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Nonword repetition abilities of children who stutter: an exploratory study

Haya Berman Hakim, Nan Bernstein Ratner*

Department of Hearing and Speech Sciences, University of Maryland, College Park, MD 20742, USA

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Abstract

Past research has suggested that children who stutter (CWS) may have less well-developed language skills than fluent children, and that such relative linguistic deficiencies may play a role in precipitating their disfluencies. However, data to support this position are primarily derived from results of standardized diagnostic inventories, which are originally designed to identify frank language impairment. Nonword repetition has emerged as a more sensitive measure of children's linguistic abilities. In this exploratory study, eight CWS (mean age 5:10, range 4:3–8:4) were compared to eight normally developing children (ND) (mean age 5:9, range 4:1–8:4) in their ability to repeat the nonwords of the Children's Test of Nonword Repetition. CWS performed more poorly than NS on measures of Number of Words Correct and Number of Phoneme Errors at all nonword lengths, although statistical differences were observed only for 3-syllable nonwords. When lexical stress of the nonwords was varied to a non-English stress pattern, all participants repeated the stimuli with less accuracy, and the CWS again exhibited more errors than NS. Fluency for the CWS group did not change systematically with increasing nonword length. These preliminary findings are interpreted in light of a number of extant theories of the underlying deficit in childhood stuttering. We conclude that children who stutter may have diminished ability to remember and/or reproduce novel phonological sequences, and that further investigation into this possibility may shed light on the emergence and characteristics of childhood stuttering.

Educational objectives: After completing this activity, the learner will: (1) be able to evaluate the research support for a linguistic component to stuttering; (2) describe the use of nonword repetition as an experimental and assessment device with children with SLI and children who stutter; (3) suggest

* Corresponding author. Tel.: +1-301-405-4271; fax: +1-301-341-2023.
E-mail address: nratner@hesp.umd.edu (N.B. Ratner).

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future directions for research to further refine the potential role that linguistic encoding plays in the etiology and persistence of stuttering.
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1. Stuttering and linguistic ability

Research correlating stuttering with linguistic demands falls broadly into two categories: one which contrasts the linguistic abilities of children who stutter (CWS) and those who do not, and one which correlates the existence of dysfluencies in individual children's utterances to specific linguistic demands. Both have produced findings suggestive of a link among linguistic capacities, demands and fluency of speech-language production. Results of standardized language tests have shown that CWS score lower than their nonstuttering peers (Byrd & Cooper, 1989; Murray & Reed, 1977; Ryan, 1992). Further, language skills appear to predict which children will recover spontaneously from stuttering and which children will stutter chronically; children with stronger language skills appear to have a higher likelihood of recovery (Yairi, Ambrose, Paden, & Throneburg, 1996). In addition, relative but subclinical depression in lexical and syntactic skills have been found in children (Bernstein Ratner, & Silverman, 2000; Wall, 1980) and adults who stutter (Homzie, Lindsay, Simpson, & Hasenstab, 1988; Prins, Main, & Wampler, 1997; Watson et al., 1994) when compared to fluent peer groups.

However, not all studies that compared stuttering and fluent populations find differences in their language or phonological abilities (Nippold, 1990, 2002), and interpretation of differences has been controversial (Watkins & Johnson, 2004). Aside from the real question of whether such differences truly exist, one potential reason for this may be the typical methodology of studies that contrast groups of stuttering and nonstuttering children (Watkins & Johnson, 2004). For example, among other concerns, they tend to employ standardized language tests or spontaneous speech sampling. As has been noted (Bernstein Ratner, 1997), standardized language tests are primarily designed to identify frank language disability for diagnostic and therapeutic purposes, and so are unlikely to provide the more precise discrimination between groups that may be required when either subtle depression of skills or weakness in a very specific domain of language exists. Trends reported in studies that have not found significant differences between groups on a variety of measures suggest that this may be the case (Miles & Bernstein Ratner, 2001). Spontaneous language sampling, while a sensitive descriptive measure of children's expressive abilities, is not necessarily a valid way of distinguishing groups of children's language abilities: "... standardized tests are designed to tell whether a child is different from other children. Speech-sample analysis, on the other hand, is not constructed psychometrically for this purpose" (Paul, 2001, p. 319). Many of the measures that flow from language sampling (e.g., MLU, TTR), have been criticized as having large ranges of normal performance at an array of ages that impede their ability to discriminate between or among groups of children (Eisenberg, Fersko, & Lundgren, 2001; Watkins & Kelly, 1995).

For this reason, researchers and clinicians have continued to search for more sensitive measures that are capable of distinguishing between groups of children, particularly on the basis of language ability. A promising measure that has gained strength in the research literature over the past decade is nonword repetition.

1.1. Phonological coding in children and the nonword repetition task (NRT)

A growing literature has examined the phonological aspects of language learning in children. Clearly, there is a cognitive/semantic component to learning new words or structures, but there also is evidence for a separate system known as the phonological loop. The phonological loop is part of working memory, a limited-capacity system that supports both the storage and processing of information; it is a temporary storage area for incoming verbal information (e.g., Baddeley, 1986; Gathercole, Hitch, Service, & Martin, 1997; Gathercole, Willis, Baddeley, & Emslie, 1994). The phonological loop is thought to contain two components: a phonological store and an articulatory rehearsal mechanism, and it provides temporary storage of speech code while the main working memory in the central executive controls "modality-free" reasoning or cognition (Baddeley, 1986). Children are presumed to use the phonological loop to store word forms in addition to using their current vocabulary knowledge when learning new words (Baddeley, Gathercole, & Papagno, 1998; Gathercole et al., 1997). Phonological short-term memory has been extensively studied in typically-developing, language-delayed and specifically language-impaired (SLI) children (e.g., Edwards & Lahey, 1998; Sahlén, Reuterskiöld, Nettelbladt, & Rodeborg, 1999).

