# Nonword repetition skills in young children who do and do not stutter

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## Abstract

The purpose of this study was to assess the nonword repetition skills of 24 children who do (CWS; $n = 12$) and do not stutter (CWNS; $n = 12$) between the ages of 3;0 and 5;2. Findings revealed that CWS produced significantly fewer correct two- and three-syllable nonword repetitions and made significantly more phoneme errors on three-syllable nonwords relative to CWNS. In addition, there was a significant relationship between performance on a test of expressive phonology and nonword repetition for CWS, but not CWNS. Findings further revealed no significant fluctuation in fluency as nonwords increased in length. Taken together, findings lend support to previous work, suggesting that nonword repetition skills differ for CWS compared with CWNS, and that these findings cannot be attributed to (a) weak language performance on the part of CWS, or (b) the occurrence of stuttering in the course of nonword production.

*Educational objectives:* After reading this article, the learner will be able to: (a) describe one common means of assessing phonological working memory in children; (b) summarize the performance differences of children who stutter compared to peers on a nonword repetition task; (c) compare the results of the present study with previous work in this area.

### Keywords

Stuttering; Phonological; Nonword repetition; Children

## 1. Nonword repetition in young children who do and do not stutter

As a group, children who stutter (CWS) tend to differ from their peers in a range of areas, including language (e.g., see Hall, 2004; Weiss, 2004, for recent reviews). Perhaps because differences in the language performance of CWS tend to be subclinical (i.e., not constituting a language disorder), the literature has not focused on the many language-related areas that have been associated with language performance in other populations. In particular, one language-related area that has received considerable attention is the role of phonological working memory in the language performance of children with specific language impairment (SLI; e.g., Baddeley & Wilson, 1993; Botting & Conti-Ramsden, 2001; Conti-Ramsden, 2003; Ellis Weismer et al., 2000; Gathercole & Baddeley, 1990; Gray, 2003; Marton & Schwartz, 2003; Montgomery, 1995a; Munson, Kurtz, & Windsor, 2005). As a group, these

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studies generally reveal that nonword repetition represents an area of weakness for children with SLI.

For example, Montgomery (1995b) examined working memory and sentence comprehension in school-age children with SLI and language-matched peers with typically developing language using nonword repetition and sentence comprehension tasks. On the nonword repetition task, the typically developing children performed significantly better than the SLI children on three- and four-syllable nonwords. On the sentence comprehension task, the two groups differed only in comprehension of redundant sentences, with the SLI group performing more poorly on these. Findings further revealed a significant, positive relationship between children's nonword repetition and sentence comprehension scores. These findings were interpreted as evidence that limited phonological working memory capacity in children with SLI contributed to their poor auditory comprehension of sentences.

More recently, Sahlen, Reuterskiold-Wagner, Nettelbladt, and Radeborg (1999) studied nonword repetition in 27 young children with language impairments, focusing on the relationship between nonword repetition and grammatical skills, and nonword repetition and phonological skills. They found significant relationships between nonword repetition performance and children's phonological stage and expressive grammar. However, when a subgroup of participants with the same phonological level was divided into two groups according to grammatical skills, the two groups did not differ in nonword repetition performance. This suggests that phonological skills, more so than expressive syntax, are related to nonword repetition performance. Munson et al. (2005) examined nonword repetition with items varying in phonotactic probability. Children with SLI were less accurate in nonword repetition than age-matched peers, with phonotactic probability impacting the SLI group's performance more than it impacted the performance of peers. These and other recent studies have focused not only on phonological working memory skills in children with language difficulties, but also on what nonword repetition, as a construct, measures in these children.

Baddeley's model (Baddeley, 1986; Gathercole & Baddeley, 1993) is widely cited as the basis for research in phonological working memory (cf. Cowan, 1996; Just & Carpenter, 1992). The model accounts for ways in which information is held in memory until it is needed for recall. The phonological loop, one of three components of the model, processes phonological information. It consists of a storage component and a rehearsal mechanism. Phonological information can be held in storage for only a short period of time (seconds) unless the information is rehearsed. By rehearsing, the information can be "refreshed" within the storage component, enabling it to remain within memory for a longer period of time (see Baddeley, 2003, for a more detailed summary of the model).

### 1.1. Nonword repetition as a measure of phonological working memory

Nonword repetition tasks have been widely used to estimate phonological working memory skills in children (e.g., Dollaghan, Biber, & Campbell, 1993,1995;Dollaghan & Campbell, 1998;Gathercole & Baddeley, 1996) and adults (Gupta, 2003). These tasks essentially rely on retrieval and output as the response that provides information about storage and rehearsal capabilities. That is, a participant who is able to retrieve a nonword stimulus and produce it accurately is presumed to have relied upon adequate rehearsal and storage abilities to reach that point. However, there has been considerable discussion about whether nonword repetition tasks are appropriate measures of phonological working memory (e.g., Howard & van der Lely, 1995;Van der Lely & Howard, 1993), especially given the range of other skills required to repeat nonwords accurately.

Within the SLI literature, for example, Edwards and Lahey (1998) examined several components of nonword repetition that may impact performance, including the roles of

auditory discrimination, motor planning (response time latency) and execution (duration of responses), and prior vocabulary knowledge in children with SLI and their peers with typical language skills. They found that children in the SLI group were less accurate in nonword repetition, and that these limitations could not be attributed to auditory discrimination, motor planning, or lexical skills. Furthermore, overall expressive language scores, but not receptive scores, were found to partially account for the nonword repetition performance of children in the SLI group. The authors interpreted these findings to suggest that difficulties in nonword repetition among children with SLI were due, in part, to their poorer phonological representations of the nonwords.

There is substantial documentation establishing a relationship between vocabulary knowledge and nonword repetition skills, although the directionality of this relationship is not clear (e.g., Gathercole & Baddeley, 1990; Gathercole, Willis, Emslie, & Baddeley, 1991; Gathercole, Service, Hitch, Adams, & Martin, 1999). Some investigators have suggested that phonological working memory (as measured by nonword repetition) drives vocabulary development (Gathercole & Baddeley, 1990; Gathercole et al., 1991; Gathercole et al., 1999), whereas others have argued that increasing vocabulary knowledge enables a child to perform better on nonword repetition tasks (e.g., Dollaghan et al., 1995; Snowling, Chiat, & Hulme, 1991). Findings from a study by Dollaghan et al. provide support for this latter position. They administered a three- and four-syllable nonword repetition task to 30 boys, ages 9;10-12;5 years, with typically developing language. They found that nonwords whose stressed syllable was a real word (e.g., "bathesis", where "bath" is the stressed syllable) were repeated with greater accuracy than nonwords whose stressed syllable was not a real word (e.g., "fathesis"). In addition, an error analysis revealed that children were significantly more likely to convert part of a nonword into a real word than they were to convert a "real word" segment into a nonword. As the authors point out, these results highlight one way in which lexical knowledge can aid a child in repetition of nonwords.

Another explanation for the observed relationship between vocabulary and nonword repetition for which there is some empirical support is that phonological processing serves as an intervening variable (Bowey, 1996; Bowey, 2001; Metsala, 1999). For example, Metsala proposed that as children develop phonemic segmentation abilities, this skill aids both word learning and the ability to repeat nonwords. In sum, the nature of the association between nonword repetition and language skills is not yet fully understood, but it is clear that nonword repetition is not a pure measure of phonological working memory.

