eventual recovery or persistence. The current findings in preschool children extend those of Carpenter and Sommers (1987), who reported no difference in verbal working memory between adults who do and do not stutter. It is important to note that, although verbal working memory coupled with speech production demands for real words did not differ between CWS-Per and CWS-Rec, the NRT scores, resulting from combined processes of auditory perception, phonological working memory, speech motor planning and execution required for production of novel phonemic sequences *did* differ. Furthermore, the differences in NRT proficiency observed in this study were apparent even when participants with concomitant language and phonological delays were omitted from the analysis. Thus, stuttering recovery or persistence does not appear to be linked to a general working memory deficit, nor does it seem to result from solely a language or phonological delay. Instead, we speculate that the added demands of perceiving, encoding, planning and executing novel phonological sequences hold predictive value for the course of stuttering.

The current findings suggest that aspects of phonological perception, encoding, and execution may distinguish CWS whose stuttering persists from those who recover. These findings are consistent with earlier findings from an electrophysiological study of older, school-age CWS with persistent stuttering in a rhyming task (Weber-Fox et al., 2008). The CWS group displayed reduced rhyming accuracy and reduced amplitudes of an event-related brain potential, called the contingent negative variation (CNV) that is thought to index phonological rehearsal and target word anticipation. Weber-Fox and colleagues (2008) suggested that the neural systems of school-age CWS with persistent stuttering may be less efficient in forming neural representations of phonological information. Around the same time, Chang and colleagues (2008) reported DTI evidence for reduced integrity of white matter tracts, particularly in the left hemisphere in school-age CWS whose stuttering persisted. These white matter tracts are important for connecting the auditory cortex where speech sounds are represented and motor speech planning and execution areas of the frontal cortex (Chang, Erickson, Ambrose, Hasegawa-Johnson, and Ludlow, 2008). More recently, Beal and colleagues (2011) utilized magnetoencephalography (MEG) to study suppression of neural activity in the auditory cortex of school-age CWS (aged 6–12) during a vowel listening and a vowel production task. The observed longer latency of the auditory M50 was interpreted as a reduced ability in the CWS for establishing neural representations of auditory speech signals. A study utilizing functional near-infrared spectroscopy (fNIRS) suggested that processing of phonemic information does not show typical left lateralization in school age and preschool CWS (Sato et al., 2011). Finally, a recent study of regional gray and white matter volumes in CWS aged 6–12, indicated that in addition to reduced gray matter volumes (GMV) in the inferior frontal gyri, CWS also displayed reduced GMV in the left putamen (Beal, Gracco, Brettschneider, Kroll, & DeNil, 2013). These areas have been linked to learning novel nonword productions in typical adults (Rauschecker, Pringle, & Watkins, 2008). Thus, the current findings that the most valuable clinical linguistic tests for helping predict stuttering persistence or recovery fall in the realm of phonological perception, speech planning, and execution, maybe be relying to some extent on these neural systems that may be functioning less efficiently in CWS, and specifically, for those whose stuttering ultimately persists (Beal et al., 2011; Chang et al., 2008; Sato et al, 2011; Weber-Fox, et al., 2008).

4.4 Receptive Language Abilities and Expressive Morphosyntactic Proficiency may have Little Value for Predicting Recovery or Persistence

Performance on the TACL-3 was not predictive of eventual recovery status. As both CWS-Rec and CWS-Per scored similarly to CWNS, the current results support similar findings of Yairi et al. (1996) that language comprehension abilities do not reliably predict future recovery status of CWS who demonstrate language comprehension abilities within normal limits.

Additionally, expressive language scores did not differ between CWS-Per and CWS-Rec. These results support the findings of Watkins et al. (1999), who reported no differences in expressive language skills for CWS-Rec and CWS-Per (ages 2–5 years) when language samples were analyzed for number of different words, number of total words, and mean length of utterance.

However, the current results differ from those of Yairi et al. (1996), which identified significantly lower performance of CWS-Per on the Preschool Language Scale, and indicated that, near stuttering onset, CWS-Per and CWS-Rec exhibit differences in morphology and syntax usage. In evaluating these studies, it is important to note the ages at which participants were tested. The current study included assessments obtained in preschool children, (ages 3;9–5;8); however, we were unable to determine exactly how soon after stuttering onset we first assessed the children. In contrast, Yairi et al. initially assessed participants earlier, as close as possible to reported onset (ages 2–5 years). Thus, assessing expressive language nearer to stuttering onset may provide more valuable information regarding future recovery or persistence.

