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Do Individual Differences in Lexical Representations or Speech Output Account for Relations Between Nonword Repetition or Vocabulary?:

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DO INDIVIDUAL DIFFERENCES IN LEXICAL REPRESENTATIONS OR SPEECH OUTPUT ACCOUNT FOR RELATIONS BETWEEN NONWORD REPETITION OR VOCABULARY?

By

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ABSTRACT

Nonword repetition tasks have often been used as measures of phonological memory. However, there is considerable evidence that these tasks may rely heavily on lexical knowledge (Dollaghan & Campbell, 1998; Treiman, Goswami, & Bruck, 1990), and the role of speech output has also been identified as a potential confounding factor in nonword repetition performance (Hulme & Snowling, 1992). A new nonword repetition task was devised for the current study; the criteria used for generating the nonword stimuli incorporated the findings of Dollaghan and Campbell (1998) and Treiman, Goswami, and Bruck (1990). Relations between this new task and word-level reading and vocabulary were compared to two other nonword repetition tasks, one that adhered to about fifty percent of the criteria, and one that adhered to virtually none of the criteria. A nonword comparison task, with stimuli also adhering to the criteria, was also administered, and the relations between this task and word-level reading and vocabulary were compared to those of the nonword repetition task performance to determine the influence of speech output.

INTRODUCTION

Successful reading is a complex process requiring the efficient use of many cognitive skills. As a result of the past twenty years of research, we have gained substantial knowledge of factors that play an integral role in learning to read (Torgesen, 1999). Although our understanding of these processes has increased significantly in recent years, the role of some specific skills, such phonological memory, is not fully understood.

According to Baddeley and Hitch (1974), phonological memory is one aspect of a greater construct of working memory. Working memory can be viewed as a tripartite system. The central executive serves as an interface between two slave systems and long-term memory. The two slave systems are referred to as the visuo-spatial sketchpad and the articulatory loop. The visuo-spatial sketchpad is assumed to hold and manipulate information about objects and locations, while the articulatory loop is a system that is assumed to be capable of storing and manipulating speech-based information. The concept of a phonological memory that forms part of the articulatory loop slave system is capable of explaining a wide range of short-term memory phenomena. In particular, this component of working memory is particularly important for new phonological learning (Baddeley, Papagno, & Vallar, 1988).

Nonword repetition tasks have been used as measures of phonological memory for several years. Nonword repetition tasks require participants to repeat nonsense words that have phonological sequences and intonation patterns that are permissible in English (or whichever language the participants speak). The nonsense words can be presented either directly by the experimenter or via a pre-recorded method. These tasks are considered to be good predictors of future reading ability (Muter & Snowling, 1998) and efficient tools for differentiating between good readers and poor readers (Stone & Brady, 1995). Performance on nonword repetition tasks is also closely linked to current (Gathercole, Willis, Emslie, & Baddeley, 1992; Gathercole & Baddeley, 1990; Masoura & Gathercole, 1999) and future (Gathercole & Baddeley, 1989) vocabulary skill. In addition, nonword repetition tasks are better able to distinguish between children with normal and poor language skills than some traditional language measures (Dollaghan & Campbell, 1998). Estimates of genetic influence on poor nonword repetition are also very high, indicating that this task is measuring a stable and important deficit (Bishop, 1996, 2002).

By way of organization, several aspects of nonword repetition will be considered. First, relations between nonword repetition and reading will be explored. This will be followed by a discussion of the relations between nonword repetition and vocabulary. Next, current views addressing what nonword repetition tasks may actually measure will

be covered, followed by a discussion of important factors that may affect performance. Finally, the present study will be described.

Relations Between Nonword Repetition and Reading

One of the most interesting aspects of nonword repetition performance is its relation with reading ability. Stone and Brady (1995) compared the correlations between various measures of phonological processing, including nonword repetition. In addition to nonword repetition, the tasks included word span, tongue twisters, word-pair repetition, rapid naming, and a working memory task that required remembering the last words of a series of sentences while judging the sentences to be true or false. The participants included a group of less-skilled third grade readers and control groups of age-matched and reading-level matched children. The less-skilled readers had significantly lower scores on the nonword repetition task both when compared with the age matched and reading-level matched readers. Nonword repetition performance accounted for 12% of the variance in reading ability when word attack was the criterion variable and 14% of the variance in reading ability when word identification was the criterion variable. These results reflect the contribution of nonword repetition after age, verbal ability, and the other phonological processing variables had been partialed out.

Muter and Snowling (1998) reported that nonword repetition performance at ages 5 and 6 was a strong predictor of reading accuracy at age 9, after controlling for full scale IQ scores ($\beta = .41$, $p<.05$ at age 5 and $\beta = .40$, $p<05$ at age 6). Nonword repetition performance at ages 5 and 6 also predicted nonword reading ability at age 9 after controlling for full scale IQ scores ($\beta = .37$, $p<.05$ at age 5 and $\beta = .39$, $p<.05$ at age 6). Nonword repetition performance at age 4 was not a statistically significant predictor of reading accuracy or nonword reading ability at age 9.

Relations between nonword repetition and reading ability are not limited to the early years of reading development. Poor readers between the ages of nine and twelve typically have difficulty with nonword repetition (Snowling, Goulandris, Bowlby, & Howell, 1986). Significant correlations between nonword repetition accuracy and reading ability have also been found at the college level (Apthorp, 1995).

The results of these studies indicate that poor nonword repetition performance is typical of at least some poor readers. One possible explanation is that phonological memory may be used during the process of decoding an unfamiliar word. Successful readers tend to read novel words by proceeding through the word, decoding each individual letter and storing it as a speech sound. When they reach they end of the word, they attempt to blend the constituent sounds into a spoken response. A child who has impaired phonological storage capacity is likely to be able to hold fewer sounds and to be less capable of using this strategy effectively (Baddeley, Papagno, & Vallar, 1988). This impaired phonological storage capacity may result in inefficient formation of phonological representations, which in turn result in a less durable memory trace. This could impede reading by disrupting the decoding process (Brady, 1997; Perfetti, 1985; Wagner & Torgesen, 1987).

Relations Between Nonword Repetition and Vocabulary

In addition to its relation with reading, nonword repetition appears to be related to vocabulary acquisition. Gathercole, Willis, Emslie, and Baddeley (1992) reported partial correlations between nonword repetition and vocabulary of $pr = .467$, $p<.001$ at age 4, $pr = .502$, $p<.001$ at age 5, $pr = .482$, $p<.001$ at age 6, and $pr = .242$, $p<.05$ at age 8, after controlling for age and nonverbal IQ scores. In addition, cross-lagged partial correlations showed that phonological memory skills, as measured by a nonword repetition task, exerted a direct causal influence on vocabulary acquisition between ages 4 and 5. The direction of the causal role shifted by the age of 6; cross-lagged partial correlations showed that vocabulary skills played a causal role in subsequent phonological memory development.

Gathercole and Baddeley (1990) found that five-year-old children with low scores on nonword repetition were slower to learn phonologically unfamiliar names than children of the same age with high scores. Children participating in this study were divided into two groups, those who had performed well on a nonword repetition task ("high repetition") and those who had scored poorly ("low repetition"). Both groups were taught names of toys over two sessions. Each child was exposed to two different sets of toys; the toys in Group A had familiar names, such as Michael, while the toys in Group B had phonologically unfamiliar names, such as Pimas. The high repetition children were faster at learning the phonologically unfamiliar names than the low repetition children [$F(1,35) = 5.000$, MSE = 9.087, $p<.05$]. In addition to this, children in the low repetition group showed poorer retention of the labels for the toys when asked to identify the toys both expressively and receptively one day later [$F(1,35) = 7.476$, MSE = .072, $p<.01$ and $F(1,35) = 10.219$, MSE = .041, $p<.01$, respectively]. The highest correlate of number of learning trials required to learn both familiar and unfamiliar names was the nonword repetition measure ($r = -.366$, $p<.05$ and $r = -.455$, $p<.05$, respectively). Gathercole and Baddeley concluded that children who perform poorly on nonword repetition tasks are not only impaired in the speed of learning new names, they also are more likely to forget those they have learned.