In the case of CWS, given that stuttering has an impact on speech output, one might also expect that output processes (e.g., articulatory speaking rate, response time, etc.), in addition to working memory abilities, might impact performance in a nonword repetition task. Moreover, although a child's level of (dis)fluency might give some indication of the child's output processes, it alone is not sufficient to infer the extent to which speech output impacts nonword repetition performance. Another consideration, particularly for CWS, in interpreting performance on a nonword repetition task is the observed association between nonword repetition and expressive phonological skills (e.g., Bowey, 2001; Sahlen et al., 1999). This link is particularly germane for CWS, because phonological difficulties are a common concomitant disorder within this group of children (e.g., Arndt & Healey, 2001). Therefore, from a methodological standpoint, it would seem important to take consistent phonological errors into consideration when scoring nonword repetition attempts, so that CWS are not penalized for errors they produce consistently in speech production.

At present, nonword repetition represents the standard for measuring phonological working memory in individuals with typical and atypical speech-language production. Thus, a nonword repetition task would appear to be an appropriate assessment tool for initial exploration of the

phonological working memory abilities of CWS. However, as revealed in studies of children with SLI, it is equally clear that, in addition to phonological working memory, nonword repetition relies upon a range of skills, including those related to speech output.

## 1.2. Memory processes in individuals who stutter

Within the area of fluency disorders, several models, such as the covert repair hypothesis (Postma & Kolk, 1993) and the EXPLAN theory (e.g., Howell, Au-Yeung, & Sackin, 1999), include phonology and phonological processing as components in their explanation of stuttering. Moreover, as previously indicated, phonological disorders frequently co-occur with stuttering in young children (Arndt & Healey, 2001). Therefore, given that current models of stuttering and clinical observations of CWS emphasize the role of aspects of phonology in understanding the population and the disorder, it seems appropriate and timely to devote attention to the phonological working memory capabilities of those who stutter.

To date, however, only a few studies have examined broad aspects of memory in individuals who stutter. In one such study, adults who stutter (AWS) and their fluent controls were asked to reproduce, in writing, sets of four CVC syllables following their presentation and an intervening task (Bosshardt, 1993). Findings revealed that AWS reproduced significantly fewer syllables in the correct position than their fluent counterparts. Taken together, findings were interpreted to suggest that phonological encoding is weaker and phonological rehearsal time is slower in AWS.

In an earlier study, Bosshardt (1990) examined both children (mean age = 13.8 years) and AWS, along with their normally fluent counterparts in their rates of subvocalization and reading, as these measures have been shown to correspond with phonological working memory skills (Baddeley, Thomson, & Buchanan, 1975). Participants read one set of phrases (definite article + noun) aloud and another set of phrases silently, using a key press to indicate when they had finished reading each phrase. The time interval from each stimulus presentation to the participant's response was then recorded for both conditions. Results revealed that both children and AWS exhibited longer response times than their normally fluent counterparts in the two reading conditions. Moreover, for the silent reading condition, this difference was greater between the groups of children than between the groups of adults. Although this study did not attempt to examine phonological memory processes per se, the authors pointed out that their findings suggest that individuals who stutter (including children) subvocalize more slowly, a quality that may impact their ability to rehearse information (within the context of the phonological loop; see Baddeley, 1986) as efficiently as their peers.

More recently, Hakim and Ratner (2004) examined phonological working memory skills in CWS ages 4-8 years. They evaluated participants' performance on the Children's Test of Nonword Repetition (CNRep; Gathercole, Willis, Baddeley, & Emslie, 1994), a test widely used in studies of phonological working memory in children with typically developing language (e.g., Gathercole, Hitch, Service, & Martin, 1997) and language impairments (e.g., Bishop, North, & Donlan, 1996). On the CNRep, children are presented with nonwords of 2-5 syllables in length via tape recording and then asked to repeat each nonword. Items are scored as correct or incorrect. They found that, at the three-syllable length, CWS repeated significantly fewer items correctly and exhibited more phoneme errors (both findings represented large effect sizes) than normally fluent children. However, the fluency of nonword productions did not change as a function of increased word length—that is, CWS were just as fluent on longer nonwords as on shorter ones.

As Hakim and Ratner (2004) acknowledged, their nonword repetition findings were likely impacted by two factors. First, as their tabled data suggest, ceiling and floor effects were likely operating for the shorter and longer syllable lists, respectively. Second, with small sample sizes

of eight children per group, it is unlikely that anything but a large statistical effect could be detected, due to insufficient power (see Jones, Gebski, Onslow, & Packman, 2001, for discussion of this issue). It should be noted that some reports of differences in nonword repetition in children with and without language impairments have employed larger samples, resulting in greater statistical power (e.g., Edwards & Lahey, 1998). However, when clinical populations are involved, one relevant question is whether small effect sizes (i.e., those that can be detected with larger samples) are clinically significant (see Jones et al., 2001). Thus, it seems reasonable to argue, particularly in preliminary work on the nature of any differences between groups in aspects of phonological memory, that the between-groups differences of interest are those that constitute relatively large effects.

Of studies that have sought to examine memory skills in individuals who stutter, Hakim and Ratner's (2004) work is particularly interesting because it links conceptually the fairly extensive literature on phonological working memory in typically developing and language disordered populations to questions of the phonological memory capabilities of CWS. The present study is intended as a follow-up study to and partial replication of their work. We chose to address the issue of the ceiling effects observed by Hakim and Ratner by recruiting a sample of younger CWS within a more restricted age range (3-5 years of age). Younger CWS provide the opportunity for examination of phonological working memory during a time of substantial language and motoric development, relative to school-age CWS. As such, the overall purpose of the present study was to characterize the phonological working memory skills of young CWS relative to their normally fluent peers. In particular, our research questions were:

1. Do young CWS differ from their normally fluent peers in the number of correct responses produced on a nonword repetition task? Similarly, do young CWS differ from their normally fluent peers in the number of phoneme errors produced on this task?

2. Is there a relationship between speech-language performance and nonword repetition performance for CWS and their normally fluent peers?

3. For CWS, is there a difference in the fluency of nonword repetition responses as nonword length (in syllables) increases?

## 2. Method

### 2.1. Participants

Two groups of 12 children (*n* = 24) between the ages of 3;0 and 5;2 (years;months) who do (CWS) and do not stutter (CWNS) participated in this study (see Table 1). All participants were native speakers of American English with no history of neurological, speech-language (other than stuttering), hearing, or intellectual problems per parent report and examiner observation. All participants were raised in a monolingual environment, except for 1 CWS and 1 CWNS. None of the CWS had received treatment for stuttering prior to participating in this study. Children were identified for participation by their parents, who were made aware of this study through advertisements in several local newspapers in the south-central Indiana area (Bloomington and surrounding areas).

**2.1.1. Matching of groups—**Participants in the two groups (CWS and CWNS) were matched by age (±4 months), gender (9 boys, 3 girls), and parental socioeconomic status. The mean age for children in the CWS group was 47.9 months (S.D. = 7.6) and the mean age for CWNS was 48.3 months (S.D. = 6.6). An independent samples *t*-test revealed no significant difference between the two groups in age, *t*(22) = -0.14, *p* = 0.89. Each child's parental socioeconomic status was determined using the Hollingshead index of social position (Myers & Bean, 1968), which is calculated based on the father's occupation and educational level (all

of the participants in this study resided in two-parent households). There was no significant difference between CWS ($M$ = 33.4, S.D. = 15.7, Hollingshead classification III) and CWNS ($M$ = 31.31, S.D. = 12.8, Hollingshead classification III) in social position, $t(22)$ = 0.39, $p$ = 0.69.