4.5 Limitations

Although measures were taken to eliminate confounding variables, we did not evaluate length of time since onset of stuttering when matching groups of participants. In addition, while we tracked information about therapeutic interventions, we did not control for subjects' participation in speech therapy in the current study. Due to the heterogeneity of our participants' experience with treatment, as reported in Table 1, we did not have enough power to include this aspect in the analysis. However, we note that 13/21 of the CWS-Rec and 14/19 of the CWS-Per received treatment for stuttering at the time of their initial visit. As such, this aspect of treatment history did not distinguish the children who would go to recover from those whose stuttering persisted. Future research may investigate the contribution that these factors, in combination with preschool phonological and speech motor skills, may make in predicting recovery or persistence.

Because recovery from stuttering occurs at various ages, it is possible that some participants who are classified as CWS-Per in the current study will recover at a later date. In addition, as contact with some participants was lost during later follow up periods, recovery data was not available for all participants through age 8–9 years. Of the 19 CWS-Per in this study, two participants were tracked only through the second year of the study. One of these participants was most recently evaluated at age 5;7 (approximately two years after reported onset of stuttering), while the other participant was most recently evaluated at age 6;11 (at least three years after reported onset of stuttering). It should be noted that, for a child who has been stuttering for two years, the remaining chance of recovery is estimated at 47%, and this chance falls to approximately 16% after three years of stuttering (Yairi & Ambrose, 2005). Given that the recovery status for these two participants was not confirmed beyond the second year of the study, the current data was analyzed with and without these participants. Results did not change, so these two participants were retained for the results reported in this study.

Regarding our analysis of the gender distribution in recovery or persistence, Yairi and Ambrose (1999) similarly reported an apparent difference in recovery rates between male and female participants, but this difference also did not reach statistical significance due to insufficient power. Overall, results of the current study indicate that, while female CWS may have a higher rate of recovery than males, this difference was not significant in predicting recovery or persistence based on gender alone for this group of preschool children.

Further investigation with a larger cohort of preschool CWS and complete longitudinal data on all participants may extend the current findings. This study has provided preliminary results regarding use of standardized clinical tests for the prediction of eventual recovery or persistence of stuttering in young children. Future investigations may include more detailed analyses of participants' linguistic and non-linguistic proficiencies in order to provide a more comprehensive understanding of the relationship between stuttering and language and speech motor proficiencies in early childhood. For example, while the current study focused on standardized test measures of language proficiency, future studies examining language proficiencies, as indexed by measures of spontaneous language samples, coupled with BBTOP-CI and NRT scores, may contribute more complementary information for predicting eventual recovery or persistence in stuttering.

4.6 Conclusions

In total, results of this study suggest a possible role for phonological and speech production abilities, including consonant production in picture naming, and auditory perception, phonological working memory, speech planning and execution for novel phonological sequences (NRT), as indices of eventual stuttering persistence or recovery. It is important to note that while group differences were apparent, some CWS-Per demonstrated high proficiency in nonword repetition, and some CWS-Rec demonstrated low proficiency. These and other individual differences in linguistic and phonological proficiencies among children who stutter were observed, underscoring the importance of considering multiple linguistic and non-linguistic factors when making predictions of eventual recovery or persistence. It is very likely that a multifactorial approach will be necessary for increasing the likelihood of accurately predicting stuttering persistence. In addition to clinical assessments and non-linguistic variables such as family history, age of onset, years of stuttering, and characteristics of stuttering-like-dysfluencies, direct measures in others domains such as speech motor kinematics, language and phonological neural processing and emotion/ temperament clinical and physiological indices may contribute substantially to better models for predicting eventual stuttering recovery or persistence.

Acknowledgments

We are grateful to Anne Smith for her insightful comments on this project and manuscript. We wish to thank Dr. Patricia Zebrowski and her research team at the University of Iowa for help with data collection. Special thanks to Barb Brown for her work in subject recruitment and clinical testing at Purdue. We also appreciate the valuable comments on this project made by Larry Leonard. Sharon Christ provided much appreciated help with the statistical analyses. And finally, we thank Nan Ratner for valuable comments to an earlier version of this manuscript. This study was completed in partial-fulfillment of the first author's MS degree. This work was funded by a grant from the National Institutes on Deafness and other Communication Disorders (DC00559).