It is believed that repetition of novel stimuli (nonword repetition), which is thought to require the temporary storage of an unfamiliar phonological sequence, relies on the phonological loop, and that success on the task depends on the capacity of the short-term storage area of the phonological loop (Gathercole et al., 1994). Numerous studies have examined the performance of children with SLI on nonword repetition tasks. Relatively consistent findings have correlated nonword repetition task ability with measures of language ability. Nonword repetition ability is highly correlated with vocabulary and reading skills in both children with SLI (Gathercole et al., 1994) and in normally developing children (Gathercole, Service, Hitch, Adams, & Martin, 1999). It also is correlated with comprehension of grammar (Gathercole et al., 1994). An impressive finding by Dollaghan and Campbell (1998) was that a nonword repetition task distinguished children enrolled in language intervention from language-normal children with a higher degree of accuracy than a norm-referenced language test.

Edwards and Lahey (1998) also found that children with SLI were less accurate than their normal-achieving counterparts on nonword repetition tasks. On the other hand, they found little correlation between nonword repetition and speech motor skills, implying that the salient connection between SLI and nonword repetition is language-based rather than motor-based. Based on the types of errors noted in their sample, they hypothesized that nonword repetition is correlated with ability to form or to hold phonological representations in working memory; they also found a greater correlation with expressive language abilities than with language comprehension. Since that time, Ellis Weismer et al. (2000) have further extended the finding of poorer nonword repetition ability in children with SLI, and have in fact suggested that it might serve as a language- and culture-free assessment measure for identifying children with SLI. Recently, in an assessment of multiple potential markers for SLI, Conti-Ramsden (2003) found nonword repetition and past tense marking to be the best markers for identifying the condition.

There also are some data linking phonological memory deficits and stuttering. Bosshardt (1993) found that adults who stutter performed more poorly on a serial short-term memory task than normally fluent adults, and interpreted his results as suggesting that adults who stutter have slower phonological encoding and rehearsal times. Ludlow, Siren, and Zikria (1997) found that adults who stutter demonstrate more difficulty learning novel phonological sequences than fluent speakers. In addition, although the relationship between articulation proficiency and dynamic measures of speech encoding is unclear, Melnick, Conture, and Ohde (2003) reported that preschool CWNS exhibited a significantly negative correlation between their speed of speech reaction time and score on the Goldman-Fristoe, but no such relation was observed with CWS. Thus, there is an apparent and established link between stuttering and diminished language ability, as well as a smaller body of evidence suggesting a link between stuttering and phonological encoding deficits. Given this, the nonword repetition paradigm provides a particularly suitable way to probe further whether or not children who stutter have weaker-than-normal language systems, and, if so, whether or not the systems that support nonword repetition are involved.

1.2. Linguistic task and fluency performance

As noted earlier, beyond using linguistic measures to discriminate between the abilities of stuttering and fluent populations, language measures appear to predict the frequency and location of stuttered events. Within individuals who stutter, more specifically, there is evidence that as length and syntactic complexity of an utterance increase, so too does the amount of stuttering (Gaines, Runyan, & Meyers, 1991; Zackheim & Conture, 2003). It also has been shown that increasing syntactic complexity alone, independent of length of an utterance, increases the number of dysfluencies (Bernstein Ratner & Sih, 1987). Furthermore, adults who stutter show decreased speech motor stability (i.e., stability of the lower lip during articulation) when syntactic complexity, but not length, of utterances increases (Kleinow & Smith, 2000). In fact, decreased motor speech stability is seen with increased syntactic complexity in normally fluent adults and children as well (Maner, Smith, & Grayson, 2000). The decrease in stability with increased syntactic complexity suggests that the extra demand placed on a speaker by increased syntactic complexity imposes demand on the speech system; the hypothesis is that in PWS, this can also precipitate dysfluencies.

A number of recent models hypothesize linguistic impairment in some domain, including those of phonology and prosody, as a portion of the underlying factors that precipitate and/or maintain stuttering (Au-Yeung & Howell, 1998; Packman, Onslow, Richard, & van Doorn, 1996; Postma & Kolk, 1993). The role of syllabic stress in precipitating stuttering in both adults (Prins, Hubbard, & Krause, 1991; Wingate, 1984) and children (Natke, Sandrieser, van Ark, Pietrowsky, & Kalveram, 2004) has been a matter of both empirical debate and theoretical speculation. However, little testing of such hypotheses has been systematically carried out in children using anything other than published standardized test results or spontaneous language data.

Thus, there is evidence both of depressed language function in PWS and of a correlation of stuttered dysfluencies with certain linguistic, particularly syntactic, variables. In terms of language capabilities, although results of standardized language tests show some differences in stuttering populations, results are neither consistent nor very illuminating about the nature, or even the degree, of the deficits. Moreover, although the evidence from studies examining specific linguistic tasks points to some relationship with stuttering, it is not at all clear what specific functions are impaired in PWS. That is, there is a notable lack of evidence pointing to a specific cognitive/linguistic deficit in PWS which might be at the root of their depressed language, not to mention their stuttering (Bernstein Ratner, 1997). Hence, the identification of a specific ability which could be shown to be depressed in those who stutter might shed light on the specific difficulties underlying stuttering, and therefore on the viability of certain models of stuttering.