In a longitudinal study, Gathercole and Baddeley (1989) found that when phonological memory, nonverbal intelligence, and reading were measured, nonword repetition accounted for the greatest amount of variance in vocabulary scores as measured by the short form of the British Picture Vocabulary Test. When the variance accounted for by chronological age and nonverbal intelligence was partialed out, nonword repetition performance still accounted for a significant 15% of the variance in vocabulary scores at age 4 and 21% of the variance at age 5. No variance in vocabulary scores was uniquely accounted for by reading ability as measured the by the British Abilities Scale Reading Test. In addition, nonword repetition scores at age 4 were highly correlated with vocabulary at age 5, accounting for 33% of the variance. Hierarchical regression analyses showed that, after accounting for nonverbal intelligence and age 4 vocabulary skills, nonword repetition performance at age 4 still accounted for 8% of the variance in vocabulary scores at age 5.

Masoura and Gathercole (1999) explored the relations between nonword repetition performance and foreign and native vocabulary knowledge. The participants in this study were Greek children with a mean age of 10 years 3 months. Both native and foreign vocabulary scores were significantly correlated with the nonword repetition measure [$r(43) = .50$, $p<.001$ and $r(43) = .36$, $p<.05$, respectively]. These correlations remained significant even after chronological age, nonverbal ability, and length of time spent studying English were partialed out. Knowledge of foreign vocabulary was associated with nonword repetition independently both of general factors and also of vocabulary competence in the native language [$pr(43) = .32$, $p<.05$]. However, when foreign vocabulary scores were partialed out, native vocabulary scores no longer maintained a significant relation with nonword repetition [$pr(43) = .30$, $p>.05$]. These findings lend support to the hypothesis that learning of new or foreign vocabulary may be dependent upon phonological memory skills. There is more opportunity for support from the lexicon in the learning of native words, and this may reduce the dependency on phonological short-term memory.

A theory put forth by Baddeley, Papagno, and Vallar (1988) provides a viable explanation of the role of phonological memory in vocabulary development. According to this theory, the role of phonological memory is to store unfamiliar strings of phonemes long enough for them to be encoded. If the phonological form of new items tends to be imprecise or unstable, more extensive exposure might be necessary to retain accurate representations of lexical items (Brady, 1997). This inefficient memory process results in the slow acquisition of new vocabulary words. These difficulties with nonword repetition reflect the indistinct representations arrived at via inefficient phonological memory skills (Elbro, 1996).

What Nonword Repetition Purports to Measure

Nonword repetition tasks are usually considered to be measures of phonological memory. However, it seems likely that performance on nonword repetition tasks is determined by multiple processes. Successful repetition requires the stimulus to be accurately perceived, encoded, remembered, retrieved, and articulated (Brady, 1997; Elbro, 1996). Processes of particular interest in the present study are encoding via phonological representations and lexical representations, and speech output.

Phonological Representations

Regardless of the multiple skills that may be necessary for successful nonword repetition, it is widely accepted that phonological memory plays an important role. Some researchers have suggested that poor nonword repetition performance may be caused by difficulties in creating or utilizing phonological codes to encode and store information (Brady, 1991; Elbro, 1996; Hulme & Snowling, 1992; Liberman, Shankweiler, & Liberman, 1989; Torgesen, 1985, 1988).

Elbro (1996) presented the distinctness hypothesis, which provides a view of impoverished phonological representations. 'Distinctness' refers to the magnitude of difference between a lexical representation and its neighbors. The more distinctive features that separate a representation from its neighbors, the more distinct is the

representation. Indistinct representations of words and nonwords are probably more difficult to remember, to recall, and to articulate than distinct representations.

The Role of Lexical Representations

Repetition of nonsense words is considered a better measure of phonological memory than similar tasks using real words because, in theory, performance will not be influenced by a test-taker's vocabulary knowledge (Gathercole & Baddeley, 1990). Although it has been assumed that using nonwords eliminates a role for lexical representations, this assumption appears to be in error. To illustrate this point, Dollaghan, Biber, and Campbell (1993,1995) created 24 pairs of nonwords, each member of a given pair differing only by one phoneme in the stressed syllable. Within a pair, this changed phoneme resulted in the stressed syllable of one nonword corresponding to an English word, while the stressed syllable of the other pair member was a nonsense word. Dollaghan and her colleagues found that nonwords with stressed syllables corresponding to real words were repeated significantly more accurately than those that were truly "nonsensical." From these studies, they concluded that the lexical status of the stressed syllable of a nonword can in fact influence nonword repetition performance. In accordance with a model put forth by Hulme, Maughan, and Brown (1991), Dollaghan et al. hypothesize that the real-word constituent syllables are already represented in the lexicon. Because of this, more working memory resources are available to perceive, remember, and reproduce these more "word-like" nonsense words.

These findings prompted Dollaghan and Campbell (1998) to develop guidelines for constructing a nonword repetition task that is less likely to utilize lexical representations already stored in long-term memory. Their goal was to devise a task that would be equally unfamiliar to all children, thus reducing bias against minorities and other test-takers with differing experiential backgrounds. In their study, nonwords consisting of one, two, three, and four syllables were used. All syllables followed a consonant-vowel-consonant (CVC) pattern. None of the nonwords or their constituent syllables corresponded to real English words, and the "late eight" consonants (z, l, s, r, sh, z, and both 'th' sounds) and lax vowel sounds were excluded. A lax vowel sound is short in duration and requires relatively little muscle activity to produce (Shriberg & Kent, 1995). Lax vowel sounds were excluded because they are more likely to be reduced to a schwa than tense vowel sounds. To reduce the predictability of the nonword structure, consonants occupied only those positions (initial, medial, or final) in which they occur less than 25% of the time in English words. No phoneme was used more than once in each nonword. Finally, the nonword repetition task was administered with careful attention to a consistent rate and intonation. Children previously identified as having language impairments had significantly lower scores on the three- and four-syllable nonwords than children with normally developing language skills. Unlike traditional language tests, the scores of the African-American test-takers did not differ significantly from those of Caucasian participants.

Differences among nonwords that might encourage or discourage the influence of existing lexical representations have also been a concern for those studying nonword

reading as opposed to nonword repetition. For example, Treiman, Goswami, and Bruck (1990) questioned whether lexical representations influence nonword reading performance. All nonwords used in this study consisted of one syllable adhering to a consonant-vowel-consonant (CVC) pattern. The VC portions of the nonwords were the focus of the study. Half of the stimuli contained VC's that had many "neighbors" in the English language, meaning that there are several words that differ from the nonword by one letter in the initial position of the syllable. The other half had few, if any, neighbors. For example, the nonword 'tain' has several neighbors (main, rain, train, etc.) whereas 'goan' has few neighbors (not many real words end in 'oan'). Treiman and her colleagues found that nonwords sharing their VC's with several real words were read significantly more accurately than nonwords sharing their VC's with few or no English words. This finding was consistent across groups of first graders, third graders, and college students. More lexicalization errors were made on the high-frequency VC's, implying that reading of these nonwords may be influenced by long-term memory processes. It is also interesting to note that poor third grade readers performed better than first graders on nonwords with high-frequency VC's, but worse on nonwords with low-frequency VC's.

The Role of Speech Output

It is important to consider the influence of speech output when interpreting the results of nonword repetition tasks. Because poor readers are more likely to mispronounce long, phonologically complex words (Brady, 1997), it is not surprising that this group typically performs less well on nonword repetition tasks. However, speech output may still be an important factor in nonword repetition performance beyond that accounted for by articulation.