**2.1.2. Group classification criteria**—A child was classified into one of two groups (CWS or CWNS) based on his/her performance on a speech disfluency measure collected during a parent-child conversational interaction. The child and his/her parent(s) verbally interacted with one another for 20-30 min while playing with some toys. A 300-word speech sample was obtained for each child and analyzed for mean frequency of stuttering-like disfluencies (part-word repetitions, single-syllable word repetitions, sound prolongations, blocks, and tense pauses; see Pellowski & Conture, 2002; Yairi & Ambrose, 1992 for use of this method of disfluency analysis). The speech samples of children classified in the CWS group were also analyzed for stuttering severity, as measured by the Stuttering Severity Instrument-3 (SSI-3; Riley, 1994). Scores for each participant on these measures are depicted in Table 1.

**2.1.2.1. Children who stutter:** Children in the CWS group exhibited three or more stuttering-like disfluencies per 100 words of conversational speech ($M$ = 6.2, S.D. = 2.2) and received a total overall score of 12 or higher on the SSI-3 ($M$ = 19.4, S.D. = 5.2; 5 CWS were classified as "mild", 5 "moderate", and 2 "severe"). Additionally, the parents of these children had all expressed concern about their child's speech fluency, reporting an average time since initial onset of stuttering (TSO) of 14.3 months (S.D. = 10.2 months; range = 2-33 months). TSO was determined using a "bracketing" procedure (see Anderson, Pellowski, Conture, & Kelly, 2003; Yairi & Ambrose, 1992, for details).

**2.1.2.2. Children who do not stutter:** Children in the CWNS group exhibited fewer than three stuttering-like disfluencies per 100 words of conversational speech ($M$ = 1.1, S.D. = 0.9). None of the parents of these children expressed concern about their child's speech fluency.

The adequacy of the group classification criteria was assessed by comparing the performance of the two groups of children on the speech disfluency measure. Data for this measure were analyzed using nonparametric statistics (the Mann-Whitney test), as data were not normally distributed. As a group, CWS exhibited significantly more stuttering-like disfluencies, $z$ = -4.16, $p$ < 0.001, than CWNS, suggesting that the two groups of children were clearly differentiated on the basis of stuttering behavior.

## 2.2. Procedures

Each participant was assessed on two separate occasions in the Speech Disfluency Laboratory at Indiana University, with each session lasting approximately 45-90 min. During the first session, the participant engaged in the parent-child interaction, responded to standardized speech and language tests, and completed a hearing screening. During the second session, the child responded to a nonword repetition task and completed several other tasks unrelated to the present investigation. All testing took place in a quiet room, where ambient noise could be minimized. The parent-child interaction and nonword repetition task were videotaped using two color video cameras (EV1-D30), Unipoint AT853 Rx Miniature Condenser Microphone, and Panasonic DVD/HD video recorder (Model N. DMR-HS2).

**2.2.1. Standardized speech-language tests**—Following the parent-child conversational interaction (see above), children were administered four standardized speech and language tests to ensure that their speech and language skills were developing normally, as well as to use in subsequent correlational analyses. The tests included in this battery were the: (a) Peabody Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997), a measure of

spoken word comprehension (i.e., receptive vocabulary); (b) Expressive Vocabulary Test (EVT; Williams, 1997), a measure of expressive vocabulary; (c) Test of Early Language Development-3 (TELD-3; Hresko, Reid, & Hammill, 1999), a measure of receptive and expressive language skills; (d) "Sounds-in-Words" subtest of the Goldman-Fristoe Test of Articulation-2 (GFTA-2; Goldman & Fristoe, 2000), a measure of speech sound articulation. No child scored greater than one standard deviation below the normative mean on the standardized tests (i.e., each child received a standard score of 85 or higher).[1] Although CWS generally scored lower than CWNS on the four speech-language tests (see Table 1), none of these differences was statistically significant, PPVT-III: $t(22) = -0.38$, $p = 0.71$; EVT: $t(21) = -0.69$, $p = 0.50$; TELD-3 spoken language: $t(21) = -0.44$, $p = 0.66$; GFTA-2: $t(22) = -0.50$, $p = 0.62$.

**2.2.2. Hearing screening**—Each child's hearing was screened using bilateral pure tone testing (20 dB SPL for 500, 1000, 2000, and 4000 Hz) and impedance audiometry (+400 to -400 da Pa; American Speech-Language-Hearing Association, 1990). All children passed the hearing screening.

**2.2.3. Nonword repetition**—Phonological working memory skills were measured using the children's test of nonword repetition (CNRep; Gathercole et al., 1994). The CNRep consists of 40 nonwords, with 10 items each containing 2-5 syllables. The 40 nonwords were recorded on a portable cassette recorder by a female speaker and separated by a 4 second interval. All participants were presented with a common random sequence of the 40 stimulus items (see Appendix A).

<u>2.2.3.1. CNRep administration:</u> The CNRep was administered to each child according to the standardization procedures described by Gathercole et al. (1994). Specifically, the child was told that, when the cassette recorder is turned on, he/she will hear a "funny, made-up word" and should try to repeat it. Prior to beginning the CNRep, children were given an opportunity to "practice" the task using examples of real words (e.g., "elephant") and nonwords (e.g., "woogie"). Once the child appeared to understand the task, the examiner turned on the cassette recorder and recorded the child's response to each item. If the child did not make an attempt to copy the nonword, the cassette recorder was paused and the child was given more time to produce the response. None of the items was presented more than once to each child.

<u>2.2.3.2. CNRep scoring:</u> Each repetition attempt produced by CWS and CWNS was scored in two ways using the procedures employed by Hakim and Ratner (2004). This scoring procedure was used because it would allow a direct comparison between findings of the present investigation and those of Hakim and Ratner. First, responses were scored as either phonologically correct or incorrect. Any response that was a dialectical variant of Standard American English or had a phoneme that was consistently misarticulated as another was scored as correct, a procedure consistent with Edwards and Lahey (1998) (cf. Adams & Gathercole, 1995; Gathercole et al., 1999). All phonemes within a nonword (except for any consistent misarticulations) had to be produced correctly for the response to be scored as correct (i.e., one or more phoneme errors resulted in an incorrect response). To compute the total CNRep score, the number of nonwords correctly repeated was calculated for each participant at each syllable length and across all stimulus items. Second, each incorrect response was transcribed by a trained graduate student using broad phonetic transcription and the number of phonemes produced incorrectly within each response was summed. The total number of incorrect phonemes was then calculated for each participant at each nonword length and across all stimulus items. In addition to these two scoring procedures, the responses of CWS were judged

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[1]EVT and TELD-3 scores were not available for one child (a CWS), as this child refused to cooperate with testing.

as either fluent or disfluent. A response was considered disfluent if it contained one or more stuttering-like or "other" (polysyllabic word repetitions, phrase repetitions, interjections, and revisions) disfluencies. The number of fluently produced responses was then calculated for each nonword length and across all stimulus items.