This research examined the performance of stuttering children on nonword repetition tasks to answer the following questions:

Do children who stutter exhibit more errors than do children who do not stutter on a nonword repetition task?

Does stuttering increase as length of the nonword increases?

Given some recent models of stuttering that posit an underlying prosodic encoding deficit in stuttering children (Karniol, 1995; Packman et al., 1996), does the imposition of non-English lexical stress differentiate repetition accuracy between children who stutter and normally fluent children?

Is variation in lexical stress more likely than English-like stress to cause stuttering?

2. Method

2.1. Participants

Participants in the study were 14 boys and 2 girls between the ages of 4:1 and 8:4. Eight of the children (CWS) had been diagnosed by a speech-language pathologist as having developmental stuttering and had been stuttering for at least six months. The other eight children, who were nonstuttering, normally developing (ND), were matched on age (within 4 months) and gender with one of the CWS participants. The mean age of the CWS group was 5:10 and of the ND group 5:9. All participants were monolingual with English as their first language. The two groups also were matched on maternal education level; the mean level of the CWS group was 16.25 years, and for the ND group it was 17.25 years.

All participants were administered the *Kaufman Brief Intelligence Test* (*K-BIT*) (Kaufman & Kaufman, 1990) on the day of testing. The *K-BIT* contains two subtests, a vocabulary subtest and a matrices subtest, whose scores are combined into one composite IQ. Participants were required to achieve a score of at least 85 (the *K-BIT* mean is 100, standard deviation 15) to be included in the study. The participants also were administered four subtests (Picture Vocabulary, Oral Vocabulary, Grammatic Understanding and Grammatic Completion from the *Test of Language Development-Primary, third ed.* (*TOLD-P:3*) (Hammill & Newcomer, 1997). With the exception of one CWS participant who scored a 6 on Picture Vocabulary, all participants achieved a score of at least 7 on each of the subtests. Participants were also screened for articulation/phonological impairments using the Word Articulation subtest of the *TOLD-P:3*.

Results of preliminary testing showed the two groups to be well-matched on these standardized measures of performance. The *K-BIT* composite IQ scores ranged from 96 to 138. The CWS group had a mean vocabulary score of 112, a mean matrices score of 106, and a mean composite score of 110; while the ND group had a mean vocabulary score of 113, a mean matrices score of 111, and a mean composite score of 114 (see Table 1). Differences between the performance of the two participant groups were subjected to related samples *t*-tests. Although the CWS group scored lower than the ND group on both the Vocabulary and Matrices subtests and on the *K-BIT* composite, none of these differences was found to be statistically significant.

Mean scores for the *TOLD-P:3* were as follows: on Picture Vocabulary, 11.5 for the CWS group and 11.6 for the ND group; on Oral Vocabulary, 10.5 for CWS and 11.4 for ND; on Grammatic Understanding, 10.5 for CWS and 11.4 for ND; and on Grammatic Completion, 11.5 for CWS and 12.9 for ND. Between-group differences were subjected to related samples *t*-tests. As with the *K-BIT scores*, although the ND group outscored the CWS on each subtest, none of the differences reached statistical significance. In sum, no statistical differences were found between groups for standardized language or intelligence measures.

Articulation screening was scored in two ways. First, using *TOLD-P:3* conventions, any item with any misarticulation was scored an error. (In other words, a child having consistent non-adult production of a single phoneme may be penalized more than once on the subtest if the phoneme re-appears in another stimulus item.) There was no significant difference ($t = -1.25$, d.f. = 14, $P = .23$) between CWS (mean score = 2.25 errors, out of 20 items) and ND (mean score = 5.12 errors, out of 20 items) in terms of misarticulations. Given that the authors were also concerned about the mean number of phonemes consistently in error in having the children repeat the nonword stimuli, we also calculated this additional value from the test items. Mean number of phonemes in error was identical for the two groups, with a mean of .75, and a range of 0–2.

A language sample was taken of each of the CWS participants during free play with the examiner. A minimum of 275 utterances for each child were used to calculate a stuttering severity score based on the *Stuttering Severity Instrument-3* (*SSI-3*) (Riley, 1986). All but one of the participants demonstrated moderate stuttering based on this instrument. The remaining participant demonstrated mild stuttering (see Table 1). The ND children were screened and did not exhibit stutter-like dysfluencies.

All participants passed a hearing screening at 20 dB at 500–4000 Hz using headphones.

2.2. Stimuli

The nonword stimuli were taken from the *Children's Test of Nonword Repetition* (*CNRep*) (Gathercole et al., 1994), which was normed on children aged 4–9 years (see Appendix). The *CNRep* consists of 40 nonsense words: 10 words each of length 2, 3, 4, and 5 syllables. In addition to these 40 stimuli, the ten 4-syllable nonwords of the *CNRep* (which were thought to be structurally most amenable to prosodic manipulation) were incorporated a

Table 1
Age, maternal education level, *Stuttering Severity Instrument-3* (*SSI-3*) and standard intelligence and language test scores of participants who stutter (CWS) and of controls (ND)