Hulme and Snowling (1992) questioned whether less-skilled readers' poor nonword repetition performance is a consequence of speech output difficulties. To test this, a nonword repetition task and a nonword discrimination task were administered to a 13-year-old developmental dyslexic referred to as JM and to reading-age matched control children. The nonword discrimination task consisted of twenty pairs of identical nonwords (bannifer/bannifer) and twenty pairs of nonwords differing by a single phoneme (thickery/shickery). The children were required to determine whether the pairs were identical or different. JM's performance on the discrimination task was virtually perfect; he judged 38 out of 40 items correctly. Reading-age matched controls had a mean score of 36.6 out of 40. However, when JM was asked to repeat the nonwords, his score dropped to 25 correct out of 40. Reading-age matched controls accurately repeated an average of 35.5 out of 40 items. These findings suggest that JM's input processing skills are intact, yet he has a striking deficit in his output phonological processes. This conclusion is further supported by the fact that the storage requirements of the discrimination task are at least as great, if not greater, than those of the repetition task. This implies that his phonological storage capacity is not his main source of difficulty. However, because these results are based on a case study of a child with an extreme case of developmental dyslexia, the results may not necessarily reflect the abilities of a larger,

more typical sample. Ceiling effects may have also played an important role in the outcome of this study; all participants' performances on the nonword comparison task were virtually perfect. Consequently, this task may not have been sensitive to differences in input processing skills. Another important point to consider is that the nonwords used in the discrimination task were the same as those used in Gathercole and Baddeley (1989), and therefore could be considered to be too word-like in light of the research of Dollaghan and Campbell (1998) and Treiman, Goswami, and Bruck (1990).

Gathercole et al. (1999) also administered nonword comparison and nonword repetition tasks to four-year-old children. The nonword comparison task consisted of groups of one-syllable nonwords arranged into lists of varying length from one to four syllables. In those cases in which the two nonword strings were different, the lists were changed by switching two of the one-syllable nonwords' positions within the list (mel, guk, vip; guk, mel, vip). The goal of the study was to determine whether speech output skills play a crucial role in nonword repetition performance as it relates to vocabulary acquisition. They found that vocabulary scores were as highly associated with performance on the nonword comparison task as on the nonword repetition task. However, the stimuli in the nonword comparison task differed by syllabic units, not individual phonemes as in Hulme and Snowling's (1992) study. Discriminating between two words differing by larger units, such as syllables, is not as challenging as discriminating between two words differing only by one phoneme (Liberman, Shankweiler, & Liberman, 1989; Treiman, 1985).

The Present Study

The first goal of this study was to determine whether previously reported relations between nonword repetition and both word-level reading and vocabulary might be attributable in part to individual differences in use of lexical representations as opposed to phonological memory per se. As previously noted, Dollaghan and Campbell (1988) reported that the difficulty of nonword repetition varied with how "word-like" the nonword items were. The present study extends this work by attempting to determine whether relations between nonword repetition and both word-level reading and vocabulary are also affected by how word-like the nonword repetition items are.

The stimuli of an experimental nonword repetition task were designed using the guidelines suggested by Dollaghan and Campbell (1998) discussed above. All syllables adhered to the consonant-vowel-consonant (CVC) pattern. None of the nonwords or their constituent syllables corresponded to real English words or letter names, and lax vowel sounds were excluded. No phoneme was used more than once in a given nonword. However, some modifications were made to the criteria suggested by Dollaghan and Campbell (1998). Instead of excluding all of the "late eight" consonants, selection of consonants was based on which phonemes are typically acquired by certain ages (Hoff, 2000). We used consonants typically acquired by age four for the one- and two-syllable stimuli. The three-, four-, five-, and six-syllable nonwords include consonants that are typically acquired by the age of six. The task construction also incorporated the findings

of Treiman, Goswami, and Bruck's (1990) research; all stressed syllables in the nonwords were made up of low-frequency VC units.

Relations between the experimental nonword repetition and word-level reading and vocabulary were compared to those for a nonword repetition task with more word-like items. The word-like nonword repetition task was designed specifically for this study. It consisted of nonwords differing from real words by one phoneme (ex. binosaur). The real words from which these word-like nonwords were chosen using Word Express (Stembach & Williams, 1988), which provides lists of words commonly acquired by first grade. The experimental nonword repetition task was also compared to the CTOPP nonword repetition subtest to determine the predictive differences between a task that fully adheres to the criteria discussed above and a task that adheres to some criteria, yet more than is adhered to by the word-like task.

The second goal of the present study was to determine whether previously reported relations between nonword repetition and both word-level reading and vocabulary might be attributable in part to individual differences in the speech-output component of the task as opposed to phonological memory per se. Although the two previous studies discussed above (Hulme & Snowling, 1992; Gathercole et al. 1999) attempted to remove the speech output component of the nonword repetition task, the flaws noted make the results equivocal. To answer this question, an experimental nonword comparison task that did not require speech output was administered. The task required a child to indicate whether a pair of presented nonwords was identical or not. In those cases in which the two nonwords in a given pair were different, the target nonword is changed by one phoneme. The original phoneme was replaced by one of the same manner of articulation (Shriberg & Kent, 1995). This should result in a more difficult task because the perceptual differences between the phonemes were not striking.

As Gathercole, Willis, Emslie, and Baddeley (1992) noted in the study discussed earlier, phonological memory skills, as measured by a nonword repetition task, exerted a direct causal influence on vocabulary skill between ages 4 and 5. However, this causal role seemed to shift by the age of 6; Gathercole et al. showed that vocabulary skills become increasingly significant in phonological memory development. In light of this finding, relations between the different nonword repetition tasks and comparison task and both reading and vocabulary were examined for both kindergarten and second grade participants.

Finally, because the experimental nonword repetition task was newly created for the present study, its psychometric properties were evaluated. Coefficient alpha was used to assess the internal consistency reliability. Correlations between the experimental nonword repetition task and the nonword repetition subtest of the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999) were used to examine concurrent validity.

METHOD

Participants

The participants in the study were 115 kindergartners ranging in age from 5 years and 2 months with a mean age 6 years, 1 month, and 105 second graders ranging in age from 7 years and 2 months to 9 years and 3 months with a mean age 8 years, 0 months. A power analysis indicated that 98 participants would be required to detect an increase in variance accounted for of ten percent from the restricted to the full model in a hierarchical regression analysis, the method of analysis that was used. The power analysis was conducted using a desired power level of .80 and an alpha of .05.

The students were recruited from local elementary schools. All participants were native speakers of English. The study was conducted at the end of the fall semester and at the beginning of the spring semester. The participants' teachers were given $10 for each child who participated to be used for classroom materials.

Boys made up 49% of the kindergarten sample. This sample was 70% Caucasian, 17% African American, 10% Asian American, and 2% Middle Eastern. The remaining 1% were described as "other" by their schools. Boys made up 47% of the second grade sample. This sample was 76% Caucasian, 18% African American, 2% Asian American, and 1% Middle Eastern. The remaining 3% were described as "other" by their schools.

Measures

Experimental nonword repetition task

The task consisted of eighteen nonwords ranging from one syllable to six syllables in length. The following instructions were read to the students prior to testing:

> Do you know I can say some made-up words? I bet you can, too. I'm going to say a made-up word and then I want you to say it just like I did. Even if it is hard to say, give it your best try. I'm going to record what you say on my tape recorder. Listen to this one.

Before beginning the task, the child completed three practice items. If the child responded incorrectly, the experimenter corrected the child and encourage the child to attempt the practice item a second time. No corrective feedback was given on the test items. Each test item was read aloud one time by the experimenter. Testing stopped when the child responded incorrectly to four items in a row.

The nonwords adhered to the criteria suggested by Dollaghan and Campbell (1998) as discussed above. In accordance with the findings of Treiman, Goswami, and Bruck (1990), the VC units of the stressed CVC syllables are low-frequency. A copy of this task is included in Appendix A.

Word-like nonword repetition task

This nonword repetition task consisted of 13 nonwords differing from real words by only one phoneme. The test items were created by replacing the initial phoneme of a real word with a different phoneme of the same class.

Before beginning the test, the child completed three practice items. Corrective feedback was given for the practice items when necessary. Each item was read aloud one time by the experimenter. Testing stopped when the child responded incorrectly to four items in a row. A copy of this task is included in Appendix B.