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Educational Objectives

The reader will be able to: (1) describe the current status of nonlinguistic and linguistic predictors for recovery and persistence of stuttering; (2) summarize current evidence regarding the potential value of consonant cluster articulation and nonword repetition abilities in helping to predict stuttering outcome in preschool children; (3) discuss the current findings in relation to potential implications for theories of developmental stuttering; (4) discuss the current findings in relation to potential considerations for the evaluation and treatment of developmental stuttering.

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Highlights

1. We studied clinical speech and language measures in preschool children who stutter.
2. Groups were formed based eventual recovery or persistence in stuttering.
3. Articulation scores were higher for the children who would eventually recover.
4. Stronger nonword Repetition abilities were associated with stuttering recovery.
5. Articulation scores accounted for 20% of the variance in eventual recovery status.

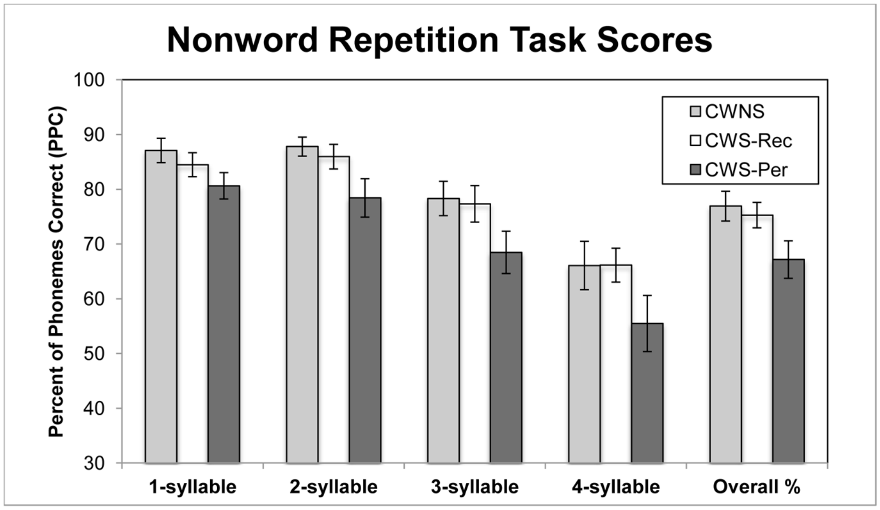

Figure 1. Nonword Repetition Task scores (mean and SEM) for CWS-Rec and CWS-Per Groups

Comparison of nonword repetition accuracy among groups. CWNS=Children who do not stutter; CWS-Rec=Children who stuttered at first assessment, but later recovered; CWS-Per=Children who stuttered at first assessment, and continued to persist.