Participant	CWS									ND								
	S1	S2	S3	S4	S5	S6	S7	S8	Avg	N1	N2	N3	N4	N5	N6	N7	N8	Avg
Age	4:3	4:8	4:9	4:10	5:11	6:1	8:3	8:4	5:10	4:1	4:4	4:7	4:9	5:9	6:1	8:4	8:4	5:9
Maternal education	16	12	16	18	18	16	18	16	16.25	18	23	14	12	18	16	19	18	17.25
SSI-3	21 mod	23 mod	20 mod	24 mod	13 mild	22 mod	25 mod	26 mod										
TOLD-P:3																		
PV	14	14	6	17	8	9	13	11	11.5	11	12	11	13	11	7	15	13	11.6
OV	14	10	11	10	13	9	9	8	10.5	13	13	10	10	10	9	14	12	11.4
GU	11	8	10	12	16	10	10	7	10.5	11	11	13	10	14	10	11	11	11.4
GC	14	9	10	15	13	12	11	8	11.5	14	14	13	13	13	9	15	12	12.9
K-BIT																		
Vocabulary	134	108	110	131	120	96	109	93	112	118	107	116	124	100	102	129	111	113
Matrices	104	101	98	109	121	105	100	106	106	110	96	120	109	92	99	137	123	111
Composite	121	105	104	122	123	100	105	99	110	116	102	120	118	96	100	138	119	114

second time with an altered stress pattern; that is, with stress placed on the final syllable, which is an atypical English stress pattern (Halle & Vergnaud, 1987), and which none of the original 4-syllable nonwords exhibited. The 50 nonwords were recorded in random order, with approximately 5 s between items, using a Marantz PMD201 portable cassette recorder via an external Sony ECM-50PBW electret condensor microphone.

2.3. Procedure

The participants were tested in a quiet setting in one session which required approximately 1.5–2 h. The test session was recorded on a Marantz PMD201 portable cassette recorder via an external microphone. All participants were first administered the hearing screening, the *K-BIT*, and the nonword repetition test. They then engaged in free play with the examiner for approximately 15 min, during which a spontaneous language sample was obtained. They were then administered the four language subtests and the articulation subtest of the *TOLD-P:3*. To maintain adequate attention to tasks, and because our intention was to assure that the children were equivalent in syntactic and lexical abilities, and not impaired in basic language skills, we did not administer the entire *TOLD-P:3*.

The nonword repetition task was administered on a Panasonic RX-CT840 portable stereo system via loudspeaker. Headphones were not used because the younger participants did not want to wear them for the extended time frame of the elicitation task. Before administering the stimulus items, a comfortable listening level was found for each participant using a tape, containing a children's story read aloud, played while the volume level was adjusted to a level the child deemed most comfortable. The examiner then gave the following instructions to the participant: "I am going to say some silly made-up words to you. Say them after me exactly the way that I say them. You will have to listen carefully because I will say the words only once." Three examples of nonsense words (*gop*, *squimber*, and *alonnic*) were given by the examiner and the child was asked to repeat each. The cassette tape containing the nonword repetition stimuli was then played for each participant. Stimuli were presented in a standard order, in which stimulus length had been randomized (see above). If the participant did not repeat a nonword immediately in the 5 s interval allotted on the tape, the examiner stopped the tape recorder to give the child time to respond, but did not repeat the stimulus item.

2.4. Scoring

Responses on the nonword repetition task were scored in three ways, using Gathercole, et al. (1994) conventions:

(1) A word was scored as correct, or incorrect if it contained one or more phoneme errors.
(2) Individual phoneme errors within each incorrect word were categorized and tabulated.
(3) For the CWS group, each response was judged as either fluent or dysfluent.

If the nonword was stuttered, a judgment was made as to whether the participant's intended pronunciation could be accurately assessed; if the stutter did make the repetition ambiguous, that item was discarded (in all, eight items were discarded).

2.5. Interjudge measurement reliability

Audiotapes from 25% of the study participants (two from each participant group), selected as representative in terms of ranges of behaviors, were transcribed independently by a second trained judge. Agreement for Number of Stimuli Correct ranged from 82% to 98% for a given participant, with a Kappa of .818 overall; Kappa coefficient for the CWS group was .79 and .85 for the ND group. Kappa values exceeding .80 are considered excellent agreement between raters (Fleiss, 1981). Phoneme-by-phoneme agreement averaged over 97% for the two groups. On stress placement for non-English stress words, the two judges showed 88% agreement. Fluency judgments showed 93% agreement between the two judges. Data from the first judge (the first author) were used in the statistical analysis.

3. Results

3.1. Number of nonword stimuli correct

Because the typical report of nonword repetition ability includes total stimuli repeated correctly, this value was first compared across groups by *t*-test. The average score for ND participants was 28.8 (out of a possible score of 40.0; S.D. = 4.74), while that for CWS was 24.5 (S.D. = 7.62). This difference is not significant ($t = 1.34$, $P = .202$, ns). However, under the assumption that length of stimulus does not affect repetition ability in a linear fashion, a series of nonparametric comparisons were computed for each stimulus length, with P set at .0125 to accommodate the multiple comparisons. While stuttering children performed more poorly at all syllable lengths, significant differences were found only for 3-syllable stimuli (Mann–Whitney U, derived Wilcoxon $Z = 2.5057$; $P = .0122$; Cohen's $d = 1.417$, effect size $r = .578$, large). Means and standard deviations for Number of Stimuli Correct out of the total of 40 stimuli at each nonword length are shown in Table 2. At the 2-syllable length, performance was nearly identical (ND $M = 8.9$ (S.D. = .83); CWS $M = 8.4$ (1.6)). At the 3-syllable length, stuttering children performed significantly more poorly than did fluent children (6.9 (S.D. = 1.4)) versus 8.9 (S.D. = 1.1). At 4 syllables, variability in individual performance was large. Mean for children who stutter was 5.6 (S.D. = 3.5);

Table 2
Mean (standard deviation) Number of Stimuli Correct for each group of nonwords by children who stutter (CWS) and who do not stutter (NS)

Group	CWS	NS
2-Syllable nonwords	8.4 (1.6)	8.9 (0.83)
3-Syllable nonwords	6.9 (1.4)	8.9 (1.1)*
4-Syllable nonwords	5.6 (3.5)	7.3 (2.3)
5-Syllable nonwords	3.6 (2.4)	3.8 (1.9)
Total	24.5 (7.62)	28.8 (4.74)

* $P < .01$.