Experimental nonword comparison task

The nonword comparison task consisted of the same 18 nonwords as the experimental nonword repetition task. Half of the original nonwords were paired with identical nonwords, and the other half were paired with nonwords differing by one phoneme. The task required the child to determine whether the two nonwords were the same or different. The following instructions were read to the child prior to testing:

> I know some made-up words. I'm going to say two made-up words in a row. Sometimes I will say two words that are the same, and other times I will say two words that are different. I want you to tell me if the made-up words I say are the same or different.

Three practice items were given before testing began. If the child responded incorrectly, the experimenter corrected the child and encouraged the child to try a second time. No corrective feedback was given on the test items.

Each of the nonword pairs were read aloud one time by the experimenter. Testing stopped when the child responded incorrectly to four items in a row. A copy of this task is included in Appendix C.

Woodcock-Johnson Letter-Word Identification

The Letter-Word Identification subtest of the Woodcock-Johnson III Test of Achievement (Woodcock, McGrew, & Mather, 2001) was used to assess letter recognition and sight word efficiency. The student was required to expressively and

receptively identify letters as well as read printed words. Testing stopped when the child responded incorrectly to 6 items in a row, provided that those 6 items are at the end of a page.

Woodcock-Johnson Word Attack

The Word Attack subtest of the Woodcock-Johnson III Test of Achievement (Woodcock, McGrew, & Mather, 2001) was used to assess letter sound identification skills and phonemic decoding efficiency. The child was required to expressively and receptively identify letter sounds as well as decode printed nonwords. Testing stopped when the child responded incorrectly to the last 6 items in a given set.

Expressive vocabulary test

The Expressive One-Word Picture Vocabulary Test – Revised (Academic Therapy Publications, 2000) was used to assess participants' expressive vocabulary skill. This task required students to orally identify pictured items. Testing stopped when the child identified six consecutive pictures incorrectly.

CTOPP Nonword Repetition

The nonword repetition subtest of the Comprehensive Test of Phonological Processing (CTOPP) (Wagner, Torgesen, & Rashotte, 1999) was administered. This test consisted of 20 nonwords. Testing stopped when the child missed three items in a row.

Procedure

All tasks were administered individually. Each child completed the battery over two or three testing sessions on different days. There were two reasons for this. First, administering the tasks in short sessions can decrease students' boredom and promote optimal performance. Second, the nonwords used in the experimental nonword repetition task and the experimental nonword comparison task are the same. Administering these two experimental tasks on different days decreased the learning effect on nonword comparison task performance.

The order of administration of tasks was held constant across all children. The order of task administration during the first testing session included the experimental nonword repetition task, Woodcock-Johnson III Letter-Word Identification, and the CTOPP Nonword Repetition subtest. The order of task administration during the second

testing session included the nonword comparison task, Woodcock-Johnson III Word Attack, Expressive One-Word Picture Vocabulary Test, and the word-like nonword repetition test.

RESULTS AND DISCUSSION

Preliminary Analyses

Outliers were identified using the median plus or minus two interquartile ranges criterion. This method revealed 24 outliers at the kindergarten level (3 on the experimental nonword repetition task, 5 on word identification, 3 on the CTOPP nonword repetition task, 4 on word attack, 1 on vocabulary, 2 on the word-like nonword repetition task, 4 on elision, and 3 on the nonword comparison task). Nineteen outliers were found at the second grade level (1 on the experimental nonword repetition task, 10 on word identification, 1 on the CTOPP nonword repetition task, 1 on vocabulary, 3 on the word-like nonword repetition task, and 6 on the nonword comparison task). All outliers were brought back to the fence (outlier scores were substituted with a value equal to the median plus or minus two interquartile ranges, depending on whether they were high or low).

The distributions for the word-like nonword repetition task were somewhat negatively skewed at both grade levels, indicating that some children had reached ceiling level on this task. To improve the distribution, the data were reflected, then a square root transformation was employed. None of the other distributions needed to be transformed.

Data for the two grade levels were examined separately. The correlations, means, and standard deviations for the tasks are provided in Tables 1 (kindergarten) and 2 (second grade). Second graders performed significantly better than the kindergarteners on all measures. Across ages, children showed adequate variability on the tasks.

All measures were significantly correlated at the kindergarten level, with the exception of the correlation between the CTOPP nonword repetition and One-Word Vocabulary tasks. There were fewer significant correlations between the tasks at the second grade level. At the second grade level, the experimental nonword repetition task was significantly correlated only with the CTOPP nonword repetition task, the word-like nonword repetition task, and the nonword comparison task. The CTOPP nonword repetition task was significantly correlated with the word-like nonword repetition task. The word-like nonword repetition task was significantly correlated with the vocabulary task and nonword comparison, while the nonword comparison task was significantly correlated with word attack and elision.

Table 1

Descriptive Statistics and Correlations – Kindergarten (N = 115)

Task	1	2	3	4	5	6	7	8
1. Experimental Nonword Repetition	1.00							
2. Word Identification	.26**	1.00						
3. CTOPP Nonword Repetition	.58**	.21*	1.00					
4. Word Attack	.28**	.79**	.28**	1.00				
5. One-Word Vocabulary	.19*	.58**	.12	.50**	1.00			
6. Word-like Nonword Repetition	.58**	.33**	.55**	.39**	.21*	1.00		
7. Elision	.25**	.56**	.31**	.60**	.46**	.33**	1.00	
8. Nonword Comparison	.23*	.27**	.21*	.29**	.36**	.19*	.21*	1.00
M	8.20	20.8	9.44	5.37	65.77	15.35	5.29	24.75
SD	2.26	5.17	2.65	2.94	13.44	2.11	3.01	4.12

* $p < .05$. ** $p < .01$

Table 2

Descriptive Statistics and Correlations – Second Grade (N = 105)

Task	1	2	3	4	5	6	7	8
1. Experimental Nonword Repetition	1.00							
2. Word Identification	.11	1.00						
3. CTOPP Nonword Repetition	.55**	.01	1.00					
4. Word Attack	.15	.61**	.18	1.00				
5. One-Word Vocabulary	.18	.21*	.13	.17	1.00			
6. Word-like Nonword Repetition	.36**	.01	.33**	.16	.30**	1.00		
7. Elision	.18	.43**	.11	.52**	.38**	.10	1.00	
8. Nonword Comparison	.35**	.19	.19	.20*	.15	.38**	.31**	1.00
M	9.87	40.22	11.05	18.23	84.20	16.85	11.62	29.10
SD	2.20	9.91	2.44	5.99	12.62	1.39	4.61	2.98

* $p < .05$. ** $p < .01$.

The reliabilities of the experimental nonword repetition task, the word-like nonword repetition task, and the nonword comparison task for both grade levels are provided in Table 3. The reliability of the CTOPP nonword repetition task was .75 for kindergarten and .65 for second grade. It is important to note that the reliabilities of the three experimental tasks were comparable to those of the CTOPP, and that the nonword comparison task did not suffer from a lack of reliability associated with the yes or no format. Correlations between the CTOPP nonword repetition task and the experimental nonword repetition task were used to evaluate concurrent validity. At the kindergarten level, the relation between the two tasks was .58. At the second grade level, the correlation was .55. These values support the concurrent validity of the experimental nonword repetition task. In summary, the psychometric properties of the newly created nonword repetition task appeared to be sufficient for its use in the present study.

Table 3

Reliabilities of the Experimental Tasks

Task	Kindergarten	Second Grade
Experimental Nonword Repetition	.68	.64
Word-like Nonword Repetition	.71	.67
Nonword Comparison	.81	.69

Evaluating the Influence of Lexical Knowledge on Relations Between Nonword Repetition and Reading-Related Skills

Analyses were conducted to compare the experimental nonword repetition task, the CTOPP nonword repetition task, and a word-like nonword repetition task. The purpose was to determine whether previously reported relations between nonword repetition and both word-level reading and vocabulary might be attributable in part to individual differences in use of lexical representations as opposed to phonological memory per se. Three different nonword repetition tasks were administered to the participants: the experimental nonword repetition task, which adheres to the criteria put forth by Dollaghan & Campbell (1998) and Treiman, Goswami, & Bruck (1990), the

CTOPP nonword repetition task, which adheres to approximately 50% of the criteria, and the word-like nonword repetition task, which adheres to none of the criteria.