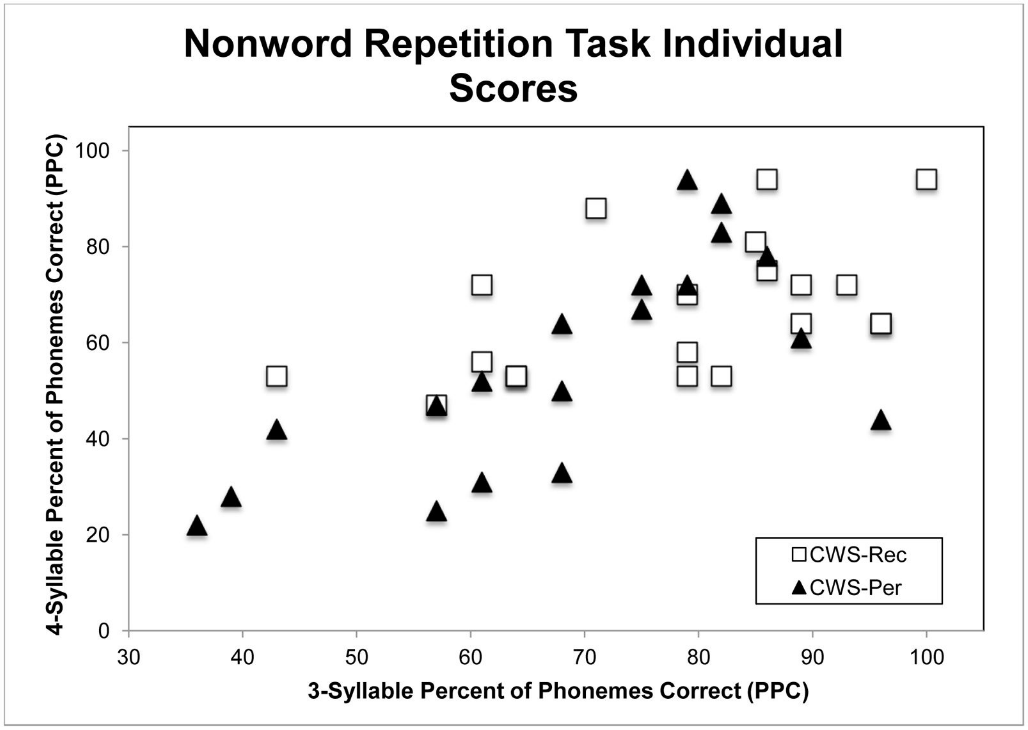

Figure 2. Individual participants' Nonword Repetition Task scores

Nonword repetition accuracy of 3- and 4-syllable nonword lengths was compared between children who stuttered at first assessment, but later recovered (CWS-Rec) and children who stuttered at first assessment, and continued to persist (CWS-Per).

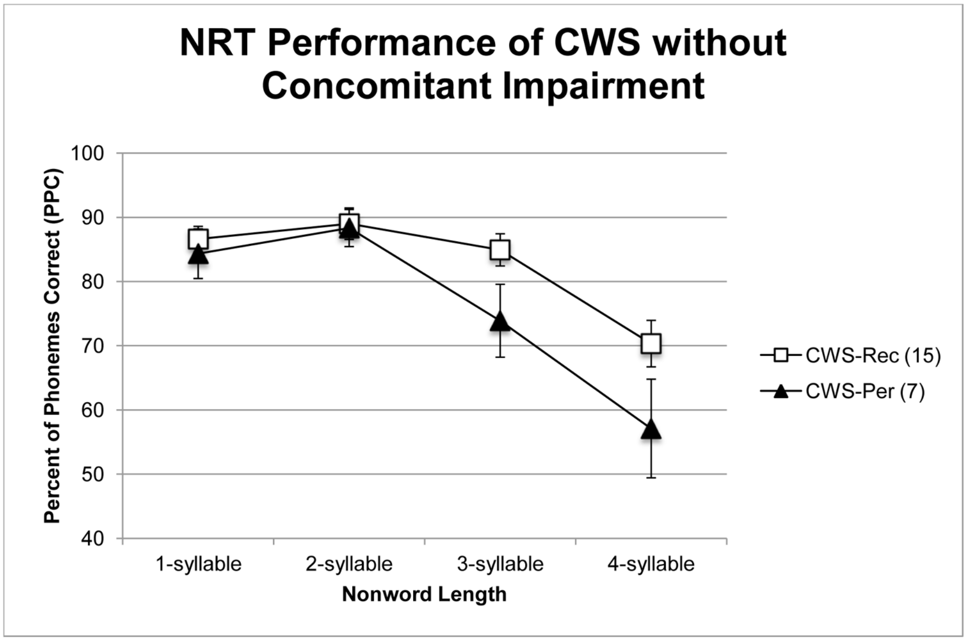

Figure 3. Nonword repetition performance of CWS without concomitant impairment

Nonword repetition accuracy on nonwords of 1–4 syllable lengths were compared between only CWS-Per and CWS-Rec with language and consonant production scores within normal limits. CWS-Rec=Children who stuttered at first assessment, but later recovered; CWS-Per=Children who stuttered at first assessment, and continued to persist.

Table 1

Recovery statuses of CWS.

Subject	Latest Study Visit	Recovery Status	Age at Latest Study Visit	Therapy Received By the Time of First Visit
1	Year 4	Recovered	8;7	S*
2	Year 5	Recovered	8;4	S, A
3	Year 5	Recovered	8;7	S, A, L
4	Year 3	Recovered	6;8	N
5	Year 5	Recovered	9;5	N
6	Year 3	Recovered	6;2	S
7	Year 5	Recovered	8;3	S, A
8	Year 5	Recovered	8;8	N
9	Year 5	Recovered	8;10	N
10	Year 5	Recovered	8;3	N
11	Year 4	Recovered	7;7	S
12	Year 4	Recovered	7;7	N
13	Year 4	Recovered	7;4	S
14	Year 4	Recovered	7;10	S
15	Year 4	Recovered	7;8	S, A
16	Year 3	Recovered	7;0	S
17	Year 3	Recovered	5;8	S, A
18	Year 5	Recovered	8;0	S
19	Year 5	Recovered	8;10	N
20	Year 3	Recovered	6;10	S
21	Year 5	Recovered	7;1	N
22	Year 3	Persisting	6;1	S
23	Year 5	Persisting	9;7	S, A
24	Year 5	Persisting	8;4	S
25	Year 3	Persisting	6;2	N
26	Year 5	Persisting	8;3	N
27	Year 5	Persisting	8;1	S
28	Year 3	Persisting	6;11	S
29	Year 4	Persisting	8;2	S, A, L
30	Year 3	Persisting	6;5	S
31	Year 3	Persisting	7;1	S, A
32	Year 2	Persisting	6;11	S
33	Year 2	Persisting	5;7	S, A, L
34	Year 5	Persisting	9;1	S, A
35	Year 4	Persisting	8;9	S
36	Year 4	Persisting	8;9	A
37	Year 3	Persisting	6;9	A
38	Year 3	Persisting	6;10	N
39	Year 4	Persisting	8;2	S, A