Table 3
Mean (standard deviation) Number of Phoneme Errors for each group of nonwords by children who stutter (CWS) and who do not stutter (ND)

Group	CWS	NS
2-Syllable nonwords	2.38 (2.26)	1.25 (1.16)
3-Syllable nonwords	5.38 (3.92)	1.29 (1.11)*
4-Syllable nonwords	9.13 (10.03)	3.88 (2.85)
5-Syllable nonwords	14.50 (10.58)	10.13 (3.64)
Total	31.4 (25.2)	16.4 (6.95)

* $P < 0.05$.

that for nonstuttering children was 7.3 (S.D. = 2.3). At 5-syllable lengths, performance was equivalently poor for both groups. Mean for children who stutter was 3.6 (S.D. = 2.4), while that for children who do not stutter was 3.8 (S.D. = 1.9). Although ND produced more nonwords correct than the CWS group at all nonword lengths, these differences were significantly different only at the 3-syllable stimulus level.

3.2. Number of Phoneme Errors

Means and standard deviations for Number of Phoneme Errors at each nonword length are shown in Table 3. This analysis showed results very comparable to those for total error score. However, group patterns for this variable violated assumptions of normality for both total score and individual stimulus lengths. Again, it is conventional to report total errors across the data set in nonword repetition studies, so we report this value first, with subsequent attention to the individual word length sets, which cannot be presumed to affect error rate linearly. Mean Number of Phoneme Errors over all stimuli was 31.4 (S.D. = 25.2) for the children who stutter, while it was 16.4 (S.D. = 6.95) for normally fluent children. A series of Mann–Whitney *U*-tests, with *P* set at .0125 to control for multiple comparisons revealed significantly poorer performance for the CWS group than the ND group only for the 3-syllable nonwords ($Z = 2.6913$ $P = .007$; Cohen's $d = 1.605$; effect-size, $r = .6258$; large). Although ND children produced more phonemes correct than the CWS group at all nonword lengths, these differences were significantly different only at the 3-syllable stimuli length.

3.3. Fluency of CWS on the nonword repetition task

The fluency of the CWS participants on the nonword repetition task did not systematically decline as a function of nonword length; for six children, fluency was virtually identical across tokens of all lengths, while two children's fluency declined significantly as nonwords became longer. (See Fig. 1 and Table 4.) Fluency on the non-English stress 4-syllable stimuli was nearly equivalent to fluency rates on the *CNRep* stimuli of the same length.

3.4. Non-English stress pattern

The Number of Stimuli Correct and the Number of Error Phonemes are shown for the two sets of 4-syllable nonwords in the nonword repetition task in Table 5. Performance

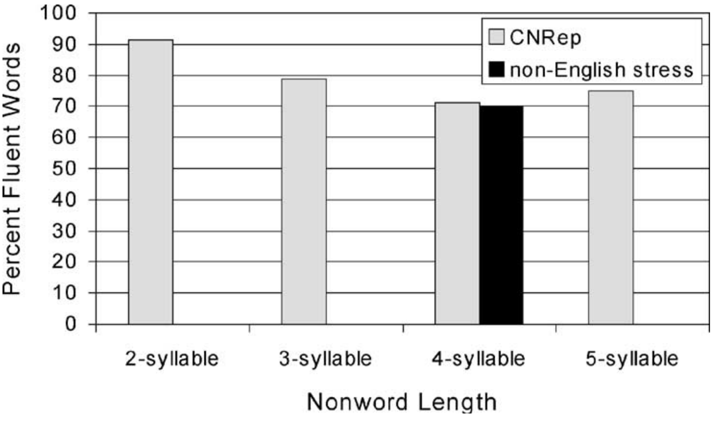

Fig. 1. Percent Fluent Nonwords produced by children who stutter (n = 8).

was worse for both groups for the 4-syllable items with non-English stress as compared to the original *CNRep* 4-syllable words; on the non-English stress items, the Number of Stimuli Correct decreased and the Number of Phoneme Errors increased. The within-group difference for the ND and CWS group on the Number of Stimuli Correct and both group differences for Number of Phoneme Errors were not significant. The CWS group performed more poorly than the ND group on the 4-syllable non-English stress items, exhibiting fewer words correct and more phoneme errors. No differences between the two groups reached statistical significance.