### 2.2.4. Measurement reliability

**2.2.4.1. Speech disfluency measures:** Interjudge measurement reliability was calculated for judgments of stuttering-like disfluencies based on six randomly selected conversational speech samples (three CWS, three CWNS), representing 25% of the study participants. The first author and a trained student independently observed the same five videotape recordings and identified all stuttering-like disfluencies. Mean interjudge measurement reliability percentage was 96.2% (range = 95.9-99.6%) based on the following measurement reliability index: $(A + B/[A + B] + [C + D]) \times 100$, where $A$ = number of words judged stuttered on both occasions, $B$ = number of words judged nonstuttered on both occasions, $C$ = number of words judged stuttered on one occasion, and $D$ = number of words judged nonstuttered on one occasion (cf. Anderson, Pellowski, & Conture, 2005).

**2.2.4.2. CNRep scoring accuracy:** Interjudge reliability was also assessed for the accuracy of the CNRep scoring based on the performance of six randomly selected participants (three CWS, three CWNS), which represents 25% of the study participants. Two trained judges independently observed each child's response to the nonword stimuli and then judged the response as either correct or incorrect. Interjudge reliability was calculated for the total number of correct responses using an "agreement reliability" formula (i.e. (number of agreements/number of agreements + disagreements) $\times$ 100; Sander, 1961). Mean interjudge agreement reliability for CNRep scoring was 88.3% (range = 78.3-96.7%).

## 3. Results

The purpose of this study was to examine the (a) differences between CWS and CWNS in the number of correct responses and phoneme errors produced on the CNRep, (b) relationship between speech-language measures and CNRep performance for CWS and CWNS, and (c) fluency of the responses produced by CWS on the CNRep. The results are organized according to these three aims.

### 3.1. Group differences in the number of correct responses on the CNRep

Between-group differences in the number of nonwords correctly repeated across each nonword length (2-5-syllables) were analyzed using multivariate and univariate analyses of covariance (MANCOVA and ANCOVA, respectively), with chronological age serving as a covariate (Fig. 1). Preliminary testing of the assumptions of the MANCOVA and ANCOVA, including homogeneity of variance and regression slopes, was found to be satisfactory. The effect size indicator partial eta$^2$ (partial $\eta^2$) is reported for each statistical comparison as a measure of the strength of the association, with a partial $\eta^2$ of 0.14 representing a "large" effect, 0.06 a "medium" effect, and 0.01 a "small" effect (Cohen, 1988). Bonferroni adjustments applied to alpha maintained the familywise potential for a type I error at 0.05.

The omnibus MANCOVA test revealed no significant multivariate main effect, Wilks' $\lambda$ = 0.71, $F(4, 18) = 1.87$, $p = 0.16$, partial $\eta^2 = 0.29$. Subsequent ANCOVA tests revealed significant between-group effects for the number of nonwords correctly repeated at the two-syllable, $F(1, 21) = 5.09$, $p < 0.05$, partial $\eta^2 = 0.20$, and three-syllable, $F(1, 21) = 4.72$, $p < 0.05$, partial $\eta^2 = 0.18$, length. As shown in Fig. 1, CWS were less successful in repeating two-syllable (adjusted $M = 5.5$, $n = 12$) and three-syllable (adjusted $M = 4.0$, $n = 12$) nonwords than CWNS (adjusted $M = 7.2$ and 6.0, respectively, $n = 12$). No significant between-group effects

were found for the repetition of four-syllable, $F(1, 21) = 3.05$, $p = 0.09$, partial $\eta^2 = 0.13$, and five-syllable, $F(1, 21) = 0.05$, $p = 0.82$, partial $\eta^2 = 0.002$, nonwords.

The between-group difference in the total number of nonwords correctly repeated was analyzed using a univariate analysis of variance (ANOVA; Fig. 2). Chronological age was not included as a covariate in this analysis, as the assumption of homogeneity of regression slopes was not tenable. Findings from the ANOVA revealed no significant between-subject effect for the total number of nonwords correctly repeated, $F(1, 22) = 2.44$, $p = 0.13$, partial $\eta^2 = 0.10$. Thus, even though CWS ($M = 14.2$, S.D. $= 7.70$) produced fewer total number of correct responses than CWNS ($M = 19.1$, S.D. $= 7.72$), this difference was not statistically significant.

### 3.2. Group differences in the number of phoneme errors on the CNRep

Between-group differences in the number of phoneme errors produced across each nonword length (2-5-syllables) were analyzed using MANCOVA and ANCOVA tests, with chronological age as a covariate (Fig. 3). One CWS and one CWNS were excluded from these analyses, because their nonword responses could not be transcribed as a result of faulty videotape recording. All assumptions were examined and met for each MANCOVA and ANCOVA, and effect sizes are represented as partial eta$^2$ (partial $\eta^2$).

The omnibus MANCOVA test indicated no significant multivariate main effect, Wilks' lambda $= 0.74$, $F(4, 16) = 1.37$, $p = 0.29$, partial $\eta^2 = 0.26$. The ANCOVA test indicated a significant between-group effect for the number of phoneme errors produced at the three-syllable length, $F(1, 19) = 5.04$, $p < 0.05$, partial $\eta^2 = 0.21$. As can be seen in Fig. 3, CWS (adjusted $M = 20.3$, $n = 11$) as a group produced almost twice as many phoneme errors in their three-syllable nonword repetition attempts than CWNS (adjusted $M = 10.8$, $n = 11$). Additional ANCOVA tests, however, revealed no significant between-group effects for the number of phoneme errors produced at two-syllable, $F(1, 19) = 2.87$, $p = 0.11$, partial $\eta^2 = 0.13$, four-syllable, $F(1, 19) = 3.69$, $p = 0.07$, partial $\eta^2 = 0.16$, and five-syllable, $F(1, 19) = 0.95$, $p = 0.34$, partial $\eta^2 = 0.05$, lengths.

Between-group differences in the total number of phoneme errors across all stimulus items were analyzed utilizing an ANCOVA, with chronological age as a covariate (Fig. 4). Findings from the ANCOVA revealed no significant between-group effect for the total number of phoneme errors produced on the CNRep, $F(1, 19) = 2.67$, $p = 0.12$, partial $\eta^2 = 0.12$. However, as revealed in Fig. 4, overall CWS (adjusted $M = 108.0$, $n = 11$) tended to produce more phoneme errors on the CNRep than their normally fluent peers (adjusted $M = 72.2$, $n = 11$).

### 3.3. Correlational analyses of speech-language measures and CNRep performance

Partial correlations were calculated for the speech-language measures (PPVT-III, EVT, TELD-3, and GFTA-2) and the number of correct responses at each nonword length and across all stimulus items for both CWS and CWNS, with the effects of age partialled out. These results are reported in Table 2 for CWS and Table 3 for CWNS. For CWS, GFTA-2 scores were significantly correlated with the repetition of three-syllable ($r = 0.76$, $p = 0.007$) and five-syllable ($r = 0.63$, $p = 0.04$) nonwords, as well as with total nonword repetition scores ($r = 0.61$, $p = 0.05$). No significant correlations were found between CNRep performance and the PPVT-III, EVT, and TELD-3 ($p$-values ranged from 0.14 to 0.79). For CWNS, there were no significant correlations between the speech-language measures and CNRep performance, although the correlation between GFTA-2 scores and the repetition of four-syllable nonwords approached significance ($r = 0.53$, $p = 0.09$; all other $p$-values ranged from 0.17 to 0.89).