Subject	Latest Study Visit	Recovery Status	Age at Latest Study Visit	Therapy Received By the Time of First Visit
40	Year 3	Persisting	6;7	S, A

*S=Stuttering; A=Articulation; L=Language; N=None

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Table 2

Age, SES, and nonverbal reasoning abilities (CMMS) of participants at first assessment.

		Age (in months)			*SES*			*CMMS*		
Group	***n* (male)**	**Range**	**M**	***(SD)***	**Range**	**M**	***(SD)***	**Range**	**M**	***(SD)***
CWNS	25 (18)	48–65	56.32	*(5.44)*	3–7	5.88	*(1.24)*	91–121	110.44	*(9.14)*
CWS-Rec	21 (14)	45–66	53.33	*(5.36)*	4–7	6.00	*(0.95)*	90–132	109.24	*(9.97)*
CWS-Per	19 (15)	48–68	57.11	*(6.71)*	4–7	5.47	*(0.96)*	90–122	107.95	*(9.01)*

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Table 3

TACL-3, SPELT-3, & BBTOP-CI scores by group.

		TACL-3			*SPELT-3*			*BBTOP-CI*		
Group	***n***	**Range**	**M**	***(SD)***	**Range**	**M**	***(SD)***	**Range**	**M**	***(SD)***
CWNS	25	91–143	115.68	*(15.38)*	86–130	109.44	*(11.23)*	92–117	103.48	*(8.67)*
CWS-Rec	21	96–139	114.10	*(11.67)*	68–122	99.29	*(14.96)*	74–115	97.24	*(12.44)*
CWS-Per	19	76–136	108.68	*(14.89)*	40–114	91.58	*(17.19)*	65–110	84.21	*(14.15)*

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Table 4

Nonword Repetition (NRT) scores by syllable length and group.

		CWNS *n=25*	CWS-Rec *n=21*	CWS-Per *n=19*
	Range	75–100	58–100	58–92
NRT-1	**M**	87.08	84.48	80.63
	(SD)	*(11.14)*	*(10.07)*	*(10.53)*
	Range	70–100	65–100	50–100
NRT-2	**M**	87.80	85.95	78.42
	(SD)	*(8.67)*	*(10.32)*	*(15.28)*
	Range	54–100	43–100	36–96
NRT-3	**M**	78.32	77.33	68.47
	(SD)	*(15.69)*	*(15.28)*	*(16.84)*
	Range	0–97	47–94	22–94
NRT-4	**M**	66.08	66.14	55.47
	(SD)	*(22.09)*	*(14.20)*	*(22.35)*
	Range	43–91	56–96	40–86
NRT-Overall %	**M**	76.92	75.29	67.16
	(SD)	*(13.55)*	*(10.62)*	*(14.89)*

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Table 5

Auditory memory proficiency by group.

		TAPS-AudNum			***TAPS-AudWord***		
Group	***n***	**Range**	**M**	***(SD)***	**Range**	**M**	***(SD)***
CWNS	25	75–111	90.88	*(7.69)*	83–145	102.00	*(18.45)*
CWS-Rec	21	77–145	102.95	*(15.50)*	78–106	90.00	*(6.12)*
CWS-Per	19	78–121	98.79	*(13.24)*	75–111	89.63	*(8.85)*

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Table 6

Binary logistic regression analysis results.

Variable	Significance
TACL-3	.20
SPELT-3	.13
BBTOP-CI	.01*
NRT Overall %	.05*
AudNum	.87
AudWord	.36