In addition to overall nonword repetition performance, participants' performance with regard to the specific error of word stress placement was examined. None of the participants made stress placement errors on any of the non-4-syllable items on the test, and only one (a CWS participant) made an error on a *CNRep* 4-syllable items. However, the CWS group

Table 4
Fluency of children who stutter on the nonword repetition task

Participant	Number of words repeated fluently					
	CNRep stress pattern				Total *CNRep* stress pattern (n = 40)	Non-English stress pattern (n = 10)
	2-Syllable (n = 10)	3-Syllable (n = 10)	4-Syllable (n = 10)	5-Syllable (n = 10)		
CWS1	10	8	9	9	36	9
CWS2	8	1	1	2	12	2
CWS3	9	9	8	9	35	8
CWS4	10	10	8	8	36	10
CWS5	10	10	9	9	38	7
CWS6	9	9	9	8	35	7
CWS7	7	6	4	7	24	4
CWS8	10	10	9	8	37	9
Total	73	63	57	60	–	56

Table 5
Mean (standard deviation) of Number of Stimuli Correct, Number of Phoneme Errors, and Number of Stress Placement Errors for 4-syllable nonwords with *CNRep* stress pattern and with non-English stress pattern

	4-Syllable *CNRep*	4-Syllable non-English stress
Number of Words Correct		
CWS	5.6 (3.5)	5.0 (1.6)
ND	7.3 (2.3)	6.1 (2.8)
Number of Phoneme Errors		
CWS	9.1 (10.0)	11.4 (8.7)
ND	3.9 (2.9)	5.5 (5.4)
Number of Stress Placement Errors		
CWS	0.13 (.35)	2.1 (1.9)
ND	0.00 (0.00)	1.6 (1.9)

made 17 stress placement errors on the non-English stress words, and the ND group 13 such errors.

4. Discussion

4.1. Nonword repetition performance

The normally fluent comparison group performed consistently better than the CWS on the nonword repetition task. At every nonword length, the ND group repeated more items correctly and demonstrated fewer phoneme errors than the CWS group. However, these trends reached statistical significance only for the 3-syllable nonwords. Besides the obvious issue of a relatively small sample size (i.e., eight children per talker group), this might be explained by floor and ceiling effects of the nonword repetition task that have been discussed to some extent by Montgomery (2003). At a stimuli length of 2 syllables, neither group demonstrated difficulty with the task, and both groups repeated over 80% of the nonwords correctly. At 3 syllables, the CWS started to show some difficulty with the task, as do many children with SLI (Montgomery, 2003), while the ND group did not. Marton and Schwartz (2003) also found 3-syllable nonwords to be the “breakpoint” at which SLI and typically-developing children were best differentiated. In our study, at 4 and 5 syllables, both groups exhibited difficulty with the task; in fact, at 5 syllables, both groups were overwhelmed with the task, achieving fewer than 40% correct, and high within- as well as across-group variability, limiting statistical likelihood of detecting group differences with such a small subject sample.

These results are consistent with the normed scores on the *CNRep* (Gathercole et al., 1994), perhaps because the present authors used similar subject inclusion criteria. On that normative sample, which included over 600 children aged 4–9, the participants’ performance steadily declined as syllable length increased from 2 to 4, but slightly improved as the length increased from 4 to 5. The authors conjectured that this might have been due to the greater number of English morphemes in the 5-syllable items (e.g., *confrantually*, *reutterpation*). Both groups of participants in the present study performed consistently better than the children in Gathercole et al. (1994) on the 2-, 3-, and 4-syllable items, but the at the same level or slightly worse on the 5-syllable items. The morphological structure of the 5-syllable stimuli did not seem to confer an advantage for this group.

4.2. Fluency

The fluency of the CWS participants on the nonword repetition task varied. For six participants, length of the stimulus had no effect on fluency, while for two CWS participants (D2 and D7), increased nonword length tended to increase dysfluency rates. An older literature on stuttering in adults has documented that dysfluencies should increase with increasing word length (Schlesinger, Melkman, & Levy, 1966; Soderberg, 1966; Wingate, 1967). However, Throneburg, Yairi, & Paden (1994) did not find that phonological difficulty, in part defined by word length, predicted disfluency in the preschool children that they studied.

Fluency rates were not found to be related to nonword repetition performance itself. That is, if a child stuttered on a given item, s/he was not more likely to make errors on that item. As noted above, only two CWS participants exhibited appreciably different performance than the rest of the group on fluency; one of the children stuttered on virtually every item, and one stuttered on about half the items, while the remaining children stuttered on only a few items. Thus, it seems that individual fluency rates varied only as a function of stimulus length.

4.3. Non-English stress pattern

Most prior research has attempted to link stutter events to the stress level of initial syllables, those most likely to be produced dysfluently. We recognize that the current question is somewhat different, and asks the exploratory question whether “atypical” stress, which should be expected to stress the phonological encoding loop, impacts fluency rates in children who stutter to any appreciable degree. Across both participant groups, nonword repetition performance was worse on the non-English stress 4-syllable words than on the original *CNRep* 4-syllable words; Number of Words Correct decreased and Number of Phoneme Errors increased. It is difficult to say whether this “stress effect” is due to a difficulty with stress or metrical pattern per se, or simply to the non-familiarity factor of storing and replicating a less English-sounding word. For example, the nonword *blonterstaping* has three nonsense syllables followed by the familiar morpheme *-ing* when pronounced in the usual way. However, the suffix *-ing* never takes primary stress in English, so when this nonword is pronounced with final syllable stress, the *-ing* loses its identification as a suffix, thus in essence giving the nonword four unfamiliar syllables, one more than in the original nonword. In other words, the loss of familiar morphemes could cause the non-English stress words to have longer strings of unfamiliar morphemes, rendering them more difficult to pronounce, independent of the unfamiliar metrical pattern. A future test of stress effects might use nonwords that have no English-like morphemes, and more closely duplicate lexical and grammatical strings having stress patterns that appear to systematically co-vary with stuttering (e.g., Natke et al., 2004).