### 3.4. Fluency of the responses of CWS on the CNRep

A nonparametric analysis of variance for repeated measures (Friedman's test) was used to determine whether there were any statistically significant differences in the fluency of production across the four nonword lengths for CWS (Fig. 5). This nonparametric test was applied, because the data did not support the normal distribution assumption required for parametric tests. One participant was excluded from this analysis due to a faulty videotaped recording. The results of Friedman's test revealed no significant variation in the number of fluently-produced nonwords across nonword lengths, $\chi^2(3, N = 11) = 5.8$, $p = 0.12$. On an individual participant basis, 9 of the 11 CWS (82%) exhibited relatively consistent fluency across all four nonword lengths, 1 CWS (9%) exhibited a slight decrement in fluency as length increased, and 1 CWS (9%) exhibited a significant decrease in fluency as length increased.

## 4. Discussion

Phonological working memory in CWS has been a relatively new area of interest. Hakim and Ratner (2004) were the first to study phonological working memory directly in CWS. Given recent attention, both theoretical (e.g., Howell et al., 1999; Postma & Kolk, 1993) and empirical (e.g., Arndt & Healey, 2001), to the role of expressive phonological skills and phonological processing, the investigation of phonological working memory seems important and timely.

The present study was intended to examine the phonological working memory skills of a group of CWS and their age-, gender-, and SES-matched peers. In particular, the study was designed to examine (a) whether the groups differed in the number of correct responses or in the number of phoneme errors produced in a nonword repetition task, (b) the relationship between language test performance and nonword repetition performance for CWS and their normally fluent peers, and (c) whether CWS differed in the fluency of their responses as nonword length varied.

### 4.1. Nonword repetition task performance

The present study was intended to partially replicate and extend the findings of Hakim and Ratner (2004), who examined the phonological working memory skills of CWS, ages 4-8 years. We focused on a slightly younger group of CWS between the ages of 3-5 years. The nonword repetition task employed in both studies, the CNRep (Gathercole et al., 1994), was the same. Findings were similar to those of Hakim and Ratner; CWS correctly produced significantly fewer two- and three-syllable nonwords than their normally fluent peers. In addition, CWS produced significantly more phoneme errors than the CWNS at the three-syllable word level. However, unlike Hakim and Ratner, present findings did not appear to be impacted by ceiling effects; rather, significant differences were observed even on the shortest (two-syllable) nonword stimuli. The absence of ceiling effects was likely due to the fact that our participants were younger than those in the earlier study. However, floor effects were evident for five-syllable nonwords (see Fig. 1).

Present findings are also similar to those reported by Montgomery (1995b), with children with SLI, ages 5-11 years. He found, in part, that children with SLI performed significantly worse than language-matched typically developing peers on three- and four-syllable nonwords, but not on one- and two-syllable nonwords. From a task development standpoint, that ceiling and floor effects are common on nonword repetition tasks is not a weakness. Rather, it is desirable for multi-level measures to "test the limits" of a particular child's skills, by containing a range of items that vary in difficulty.

The role of subvocalization of stimuli on repetition of the nonwords is unknown. Bosshardt (1990) found that children and adults who stutter subvocalize more slowly, a factor that could impact the accuracy of nonword repetition. However, Bosshardt's participants were older

(mean age = 13.8 years) than those in the present study. Because children under the age of 4 years have not been observed to use subvocalization as a memory strategy (e.g., see Garrity, 1977, for a discussion), it is likely that some of the participants used subvocalization to aid performance and others did not. Nevertheless, while use of subvocalization may have varied within groups, it should not have varied between matched pairs across groups, as there is no evidence to suggest that, as a group, CWS would use subvocalization to a lesser extent than their peers. Rather, the use of subvocalization by some children should have impacted group results fairly equally.

### 4.2. Relationship between language skills and nonword repetition

A second focus of the study was to examine the relationship between language skills and nonword repetition. This focus derived from findings within the phonological working memory literature suggesting a relationship between nonword repetition and language skills in children (e.g., Baddeley & Wilson, 1993; Botting & Conti-Ramsden, 2001; Bowey, 2001; Conti-Ramsden, 2003; Ellis Weismer et al., 2000; Gathercole & Baddeley, 1990; Gray, 2003; Marton & Schwartz, 2003; Montgomery, 1995a,b; Munson et al., 2005; Roy & Chiat, 2004). Based on this literature, it was expected that language skills (particularly vocabulary and expressive phonology) and phonological working memory skills would be related in our participants, irrespective of their fluency status.

Findings of the present study were not completely consistent with that prediction. For CWNS, there were no significant relationships between nonword repetition (CNRep) scores and any of the language scores. For CWS, however, there was a significant relationship between the GFTA-2 and the total CNRep Score. An even stronger correspondence was observed between the GFTA-2 and repetition of three-syllable nonwords, a length at which CWS produced fewer correct items and more errors than peers. The relationship was in the expected direction; children whose phonological skills were stronger were those who performed better on the CNRep.

At first glance, it is not completely clear why CWNS failed to exhibit significant correlations between nonword repetition scores and speech-language measures, especially since other studies, as previously indicated, have reported significant relationships among these variables (e.g., Bowey, 2001; Munson et al., 2005). One possible explanation for these differences in findings, however, may be related to the type of language measures used in these studies. For example, in the current study, the TELD-3, which targets a number of language sub-areas (semantics, syntax, and morphology), was used as a measure of expressive and receptive language development. Other investigators have employed different standardized measures of language development, such as the Clinical Evaluation of Language Fundamentals—third edition by Semel, Wiig, and Secord (1997) (e.g., Munson et al., 2005), or more specific measures of grammatical complexity, such as the Index of Productive Syntax developed by Scarborough (1990) (e.g., Adams & Gathercole, 2000).

Nevertheless, current findings are particularly interesting in light of the fact that there were no significant differences in performance between groups on any of the language measures, including the GFTA-2, nor was there a between-group difference on the total CNRep score. That is, the relationship observed between the CNRep and the GFTA-2 for CWS cannot be attributed to significantly poorer performance by CWS on either measure. Rather, findings indicate that, despite similar performance between the groups on both, CWS demonstrated a relationship between phonological working memory and expressive phonological skills, whereas their peers did not. The fact that the GFTA-2 was the only measure that correlated with the CNRep is not surprising, given that both measures tap aspects of phonology. Indeed, other studies have documented the connection between measures of phonology and nonword repetition, as well (e.g., Bowey, 2001; Metsala, 1999; Sahlen et al., 1999).

Of importance, as noted in Section 2, children were not penalized for inaccurate nonword productions that contained phonological errors identified as consistent errors on the GFTA-2. Thus, in calculating percent correct for the CNRep, a child was not penalized for phoneme errors identified as being consistent within the child's phonological repertoire. Some have argued that such a procedure could mask an otherwise strong association between phonology and nonword repetition, because it gives more credit to children with phonological substitutions (e.g., Sahlen et al., 1999). However, we view this procedure as inherently conservative, because the repetition error counts for children with relatively more consistent phonological errors are not inflated as a function of their phonological errors. Moreover, since CWS are more likely than peers to demonstrate concomitant phonological disorders, by including consistent phonological errors in CNRep scoring we would have increased the likelihood of observing group differences in repetition performance.

A theoretical question that derives from these findings is whether the poorer phonological working memory performance of CWS, compared to peers, implicates rehearsal or storage mechanisms. The relationship observed between expressive phonological skills and phonological working memory favors the interpretation that the rehearsal mechanism is central in accounting for between-group differences. Rehearsal requires repetition of phonological information prior to storage. The fact that CWS with lower GFTA-2 scores were those who had lower CNRep scores suggests, perhaps, that expressive phonology skills has an impact on the rehearsal mechanism, which, in turn, influences the quality of the representation placed within storage.