Comparing the Experimental Nonword Repetition Task to the Word-like Nonword Repetition Task

A series of hierarchical regression analyses was conducted to test whether word-like nonword repetition accounted for variance above that accounted for by the experimental nonword repetition task. The dependent variables in these analyses were word reading, nonword reading, and vocabulary. It was hypothesized that, if the word-like nonword repetition task accounted for variance above that accounted for by the experimental nonword repetition task, the relations between nonword repetition and the dependent variables are affected by lexical knowledge. The beta values as well as the R^2 and ΔR^2 values can be found in Tables 4 (kindergartners) and 5 (second graders).

The relation between word reading and the experimental nonword repetition task at the kindergarten level was small but significant; the experimental nonword repetition task accounted for 7% of the variance in word reading. The addition of the word-like nonword repetition task resulted in a significant 5% increase in variance accounted for. The relation between nonword reading and the experimental nonword repetition task was also small but significant at the kindergarten level; in this analysis, the experimental nonword repetition task accounted for 8% of the variance in nonword reading. The addition of the word-like nonword repetition task to the equation resulted in an 8% increase in variance accounted for. These findings suggest that, at the kindergarten level, the experimental nonword repetition task taps a skill that is involved in word reading and nonword reading. However, because the word-like nonword repetition task accounted for variance above that accounted for by the experimental nonword repetition task when word reading and nonword reading were the dependent variables, we can conclude that the relations between nonword repetition and these dependent variables can be attributed in part to lexical knowledge at the kindergarten level.

Lexical knowledge is an important factor in reading performance; therefore, additional analyses were conducted to control for vocabulary when word reading and nonword reading were the dependent variables. The beta values as well as the R^2 and ΔR^2 values for these analyses at the kindergarten level can be found in Table 6. Vocabulary accounted for a significant 34% of the variance in word reading and a significant 25% of the variance in nonword reading at the kindergarten level. The addition of the experimental nonword repetition task resulted in a significant 3% increase in variance accounted for in word reading and a significant 5% of variance accounted for in nonword reading. The addition of the word-like nonword repetition task did not result in a significant increase in variance accounted for in word reading. However, the addition of the word-like nonword repetition task did result in a significant 5% increase in variance accounted for in nonword reading. This suggests that lexical knowledge accounts for significant variance in both word reading and nonword reading. However, the experimental nonword repetition task still accounts for some significant variance in these dependent variables, even after controlling for vocabulary. Because the word-like nonword repetition task did not account for significant variance in word reading after

controlling for vocabulary and experimental nonword repetition task performance, but it did account for significant variance before controlling for vocabulary, we can conclude that vocabulary accounted for all of the variance associated with lexical knowledge that had been accounted for by the word-like nonword repetition task in the initial analysis.

The relation between vocabulary and the experimental nonword repetition task was small but significant at the kindergarten level; the experimental nonword repetition task accounted for 4% of the variability in vocabulary skill. Unlike the analyses with word reading and nonword reading as the dependent variables, the addition of the word-like nonword repetition task did not result in a significant increase in the equation with vocabulary as the dependent variable. Because the word-like nonword repetition task did not account for additional variance above that accounted for by the experimental nonword repetition task when vocabulary was the dependent variable, it appears that the relation between the experimental nonword repetition task and vocabulary was not affected by lexical knowledge.

The relations between the experimental nonword repetition task and all three dependent variables (word reading, nonword reading, and vocabulary) were not significant at the second grade level. This suggests that the abilities measured by the experimental nonword repetition task are related to word and nonword reading as well as vocabulary at a younger age (kindergarten), but these abilities become less important for these skills as children develop.

Comparing the Experimental Nonword Repetition Task to the CTOPP Nonword Repetition Task

A series of hierarchical regression analyses was conducted to test whether the CTOPP nonword repetition task accounted for variance above that accounted for by the experimental nonword repetition task. The beta values as well as the R^2 and ΔR^2 values can be found in Tables 7 (kindergartners) and 8 (second graders).

As mentioned previously, the relations between the three dependent variables (word reading, nonword reading, and vocabulary) and the experimental nonword repetition task were all significant at the kindergarten level, even after controlling for vocabulary (see Table 9 for beta values and the R^2 and ΔR^2 values). The addition of the CTOPP nonword repetition task did not result in a significant increase in any of these equations. Also mentioned previously, the relations between the dependent variables and the experimental nonword repetition task were not significant at the second grade level.

It was hypothesized that, if the CTOPP nonword repetition task accounted for variance above that accounted for by the experimental nonword repetition task, the predictive power of CTOPP task may be attributable in part to lexical influences. Because it did not account for significant variance above that accounted for by the experimental task, we can conclude that the CTOPP is sufficiently "nonword-like." Differences between the CTOPP nonword repetition task and the experimental nonword repetition task will be discussed in the next section.

Table 4

Hierarchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the Word-like Nonword Repetition Task: Kindergartners (N = 115)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Experimental Nonword Repetition	.60	.21	.26	.07**		.37	.12	.28	.08**		1.11	.55	.19	.04*	
Step 2															
Experimental Nonword Repetition	.25	.25	.11			.11	.14	.09			.56	.67	.09		
Word-like Nonword Repetition	-2.50	1.04	-.26	.12*	.05*	-1.83	.58	-.34	.16**	.01**	-3.91	2.79	-.16	.05	.01

$p < .05$. ** $p < .01$

Table 5

Hierarchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the Word-like Nonword Repetition Task: Second Graders (N = 105)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Experimental Nonword Repetition	.49	.44	.11	.01		.41	.27	.15	.02		1.03	.56	.18	.03	
Step 2															
Experimental Nonword Repetition	.58	.48	.13			.28	.28	.10			.47	.58	.08		
Word-like Nonword Repetition	1.30	2.42	.06	.01	.00	-1.74	1.45	-.13	.03	.01	-7.86	2.96	-.27	.09**	.06

* $p < .05$. ** $p < .01$.

Table 6

Hiearchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the Word-like Nonword Repetition Task: Controlling for Vocabulary (Kindergartners, N = 115)

Variable	Word Reading					Nonword Reading				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1										
Vocabulary	.22	.03	.58	.34**		.11	.02	.50	.25**	
Step 2										
Vocabulary	.21	.03	.55			.10	.02	.47		
Experimental Nonword Repetition	.37	.18	.16	.36*	.03*	.26	.11	.20	.30*	.05*
Step 3										
Vocabulary	.21	.03	.53			.10	.02	.44		
Experimental Nonword Repetition	.14	.21	.06			.06	.12	.05		
Word-like Nonword Repetition	-1.70	.88	-.18	.38	.02	-1.45	.52	-.27	.34**	.04**

* $p < .05$. ** $p < .01$.

Table 7

Hierarchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the CTOPP Nonword Repetition Task: Kindergartners (N = 115)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Experimental Nonword Repetition	.60	.21	.26	.07**		.37	.12	.28	.08**		1.11	.55	.17	.04*	
Step 2															
Experimental Nonword Repetition	.50	.25	.22			.24	.14	.19			1.03	.68	.17		
CTOPP Nonword Repetition	.16	.22	.08	.07	.00	.19	.12	.17	.10	.02	.12	.58	.02	.04	.00

* $p < .05$. ** $p < .01$.

Table 8

Hierarchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the CTOPP Nonword Repetition Task: Second Graders (N = 105)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Experimental Nonword Repetition	.49	.44	.11	.01		.41	.27	.15	.02		1.03	.56	.18	.03	
Step 2															
Experimental Nonword Repetition	.66	.53	.15			.20	.32	.07			.87	.67	.15		
CTOPP Nonword Repetition	-.29	.48	-.07	.02	.01	.34	.29	.14	.04	.02	.25	.60	.05	.03	.00

* $p < .05$. ** $p < .01$.