The CWS group performed slightly worse on the non-English stress words than the ND group in terms of Number of Words Correct and Number of Phoneme Errors, as they did on these same measures for the rest of the nonword repetition stimuli. The CWS participants also exhibited slightly more stress placement errors than the ND group on these words, more often repeating the word with stress on one of the first 3 syllables. However, these stimuli did not, in fact, cause more dysfluencies, nor did they cause proportionally more errors for these participants than for the comparison group.

4.4. Implications of the present findings

The trends in this small pilot study suggest that children who stutter perform somewhat more poorly than normally fluent comparison children on a nonword repetition task, an emerging marker of Specific Language Impairment. These trends lend support to the hypothesis of a relationship between stuttering and some level of linguistic processing deficit. As a population, young children who stutter are more likely to be diagnosed with frank language impairment (Arndt & Healey, 2001) than their fluent peers. For children not so identified, subtle differences in language performance from typical fluent peers have been found for receptive and expressive vocabulary (Anderson & Conture, 2000; Bernstein Ratner and Silverman, 2000), as well as length and lexical diversity of spoken utterances (Silverman & Bernstein Ratner, 2002). If these trends can be verified by further students, using larger numbers of participants, then we may be able to identify a specific linguistic/cognitive deficit in children who stutter that conceivably explains their difficulty in generating fluent speech.

As noted earlier, relatively poorer performance on the nonword repetition task is a characteristic of children with SLI. If, as our results suggest, children who stutter have similar difficulties, we have shown a common deficit that these two groups of children share. However, if the nonword repetition task indeed somehow measures phonological encoding capability, then slower-than-normal phonological encoding cannot be the only cause of stuttering, as children with SLI do not typically stutter, although they do demonstrate increased frequency of stutter-like disfluencies (Hall, Yamashita, & Aram, 1993; Boscolo, Bernstein Ratner, & Rescorla, 2002). As that study notes, childhood stuttering and SLI may lie on a continuum, in which relative degrees of language knowledge and encoding facility interact to produce different profiles of error and dysfluency.

In a more recent set of studies, Marton & Schwartz (2003) differentially appraised multiple aspects of working memory in children with SLI, using the single item repetition task described in this study, as well as a task in which target items were embedded in sentences of varying syntactic complexity. Syntactic complexity, but not length, was found to adversely affect the accuracy of repetition of embedded target items in children with SLI, over and above deficits noted in nonword repetition alone. The authors note that the literature on sentence repetition abilities in children with SLI is sparse and would profit from additional investigation. We note that complexity, rather than length, of sentence repetition targets has been associated with decrements in the fluency of CWS (Bernstein Ratner & Sih, 1987; Bernstein Ratner, 1997) and motor stability in adults who stutter (Kleinow & Smith, 2000) as well as nonstuttering children (Maner et al., 2000), making the Marton and Schwartz protocol a potentially appropriate methodology for future more intensive comparisons between CWS and their typically fluent peers. Additional understanding of the relative language and memory abilities of CWS may also be gained by studies that employ children with SLI as an additional comparison cohort.

We recognize that the subtask in our study that manipulated stress was extremely exploratory in nature; previous work has either manipulated stress in elicited stimuli administered to adults or examined how stress and stuttering co-vary in children's spontaneous speech. Thus, our data are best viewed as a preliminary test of the hypothesis that stress manipulation, by increasing the demand of phonological encoding, might exert a greater effect on children who stutter than children who do not stutter, and might additionally impact their fluency rates. Because changing prosody did not appear to affect children's fluency, they do not provide ready support for models of stuttering that posit an underlying prosodic encoding impairment as its root cause, although only word-level prosody was manipulated in this study. To our knowledge, this is the first time that the prosodic difficulty of novel elicited stimuli has been manipulated in stuttering research. Although a number of prosodic models of stuttering have been advanced, we note that empirical assessment of the potential roles of stress and prosody in precipitating stutter events has been carried out to date only in adults who stutter (Hubbard & Prins, 1994).

4.5. Implications for future research

A test of phonological short-term memory raises the question of a potential relationship between our findings and the literature on the potentially higher level of phonological disorder in young children who stutter. Numerous reports in the literature have documented a higher than expected rate of concomitant phonological and language problems among CWS. In one study, speech-language pathologists reported that about half of their stuttering children also had one or more additional articulation or speech disorders (Blood & Seider, 1981). Arndt and Healey (2001), in the most recent demographic survey of children who stutter, found reports of phonological disorder in approximately one-third of stuttering children.

Children whose stuttering persists have poorer mean scores on measures of phonological development than children whose stuttering spontaneously remits (Paden, Yairi, & Ambrose, 1999). However, the phonologic difficulty of a word does not appear to contribute to dysfluency in children who stutter, even in those with disordered phonology (Throneburg et al., 1994). In evaluating the potential relevance of the literature on phonological ability in CWS, we note that the rate of phonological disorder in CWS is currently a matter of dispute (Nippold, 2002). In fact, group phonological profiles on the *TOLD* screener showed the CWS in this study to have slightly better ability than their fluent peers. Further, expressive phonological disorder/delay has not been linked to phonological working memory, as has SLI. Our major concern in testing the phonological abilities of the study children was to judge accuracy of repetition attempts. Thus, we do not feel that the current study provides additional evidence for or against the role of articulation ability in childhood stuttering.

Future researchers might attempt to duplicate the results of this preliminary study using larger numbers of participants, which would increase the likelihood of demonstrating statistically significant differences between the two groups and to confirm the generalizability of the present results. It might be interesting to examine a matched group of SLI children along with fluent comparison peer's. Given the intriguing similarities already noted between CWS and SLI children, namely depressed language skills and difficulty with nonword repetition, we might find other correspondences between the two groups.