This supposition is consistent with the findings and interpretation of Bosshardt (1993) with AWS. As previously mentioned, adults who participated in the Bosshardt study were asked, among other things, to read sets of four CVC syllables and, following an intervening task, reproduce the syllables in writing. Bosshardt found that AWS reproduced significantly fewer syllables in the correct position than their fluent counterparts. These results, as well as those of the other experimental tasks, were interpreted to suggest that phonological encoding is weaker and phonological rehearsal time is slower in AWS. Thus, findings from this study implicate the rehearsal mechanism as well.

In interpreting the present findings, it should be noted that the GFTA-2 is not intended to assess rehearsal capabilities even indirectly. Rather it is intended to assess children's expressive phonological skills at the word level. Thus, a more thorough assessment of phonological skills, including memory tasks that tap phonological knowledge, is necessary to carefully examine the rehearsal capabilities of CWS. The present investigation might serve to motivate future study in this area.

### 4.3. Fluency in production of nonwords

A final aim of the present study was to examine the fluency of responses to CNRep items as they increased in syllable length. Although the literature in working memory suggests a relationship between language and memory, there is no evidence to suggest that stuttering or disfluency in general might be linked to memory. Nonetheless, given that the children were diagnosed with a fluency disorder, it seemed critical to examine the possibility that disfluency could be linked to the production of nonwords in the phonological working memory task. Moreover, it is critical from a study design perspective, to rule out the possibility that CNRep performance by CWS was not impacted by children's stuttering. That is, if the results indicated that CWS produced more disfluency on longer items, then one possible explanation for poorer performance would have been that the performance of CWS was impacted by speech production difficulties, rather than or in addition to potential differences in nonword repetition skills.

Consistent with Hakim and Ratner's (2004) findings, present results revealed no significant fluctuation in fluency as nonwords increased in length. Thus, it would appear that even though CWS had greater difficulty correctly repeating the two- and three-syllable nonwords than their normally fluent peers, these difficulties did not manifest themselves in children's fluency of production. Findings of the present study, however, do not rule out the possibility that CNRep performance was impacted by more general speech output processes that may have differed between groups. For example, in theory, the groups could have differed in the duration of their responses or response time latencies, each of which could have had an effect on the rehearsal mechanism.

## 5. Conclusions, limitations, and future directions

Although the present study serves as a partial replication of the work of Hakim and Ratner (2004), it also represents an extension of their findings, by investigating the nonword repetition skills of a group of younger children and examining the relationship between aspects of language and nonword repetition. Present findings complement the existing literature by suggesting that even younger CWS differ from their peers in production of nonwords. Furthermore, for CWS, performance on the nonword repetition task was significantly related to performance on a test of phonology, the GFTA-2. This relationship, however, did not emerge for CWNS.

In interpreting these findings, it may be tempting to infer that, like children with language impairments, CWS simply have weaknesses in both language and phonological working memory. Present data, however, do not support this conclusion. Rather, CWS performed similarly to their peers across all language measures, while demonstrating differences from peers only in nonword repetition. From a theoretical perspective, it is interesting that CWS are similar to other populations with a clinical diagnosis of language impairment, in that these populations also show a deficit in nonword repetition. Thus, these findings, in concert with those of Hakim and Ratner (2004), suggest that models of childhood stuttering that emphasize the importance of language among other factors should not ignore the potential role of phonological working memory in explaining observed language differences.

One potential limitation of the present study is that, like Hakim and Ratner (2004), our sample size was relatively small. Therefore, the statistical differences we were able to detect were only those that represented large effect sizes. It is likely, for example, that had the sample been larger, between-group differences would have emerged in the production of four-syllable nonwords and, perhaps, across all stimulus items (i.e., total CNRep). On the other hand, it might be argued that, for a relatively preliminary examination of phonological working memory, detection of large effect sizes is the most relevant and practical. That is, if the sample had been substantially larger, detecting smaller effects would have been possible but may have led to questions about the practical significance of such effects.

The present finding of a significant relationship between a test of phonology and nonword repetition deserves further exploration. As we have indicated, nonword repetition should not be viewed as a pure measure of phonological working memory, as the performance of CWS may have been impacted by output demand inherent in this type of task. Edwards and Lahey (1998) have provided a useful procedure for investigating the potential contributions of variables, including output variables that may impact nonword repetition performance. Future research might use a similar procedure to examine the relative contribution of extraneous factors to nonword repetition performance. This future research is critical to ascertain whether or not an aspect or several aspects of the nonword repetition task, rather than phonological working memory in general, correlates with the phonological skills of CWS. The present study, in conjunction with the study by Hakim and Ratner (2004), serves as a base for future

exploration into phonological working memory and its potential role in the speech and language production of CWS.

## Appendix A List of nonwords from the CNRep (Gathercole et al., 1994)

| Item | Number of syllables | Nonword | Item | Number of syllables | Nonword |
|------|--------------------|---------|------|--------------------|---------|
| 1 | 2 | Diller | 21 | 5 | Defermication |
| 2 | 3 | Skiticult | 22 | 3 | Commerine |
| 3 | 4 | Empliforvent | 23 | 2 | Pennel |
| 4 | 2 | Ballop | 24 | 4 | Blonterstaping |
| 5 | 5 | Sepretennial | 25 | 5 | Confrantually |
| 6 | 4 | Commeecitate | 26 | 2 | Prindle |
| 7 | 3 | Brasterer | 27 | 3 | Bannifer |
| 8 | 5 | Versatrationist | 28 | 5 | Reutterpation |
| 9 | 4 | Woogalamic | 29 | 3 | Barrazon |
| 10 | 2 | Glistow | 30 | 2 | Hampent |
| 11 | 4 | Pennerriful | 31 | 3 | Trumpetine |
| 12 | 2 | Sladding | 32 | 5 | Voltularity |
| 13 | 5 | Detratapillic | 33 | 4 | Perplisteronk |
| 14 | 3 | Glistering | 34 | 2 | Tafflest |
| 15 | 3 | Thickery | 35 | 4 | Loddenapish |
| 16 | 5 | Pristoractional | 36 | 3 | Doppelate |
| 17 | 4 | Fenneriser | 37 | 5 | Underbrantuand |
| 18 | 2 | Bannow | 38 | 4 | Contramponist |
| 19 | 5 | Altupatory | 39 | 3 | Frescovent |
| 20 | 4 | Stopograttic | 40 | 2 | Rubid |

## CONTINUING EDUCATION

Nonword repetition skills in young children who do and do not stutter

## QUESTIONS

1. The primary purpose of this study was to:

   a. compare two assessments of phonological working memory for use with young children who stutter

   b. evaluate a phonological working memory treatment for use with children who stutter

   c. assess the phonological working memory skills of children who stutter relative to their peers

   d. none of the above

2. One type of task frequently used to assess phonological working memory in children is:

   a. a nonword repetition task

   b. a confrontation naming task

   c. a sentence repetition task

    **d.** a test of expressive phonology

  **3.** In the present study, of children who stuttered:

    **a.** all had a concomitant diagnosis of language impairment

    **b.** all had a concomitant diagnosis of phonological impairment

    **c.** all scored within normal limits on language measures

    **d.** most scored within normal limits on language measures

  **4.** Results of the present study were that:

    **a.** the children who stuttered repeated significantly fewer two- and three-syllable nonwords, relative to peers

    **b.** the children who stuttered made significantly more phoneme errors in their repetition of three-syllable words, relative to peers