Table 9

Hierarchical Regression Analyses Comparing the Experimental Nonword Repetition Task to the CTOPP Nonword Repetition Task: Controlling for Vocabulary (Kindergartners, N = 115)

Variable	Word Reading					Nonword Reading				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1										
Vocabulary	.22	.03	.58	.34**	.34	.11	.02	.50	.25**	
Step 2										
Vocabulary	.21	.03	.55			.10	.02	.47		
Experimental Nonword Repetition	.37	.18	.16	.36*	.02*	.26	.11	.20	.30*	.04*
Step 3										
Vocabulary	.21	.03	.55			.10	.02	.47		
Experimental Nonword Repetition	.28	.21	.12			.14	.13	.11		
CTOPP Nonword Repetition	.13	.18	.07	.37	.01	.18	.11	.16	.31	.01

* $p < .05$. ** $p < .01$.

Comparing the CTOPP Nonword Repetition Task to the Word-like Nonword Repetition Task

A series of hierarchical regression analyses was conducted to test whether the word-like nonword repetition task accounted for variance above that accounted for by the CTOPP nonword repetition task. The beta values as well as the R^2 and ΔR^2 values can be found in Tables 10 (kindergartners) and 11 (second graders). The relation between word reading and the CTOPP
nonword repetition task was significant at the kindergarten level, with the CTOPP task accounting for 4% of the variance in word reading. The addition of the word-like nonword repetition task to the equation resulted in a significant 6% increase in variance accounted for. The relation between nonword reading and the CTOPP nonword repetition task as the only predictor was also significant, with the CTOPP task accounting for 7% of the variance. The addition of the word-like nonword repetition task to the equation resulted in a significant 8% increase in variance accounted for. The relation between vocabulary and the CTOPP nonword repetition task was not significant at the kindergarten level.

As we expected, performance on the word-like nonword repetition task appeared to be more influenced by the use of lexical representations than is performance on the CTOPP subtest when word reading and nonword reading are the dependent variables. Because the word-like nonword repetition task accounted for variance above that accounted for by the CTOPP nonword repetition task when word reading and nonword reading were the dependent variables, we can conclude that the relations between nonword repetition and these dependent variables are by inflated lexical knowledge. It is surprising, however, that the relation between the CTOPP task and vocabulary was not significant.

Because reading skill is dependent upon lexical knowledge, additional analyses controlling for vocabulary were conducted. The beta values as well as the R^2 and ΔR^2 values for these analyses at the kindergarten level can be found in Table 12. Vocabulary accounted for a significant 34% of the variance in word reading and a significant 25% of the variance in nonword reading. The addition of the CTOPP nonword repetition task did not result in a significant increase in variance accounted for in word reading skill. The CTOPP nonword repetition task did account for an additional 5% in variance in nonword reading, and the word-like nonword repetition task accounted for a further 4% increase in variance accounted for. This suggests that the CTOPP did not account for significant variance in word reading skill after controlling for vocabulary, but it did account for significant variance in nonword reading. Furthermore, the word-like task accounts for a small but significant portion of the variance after controlling for vocabulary and CTOPP nonword repetition task performance. These results mirror those of the analyses discussed in the previous section with the experimental nonword repetition task entered into the regression equation before the word-like task.

Table 10

Hierarchical Regression Analyses Comparing the CTOPP Nonword Repetition Task to the Word-like Nonword Repetition Task: Kindergartners (N = 115)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
CTOPP Nonword Repetition	.40	.18	.21	.04*		.31	.10	.28	.08**		.63	.47	.12	.02	
Step 2															
CTOPP Nonword Repetition	.07	.21	.04			.10	.12	.09			.05	.56	.01		
Word-like Nonword Repetition	-2.91	1.01	-.31	.11**	.07**	-1.83	.56	-.34	.16**	.08**	-5.14	2.72	-.21	.05	.03

* $p < .05$. ** $p < .01$.

Table 11

Hierarchical Regression Analyses Comparing the CTOPP Nonword Repetition Task to the Word-like Nonword Repetition Task: Second Graders (N = 105)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
CTOPP Nonword Repetition	.04	.4	.01	.00		.44	.24	.18	.03		.68	.51	.13	.02	
Step 2															
CTOPP Nonword Repetition	.05	.43	.01			.35	.25	.14			.20	.52	.04		
Word-like Nonword Repetition	.34	2.41	.02	.00	.00	-1.61	1.42	-.12	.04	.01	-8.36	2.93	-.29	.09**	.07

* $p < .05$. ** $p < .01$.

Table 12

Hierarchical Regression Analyses Comparing the CTOPP Nonword Repetition Task to the Word-like Nonword Repetition Task: Controlling for Vocabulary (Kindergartners, N = 115)

Variable	Word Reading					Nonword Reading				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1										
Vocabulary	.22	.03	.58	.34**		.11	.02	.50	.25**	
Step 2										
Vocabulary	.22	.03	.57			.10	.02	.48		
CTOPP Nonword Repetition	.27	.15	.14	.36	.02	.24	.09	.22	.30**	.05**
Step 3										
Vocabulary	.21	.03	.54			.10	.02	.44		
CTOPP Nonword Repetition	.06	.17	.03			.10	.10	.09		
Word-like Nonword Repetition	-1.86	.86	-.20	.38*	.03	-1.34	.51	-.25	.34**	.04**

* $p < .05$. ** $p < .01$.

The relations between the three dependent variables (word reading, nonword reading, and vocabulary) and the CTOPP nonword repetition task as the only independent variable were not significant at the second grade level. The developmental differences between kindergartners and second graders are once again highlighted by this set of analyses.

Developmental Differences in the Influence of Lexical Knowledge on Nonword Repetition Task Performance

Because the sample in this study included both kindergartners and second graders, it was possible to address questions pertaining to developmental differences. Differences in the prediction accuracy of the nonword repetition task between kindergartners and second graders were examined by conducting three hierarchical regression analyses with word reading, nonword reading, and vocabulary as the dependent variables. Although most of the hierarchical regression analyses discussed previously indicated that there are differences between kindergartners and second graders, interaction terms of grade by experimental nonword repetition task score did not account for additional significant variance after controlling for grade and experimental nonword repetition task score. These analyses indicated that there were no predictive differences between the two grade levels on the experimental nonword repetition task.

Evaluating the Influence of Speech Output on Experimental Nonword Repetition Performance

A series of hierarchical regression analyses was conducted to test whether the experimental nonword repetition task accounted for variance above that accounted for by the nonword comparison task when word reading, nonword reading and vocabulary were dependent variables. The beta values as well as the R^2 and ΔR^2 values can be found in Tables 13 (kindergartners) and 14 (second graders). The relation between word reading and the nonword comparison task was significant at the kindergarten level, with the nonword comparison task accounting for 8% of the variance in word reading. The addition of the experimental nonword repetition task resulted in a significant 4% increase in variance accounted for. The relation between nonword reading and the nonword comparison task was also significant at the kindergarten level, with the nonword comparison task accounting for 8% of the variance in nonword reading. The addition of the experimental nonword repetition task resulted in a significant 5% increase in variance accounted for. The relation between vocabulary and the nonword comparison task was significant, with the nonword comparison task accounting for 13% of the variance in vocabulary at the kindergarten level. The addition of the experimental nonword repetition task did not result in a significant increase in variance accounted for.

Because there is additional significant variance accounted for by nonword repetition beyond that accounted for by nonword comparison when word reading and nonword reading are the dependent variables, speech output factors appear to be contributing to the relations between nonword repetition and these two outcome variables at the kindergarten level. This does not appear to be the case when vocabulary is the dependent variable.

The relations between two of the dependent variables, word reading and vocabulary, and the nonword comparison task were not significant at the second grade level. However, the relation between nonword reading and the nonword comparison task was significant, with the nonword comparison task accounting for 4% of the variance in nonword reading. The addition of the experimental nonword repetition task did not result in a significant increase in variance accounted for. These results suggest that the nonword comparison task taps a skill that is uniquely important to nonword reading, but not word reading or vocabulary skill, at the second grade level. The results also imply that speech output may not be affecting nonword repetition performance at the second grade level when nonword reading is the dependent variable.