As with other investigations using nonword repetition, it is difficult to know whether weaknesses in responding to the task reflect difficulty in encoding the input, storing it in memory, or accessing it efficiently. In addition to the nonword repetition task, there are other research paradigms that have been used to assess phonological encoding capacity. For example, in the cross-modal picture-word interference task, participants are presented with a picture to name while simultaneously hearing an interfering word (IW). Brooks and MacWhinney (2000) found that using phonologically-related IWs produces a priming effect in participants of all ages. In somewhat similar experiments with persons who stutter, Wijnen and Boers (1994) found that PWS required both the first consonant and vowel for phonological priming to have an effect, while the non-stutterers showed a priming effect with only the onset consonant, suggesting a weakness that affects phonological access. Burger and Wijnen (1999) could not replicate these results exactly, although adults who stutter were relatively delayed in phonological encoding. In a very recent attempt to employ phonological priming techniques with young children who stutter, Melnick et al. (2003) did not find differences in priming facilitation between CWS and normally fluent peers. As suggested by the large variability in performance reported by Melnick et al., fairly large subjects samples may not be necessary to more adequately assess meaningful patterns of priming ability across populations; however, they did find a significant between-group difference between speech reaction time and scores on a standardized test of articulation, suggesting that the organization between speed and accuracy of speech production is less than well developed for young children who stutter. Thus, repeating phonological priming experiments with both children and adults who stutter might reveal differences in their phonological encoding.

Finally, more research needs to be done to clarify why the fluency breakdowns characteristic of stuttering are distinct from those observed in other populations, or under other language demand tasks. Candidates for such differences may lie in the nature of the internal monitor and its responses to phonological encoding difficulty.

5. Conclusions

If there is an underlying linguistic deficit that plays a role in precipitating or maintaining stuttering, we would suggest that experimental tasks, rather than standardized diagnostic test batteries, will be needed to discover the nature and extent of the deficit. The use of standardized diagnostic instruments is more likely to uncover true co-morbid disability of fluency and either language or articulation. Furthermore, such tests are unlikely to identify subtle and perhaps quite task-limited areas of relative impairment in linguistic encoding and/or retrieval. This exploratory study found a trend for children who stutter to perform more poorly on a nonword repetition task than normally fluent children. Moreover, for all children, accurate nonword repetition performance decreased when the stress pattern of the nonwords did not conform to the usual English stress patterns, but fluency was not affected systematically. Future research should seek to confirm the generalizability of these preliminary findings as well as to explore how phonological encoding deficits may be related to the phenomenology that characterizes instances of stuttering.

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Appendix A

Nonword Stimuli in the *Children's Test of Nonword Repetition* (Gathercole et al., 1994)

Two syllables	Three syllables	Four syllables[a]	Five syllables
Ballop	Bannifer	Blonterstaping	Altupatory
Bannow	Barrazon	Commeecitate	Confrantually
Diller	Brasterer	Contramponist	Defermication
Glistow	Commerine	Empliforvent	Detratapillic
Hampent	Doppelate	Fenneriser	Pristoractional
Pennel	Frescovent	Loddenapish	Reutterpation
Prindle	Glistering	Pennerriful	Sepretennial
Rubid	Skiticult	Perplisteronk	Underbrantuand
Sladding	Thickery	Stopograttic	Versatrationist
Tafflest	Trumpetine	Woogalamic	Voltularity

[a] For the non-English stress condition, all 4-syllable items were reproduced with word-final stress.

CONTINUING EDUCATION QUESTIONS
Nonword repetition abilities of children who stutter: an exploratory study
QUESTIONS

1. Research examining the relationship between language encoding and stuttering has indicated that:
   a. language encoding is aggravated during stuttering moments
   b. language encoding difficulty in stuttering stems from deficits in motor programming for speech

   c. stuttering children and adults have shown subtle deficits in lexical and grammatical encoding on experimental and clinical tasks
   d. no relationship exists between language and stuttering in children
   e. all of the above
2. Tests of nonword repetition:
   a. may be more sensitive indices of specific language impairment than conventional language tests
   b. may offer culture-free testing for language impairment
   c. appear to assess integrity of the "phonological loop" in lexical encoding
   d. all of the above
   e. none of the above
3. This study evaluated the role of prosodic stress in precipitating stutter events. It found that:
   a. any alteration in typical stress provoked fluency breakdown in CWS but not fluent children
   b. any alteration in typical stress provoked fluency breakdown in both groups of children
   c. alterations in stress caused most words to be repeated inaccurately
   d. CWS were basically able to repeat words with altered stress, and fluency was not systematically impaired under such conditions
   e. prosodic stress is an important factor in fluency breakdown that should be more carefully controlled in future studies
4. Study results suggest that:
   a. children who stutter tend to have depressed abilities to repeat nonword stimuli, further supporting the role of language encoding in stuttering
   b. CWS show no difference in nonword repetition ability from their fluent peers
   c. increased grammatical complexity of carrier phrases diminished repetition accuracy for the CWS but not their peers
   d. nonword repetition does not appear to be a promising clinical or research tool for studying stuttering
   e. conventional nonword stimuli used in SLI research will need to be changed if they are to be used in future studies with stuttering children
5. The authors of the current study suggest:
   a. the need for language therapy as a component of fluency work with CWS
   b. the need for phonological therapy for all CWS
   c. the need for further experimental investigations of psycholinguistic function in CWS
   d. the need for further research into speech kinematics of CWS
   e. the need for the development of clinical language assessment batteries specifically tailored to the needs of CWS

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