    **c.** children's performance on a measure of receptive vocabulary was significantly related to phonological working memory skills

    **d.** a and b

  **5.** Findings of the present study suggest that:

    **a.** young children who stutter do so because of clinically significant deficits in phonological working memory

    **b.** one aspect of the profile of young children who stutter is weaker nonword repetition skills relative to peers

    **c.** the severity of a child's stuttering will likely impact phonological working memory skills

    **d.** all of the above

## Biographies

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**Nancy E. Hall**, PhD, CCC-SLP is an Associate Professor and Department Chair in the Department of Communication Sciences and Disorders at the University of Maine, where she researches the interaction between language and fluency across the lifespan. She has published in the areas of fluency and language, as well as the identification of language disorders in children. She has taught graduate courses in stuttering and language disorders in children, and undergraduate courses in research, scholarship and clinical practice. Dr. Hall is a Board Recognized Fluency Specialist and serves as the Director of the University of Maine's Stuttering Clinic.

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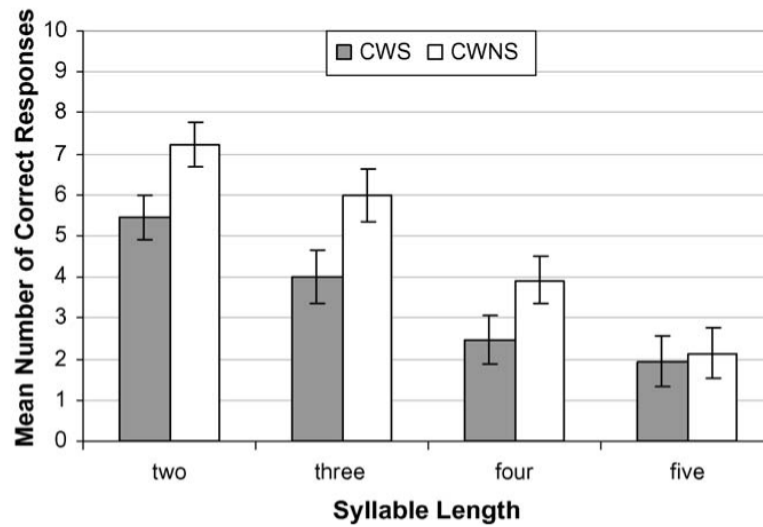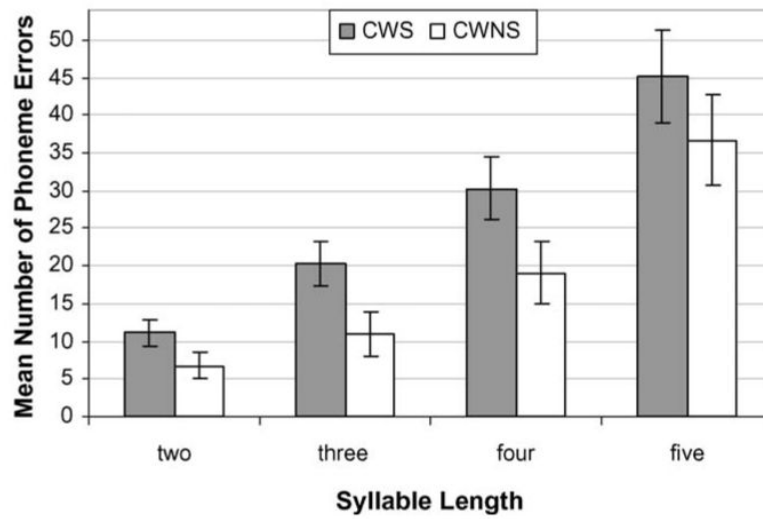
**Fig. 1.**
Adjusted mean (and standard error of the mean) number of nonwords correctly repeated at each nonword length for 12 children who stutter and 12 children who do not stutter between the ages of 3;0 and 5;2 (years;months).
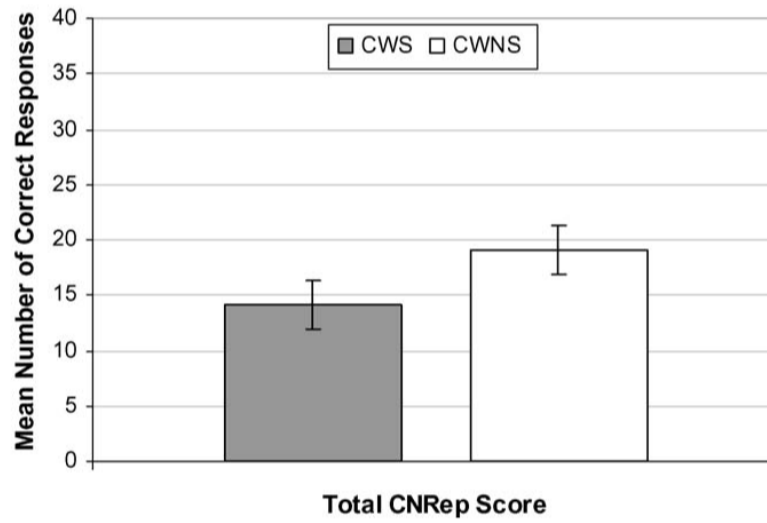
**Fig. 2.**
Mean (and standard error of the mean) number of nonwords correctly repeated across all stimulus items for 12 children who stutter and 12 children who do not stutter between the ages of 3;0 and 5;2 (years;months).
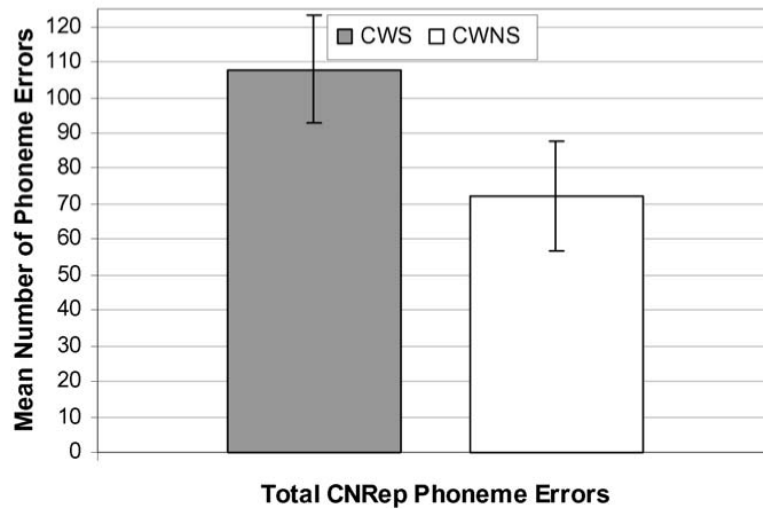
**Fig. 3.**
Adjusted mean (and standard error of the mean) number of phoneme errors produced at each nonword length for 11 children who stutter and 11 children who do not stutter between the ages of 3;0 and 5;2 (years;months).