Developmental Differences in the Influence of Speech Output on Nonword Repetition Performance

Because the sample contained both kindergartners and second graders, the question of whether the influence of speech output affects nonword repetition performance to different degrees in kindergartners than in second graders was also addressed. Three separate hierarchical regression analyses were conducted with word reading, nonword reading, and vocabulary as the dependent variables. Although most of the hierarchical regression analyses discussed previously indicated that there are differences between kindergartners and second graders, interaction terms of grade by word-like nonword repetition score did not account for additional significant variance after grade, experimental nonword repetition task score, and the interaction term of grade by experimental nonword repetition task score. These analyses indicated that there were no developmental differences in the role of speech output processes between the two grade levels.

Table 13

Hierarchical Regression Analyses Examining the Influence of Speech Output on Nonword Repetition Performance: Kindergartners (N = 115)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Nonword Comparison	.34	.11	.27	.08**		.21	.06	.29	.08**		1.18	.29	.36	.13**	
Step 2															
Nonword Comparison	.28	.11	.23			.17	.06	.24			1.10	.29	.34		
Experimental Nonword Repetition	.49	.21	.21	.12*	.04*	.30	.12	.23	.13*	.05*	.66	.53	.11	.14	.01

$p < .05$. ** $p < .01$.

Table 14

Hierarchical Regression Analyses Examining the Influence of Speech Output on Nonword Repetition Performance: Second Graders (N = 105)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Nonword Comparison	.62	.32	.19	.03		.41	.19	.20	.04*		.65	.41	.15	.02	
Step 2															
Nonword Comparison	.56	.35	.17			.35	.21	.17			.44	.44	.10		
Experimental Nonword Repetition	.22	.47	.05	.04	.01	.24	.28	.09	.05	.01	.82	.59	.14	.04	.02

* $p < .05$. ** $p < .01$

CONCLUSION

Evaluating the Influence of Lexical Knowledge on Relations Between Nonword Repetition and Reading-related Skills

The analyses discussed in the previous section allowed us to assess the influence of lexical knowledge on relations between three different nonword repetition tasks and word reading, nonword reading, and vocabulary skill.

Experimental Nonword Repetition and Word-like Nonword Repetition

The experimental nonword repetition task accounted for significant variance in word identification, word attack, and vocabulary at the kindergarten level. The word-like nonword repetition task accounted for additional significant variance when word identification and word attack were the dependent variables. After controlling for vocabulary, the relation between the experimental nonword repetition task and word identification remained significant, but the word-like task no longer accounted for significant variance. The relations between word attack and both the experimental nonword repetition task and the word-like nonword repetition task remained significant after controlling for vocabulary.

Although the relations between word identification and vocabulary were significant at the second grade level, the relations between the dependent variables and the two nonword repetition tasks (experimental and word-like) were not significant even before controlling for vocabulary.

Because the word-like nonword repetition task accounted for variance above that accounted for by the experimental nonword repetition task when word reading and nonword reading were the dependent variables, we can conclude that the relations between nonword repetition and these dependent variables can be attributed in part to lexical knowledge at the kindergarten level. The word-like nonword repetition task did not account for additional variance above that accounted for by the experimental nonword repetition task when vocabulary was the dependent variable; therefore, it appears that the relation between the experimental nonword repetition task and vocabulary was not affected by lexical knowledge.

The experimental nonword repetition task also accounted for a significant 4% of the variance in vocabulary; however, the percentage of variance accounted for is lower than expected in light of the findings of Gathercole and Baddeley (1989). They found that a significant 21% of the variance in vocabulary was accounted for by nonword

repetition performance. This discrepancy could not be due only to the fact that our stimuli were less word-like. Additional analyses revealed that the word-like nonword repetition task designed specifically for this study, with stimuli that were more word-like than those of Gathercole and Baddeley (1989), accounted only for a significant 5% of the variance in vocabulary at the kindergarten level and a significant 9% of the variance in vocabulary at the second grade level. The beta values as well as the R^2 and ΔR^2 values can be found in Tables 15 (kindergartners) and 16 (second graders). It is also interesting to note that the correlations found in the present study between the new nonword repetition task and vocabulary were much lower at the kindergarten level ($r = .19$, $p<.05$) than those found by Gathercole, Willis, Emslie, & Baddeley (1992) for the same age group ($r = .48$, $p<.001$). At the kindergarten level, the correlations between the word-like nonword repetition task and vocabulary are also lower in our study ($r =.21$, $p<.05$) than in theirs ($r = .48$, $p<.001$). At the second grade level, the correlation between the experimental nonword repetition task and vocabulary was not significant; however, the correlation between the word-like task and vocabulary in our study ($r = .30$, $p<.01$) is higher than in the Gathercole et al. study ($r = .24$, $p<.05$). Gathercole et al. (1992) controlled for age and nonverbal IQ, which could explain why the correlation in the present study was higher.

Experimental Nonword Repetition and the CTOPP Nonword Repetition Task

The experimental nonword repetition task accounted for significant variance in word identification and word attack at the kindergarten level. These relations remained significant after controlling for vocabulary. The relation between vocabulary and the experimental nonword repetition task was also significant. The CTOPP nonword repetition task did not account for additional significant variance in any of the dependent variables. At the second grade level, none of the relations between the experimental nonword repetition task and the three dependent variables were significant.

Because the CTOPP nonword repetition task did not account for significant variance above that accounted for by the experimental task, we can conclude that performance on the CTOPP is not affected by lexical influences; it is sufficiently "nonword-like." It is interesting to note the similarities and differences in the predictive power of the CTOPP nonword repetition task and the experimental nonword repetition task at the kindergarten level. The experimental task accounted for 7% of the variance in word reading, while the CTOPP accounted for 4%. The experimental task accounted for 8% of the variance in nonword reading; similarly, the CTOPP accounted for 7%. The experimental task accounted for 4% of the variability in vocabulary; the relation between the CTOPP task and vocabulary was not significant. These results indicate that the CTOPP task and the experimental task are similar in their predictive ability when nonword reading is the dependent variable. The experimental task is a slightly better predictor when word reading and vocabulary are the dependent variables.

CTOPP Nonword Repetition and the Word-like Nonword Repetition Task

The CTOPP nonword repetition task accounted for significant variance in word identification and word attack at the kindergarten level. After controlling for vocabulary, the relation between word attack and the CTOPP nonword repetition task remained significant, while the relation between word identification and the CTOPP nonword repetition task did not. Before controlling for vocabulary, the word-like nonword repetition task accounted for additional significant variance in both word identification and word attack. After controlling for vocabulary, the word-like nonword repetition task still accounted for an additional significant amount of variance when word attack was the dependent variable. Surprisingly, the relation between the CTOPP nonword repetition task and vocabulary was not significant at the kindergarten level. At the second grade level, none of the relations were significant between the CTOPP nonword repetition task and the three dependent variables.

At the kindergarten level, the word-like nonword repetition task accounted for variance above that accounted for by the CTOPP nonword repetition task when word reading and nonword reading were the dependent variables; this implies that the relations between the CTOPP nonword repetition task and these dependent variables are inflated lexical knowledge. However, the analyses that compared the experimental nonword repetition task to the CTOPP led us to conclude that this task was sufficiently "nonword-like." This renders the results regarding the wordlikeness of the CTOPP nonword repetition task ambiguous.

Evaluating the Influence of Speech Output on Experimental Nonword Repetition Performance

The nonword comparison task accounted for a significant amount of variance in word reading and nonword reading at the kindergarten level. The experimental nonword repetition task accounted for additional significant variance for both dependent variables. The nonword comparison task accounted for significant variance in vocabulary; however, the experimental nonword repetition task did not account for additional significant variance.