**Fig. 4.**
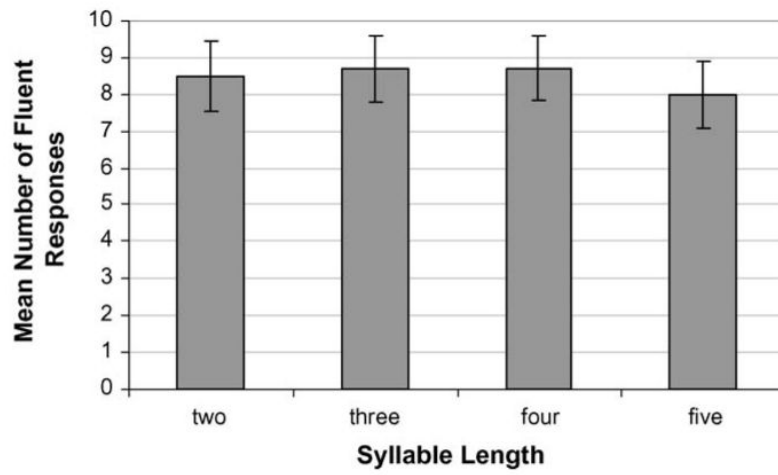Adjusted mean (and standard error of the mean) number of phoneme errors produced across all stimulus items for 11 children who stutter and 11 children who do not stutter between the ages of 3;0 and 5;2 (years;months).

**Fig. 5.**
Mean (and standard error of the mean) number of fluent responses produced at each nonword length for 11 children who stutter between the ages of 3;4 and 5;2 (years;months).

**Table 1**

Participant characteristics

| Participant | Gender | Age (months) | PPVT-III | EVT | TELD-3 | GFTA-2 | SLD | SSI-3 |
|---|---|---|---|---|---|---|---|---|
| Children who stutter | | | | | | | | |
| 1 | M | 36 | 93 | 98 | 102 | 117 | 7.00 | 16 |
| 2 | M | 40 | 95 | n/a* | n/a* | 104 | 7.60 | 23 |
| 3 | M | 41 | 96 | 112 | 122 | 99 | 6.70 | 20 |
| 4 | F | 42 | 116 | 119 | 119 | 94 | 7.00 | 20 |
| 5 | M | 44 | 105 | 122 | 140 | 121 | 7.50 | 21 |
| 6 | F | 49 | 108 | 117 | 117 | 100 | 3.00 | 12 |
| 7 | F | 49 | 121 | 125 | 131 | 95 | 4.50 | 16 |
| 8 | M | 51 | 108 | 103 | 99 | 97 | 4.60 | 18 |
| 9 | M | 52 | 130 | 125 | 123 | 115 | 4.30 | 15 |
| 10 | M | 52 | 119 | 124 | 124 | 113 | 11.00 | 29 |
| 11 | M | 57 | 116 | 133 | 113 | 118 | 4.30 | 15 |
| 12 | M | 62 | 94 | 91 | 86 | 109 | 7.30 | 28 |
| Mean (S.D.) | n/a | 47.9 (7.6) | 108.4 (12.2) | 115.4 (13.0) | 116.0 (15.3) | 106.8 (9.8) | 6.2 (2.2) | 19.4 (5.2) |
| Children who do not stutter | | | | | | | | |
| 1 | M | 38 | 94 | 111 | 114 | 106 | 1.60 | n/a |
| 2 | M | 43 | 100 | 111 | 116 | 121 | 0.60 | n/a |
| 3 | M | 45 | 110 | 112 | 90 | 94 | 2.00 | n/a |
| 4 | F | 43 | 125 | 124 | 129 | 110 | 0.60 | n/a |
| 5 | M | 42 | 88 | 111 | 113 | 110 | 1.00 | n/a |
| 6 | F | 46 | 112 | 125 | 126 | 120 | 2.70 | n/a |
| 7 | F | 53 | 118 | 132 | 129 | 120 | 0.00 | n/a |
| 8 | M | 53 | 107 | 109 | 120 | 107 | 0.60 | n/a |
| 9 | M | 48 | 116 | 127 | 120 | 109 | 0.30 | n/a |
| 10 | M | 53 | 121 | 126 | 128 | 89 | 2.30 | n/a |
| 11 | M | 57 | 117 | 116 | 119 | 112 | 0.30 | n/a |
| 12 | M | 59 | 115 | 117 | 117 | 108 | 1.30 | n/a |
| Mean (S.D.) | n/a | 48.3 (6.6) | 110.3 (11.2) | 118.4 (7.9) | 118.4 (10.6) | 108.8 (9.7) | 1.1 (0.9) | n/a |

*Note:* PPVT-III, Peabody Picture Vocabulary Test-III (standard score); EVT, Expressive Vocabulary Test (standard score); TELD-3, Test of Early Language Development-3 (Spoken Language standard score); GFTA-2, Goldman-Fristoe Test of Articulation-2 (standard score); SLD, mean frequency of stuttering-like disfluencies per 100 words (percent); SSI-3, Stuttering Severity Instrument-3 (total score).

*
test scores could not be obtained, because the participant refused to cooperate with further testing.

**Table 2**

Partial correlations between speech-language measures and nonword repetition for children who stutter

| | Two-syllable | Three-syllable | Four-syllable | Five-syllable | CNRep total | PPVT-III | EVT | TELD-3 | GFTA-2 |
|---|---|---|---|---|---|---|---|---|---|
| Two-syllable | - | | | | | | | | |
| Three-syllable | 0.686 [*] | - | | | | | | | |
| Four-syllable | 0.825 [**] | 0.654 [*] | - | | | | | | |
| Five-syllable | 0.584 | 0.821 [**] | 0.541 | - | | | | | |
| CNRep total | 0.860 [***] | 0.925 [***] | 0.840 [***] | 0.865 [***] | - | | | | |
| PPVT-III | -0.188 | 0.242 | -0.119 | 0.389 | 0.129 | - | | | |
| EVT | -0.176 | 0.329 | -0.257 | 0.501 | 0.168 | 0.837 [**] | - | | |
| TELD-3 | -0.190 | 0.361 | -0.096 | 0.319 | 0.156 [*] | 0.772 [**] | 0.860 [***] | - | |
| GFTA-2 | 0.311 | 0.756 [**] | 0.324 | 0.631 [*] | 0.611 [*] | -0.003 | 0.132 | 0.064 | - |

*
$p \leq 0.05$.

**
$p \leq 0.01$.

***
$p \leq 0.001$.

**Table 3**

Partial correlations between speech-language measures and nonword repetition for children who do not stutter

| | Two-syllable | Three-syllable | Four-syllable | Five-syllable | CNRep total | PPVT-III | EVT | TELD-3 | GFTA-2 |
|---|---|---|---|---|---|---|---|---|---|
| Two-syllable | - | | | | | | | | |
| Three-syllable | 0.732** | - | | | | | | | |
| Four-syllable | 0.398 | 0.764** | - | | | | | | |
| Five-syllable | 0.282 | 0.507 | 0.538 | - | | | | | |
| CNRep total | 0.747** | 0.919*** | 0.836*** | 0.726** | - | | | | |
| PPVT-III | 0.051 | -0.073 | 0.045 | 0.251 | 0.104 | - | | | |
| EVT | -0.201 | -0.166 | 0.185 | 0.244 | 0.049 | 0.666* | - | | |
| TELD-3 | -0.122 | -0.369 | -0.082 | -0.348 | -0.255 | 0.321 | 0.590* | - | |
| GFTA-2 | 0.308 | 0.245 | 0.526 | 0.305 | 0.442 | -0.078 | 0.198 | 0.464 | - |

*
$p \leq 0.05$.

**
$p \leq 0.01$.

***
$p \leq 0.001$.