Because there is additional significant variance accounted for by nonword repetition beyond that accounted for by nonword comparison when word reading and nonword reading are the dependent variables, speech output factors appear to be contributing to the relations between nonword repetition and these two outcome variables at the kindergarten level. In other words, although nonword repetition tasks are typically used as measures of phonological memory, performance on these tasks may be affected by other factors, specifically individual differences in speech output skills. However, these results should be interpreted with caution. Although both the experimental nonword repetition task and the nonword comparison task were designed to be measures of phonological memory, these two tasks admittedly have different cognitive requirements. Nonword repetition tasks require participants to perceive, encode,

Table 15

Hierarchical Regression Analyses Comparing the Word-like Nonword Repetition Task to the Experimental Nonword Repetition Task: Kindergartners (N = 115)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Word-like NWR	-3.1	.84	-.33	.11**		-2.10	.47	-.39	.15**		-5.26	2.26	-.21	.05*	
Step 2															
Word-like NWR	-2.50	1.04	-.264			-1.83	.58	-.34			-3.91	2.79	-.16		
Experimental Nonword Repetition	.25	. 25	.11	.12	.01	.11	.14	.09	.16	.01	.56	.67	.09	.05	.00

$p < .05$. ** $p < .01$.

Table 16

Hierarchical Regression Analyses Comparing the Word-like Nonword Repetition Task to the Experimental Nonword Repetition Task: Second Graders (N = 105)

Variable	Word Reading					Nonword Reading					Vocabulary				
	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Step 1															
Word-like NWR	.24	2.27	.01	.00		-2.26	1.35	-.16	.03		-8.72	2.75	-.30	.09**	
Step 2															
Word-like NWR	1.30	2.42	.06			-1.74	1.45	-.13			-7.86	2.96	-.27		
Experimental Nonword Repetition	.58	.48	.13	.01	.01	. 28	28.	.10	.04	.01	. 47	.58	.08	.09	.00

* $p < .05$. ** $p < .01$.

remember, retrieve, and articulate the stimuli. While the nonword comparison task also requires participants to perceive and encode the stimuli, the participants do not have to articulate the stimuli; instead, two nonwords must be remembered and compared. This difference between recall and recognition should be considered when interpreting the results of the analyses with the nonword comparison task. Regardless of the differences in task demands, it is interesting to note that the nonword comparison task was more strongly correlated with vocabulary than any of the nonword repetition measures at the kindergarten level. Perhaps the nonword comparison task is a more "pure" measure of phonological memory than nonword repetition tasks.

The nonword comparison task did not account for additional significant variance above that accounted for by the experimental nonword repetition task when vocabulary was the dependent variable. This implies that speech output factors are not affecting the relations between performance on the experimental nonword repetition and vocabulary at the kindergarten level.

At the second grade level, the relations between two of the dependent variables, word reading and vocabulary, and the nonword comparison task were not significant. However, the relation between nonword reading and the nonword comparison task was significant. The addition of the experimental nonword repetition task did not result in a significant increase in variance accounted for. These results suggest that the nonword comparison task taps a skill that is uniquely important to nonword reading, but not word reading or vocabulary skill, at the second grade level. The results also imply that speech output may not be affecting nonword repetition performance at the second grade level when nonword reading is the dependent variable. It is interesting to note that speech output factors appeared to affect the relation between nonword reading and nonword repetition performance at the kindergarten level as well.

Summary

The psychometric properties of the experimental nonword repetition task appeared to be sufficient for the purposes of its uses in the present study. The newly created task was also a reasonably good predictor of word reading, nonword reading, and vocabulary skill, especially at the kindergarten level. However, these relations weren't as strong as expected in light of past research.

Although the experimental nonword repetition task was specifically created to be as nonword-like as possible, there was still some evidence of lexical influence on task performance. It is also important to note that, after controlling for vocabulary, all of the significant relations decreased. This could be an important factor to keep in mind when interpreting the results of any nonword repetition task.

Speech output also appears to play a role in nonword repetition performance, particularly at the kindergarten level. This could be another important factor when interpreting performance on nonword repetition tasks; underestimations of some

children's true phonological memory capacities could result if recall-only measures are used.

Although the results of the hierarchical regression analyses indicated that there were developmental differences in the predictive ability of the experimental nonword repetition task, the role of the lexical influences in nonword repetition performance, and the influence of speech output in nonword repetition performance, the results of the analyses specifically designed to address these developmental differences implied that there were no disparities between the two age groups.

APPENDIX A

Nonword Repetition

Child's Number: _____

Date: _____

Materials: None
Ceiling: 4 incorrect responses in a row
Scoring: 1 for correct response, 0 for incorrect response
Note: Do not repeat an item unless there is a disruption or distraction.
All vowels are long unless otherwise noted.

DIRECTIONS:

Do you know I can say some made-up words? I bet you can, too. I'm going to say a made-up word and then I want you to say it just like I did. Even if it is hard to say, give it your best try. I'm going to record what you say on my tape recorder. Listen to this one.

Practice Items: If the child answers a practice item incorrectly, repeat the item and encourage the child to try again.

A. dap _____
B. meg _____
C. ni-lop _____

Test Items: Do not give feedback on test items. Score (1 or 0)

1. nib _____
2. teg _____
3. tof (short o) _____

For items 6-15, stress first syllable:

4. taw'-foig _____
5. ni'-mof _____
6. do'-buk (short o) _____

7. va'-foi-mub _____
8. ta'-cho-sik _____
9. noi'-gaw-jef _____

For items 10-12, stress second syllable:

10. taw-moi'-fo-bok (1st o short) _____
11. zo-che'-bu-dig (short o) _____

12. cha-hoi'-ge-sob _____

For items 13-18, stress 3rd syllable:

13. vo-cho-ta'-foi-dej (1st o short) _____
14. loi-yi-cho'-do-fash (2nd o short) _____
15. naw-fu-ji'-bo-chap (short o) _____

16. re-jo-gaw'-cha-doi-fib _____
17. va-che-haw'-yi-fu-gois _____
18. loi-ji-daw'-fa-ge-zos _____

APPENDIX B

Word-like Nonword Repetition Task

Child's Number: _____
Date: _____

Materials: None
Ceiling: 4 incorrect responses in a row
Scoring: 1 for correct response, 0 for incorrect response
Note: Do not repeat a test item unless there is a disruption or distraction.

DIRECTIONS:

Do you know I can say some made-up words? I bet you can, too. I'm going to say a made-up word and then I want you to say it just like I did. Even if it is hard to say, give it your best try. I'm going to record what you say on my tape recorder. Listen to this one.

Practice Items: If the child answers a practice item incorrectly, repeat the item and encourage the child to try again.

A. ged ('bed') _____
B. shan ('fan') _____
C. tane ('cane') _____

Test Items: Do not give feedback on test items. Score (1 or 0)

1. gat ('cat') _____
2. zeet ('feet') _____
3. vall ('fall') _____

4. yotter ('water') _____
5. shellow ('hello') _____
6. vower ('shower') _____

7. famburger _____
8. danana _____
9. binosaur _____

10. pelevision _____
11. tindergarten _____
12. zymnasium _____

13. lefrigerator _____

APPENDIX C

Nonword Comparison

Child's Number:_____
Date:_____

Materials: None
Ceiling: 4 incorrect responses in a row
Scoring: 1 for correct response, 0 for incorrect response
Note: Do not repeat an item unless there is a disruption or distraction.
All vowels are long unless otherwise noted.

DIRECTIONS

I know some made-up words. I'm going to say two made-up words in a row. Sometimes I will say two words that are the same, and other times I will say two words that are different. I want you to tell me if the made-up words I say are the same or different.

Practice Items: If the child answers a practice item incorrectly, repeat the item and encourage the child to try again.

D. dape	dage	_____
E. meeg	(same)	_____
F. nie-lope	nie-mope	_____

Test Items:	Do not give feedback on test items.	Score (1 or 0)
7. nibe	nipe	_____
8. dife	(same)	_____
9. tabe	(same)	_____
10. tof (short o)	gof	_____
11. teeg	(same)	_____
12. nafe	nase	_____

For items 7-18, stress first syllable:

13. tay'-foig	(same)	_____
14. nie'-mofe	(same)	_____
15. do'-buk (short o)	do'-bup	_____
16. noi'-fob	moi'-fob	_____
17. nay'-doib	nay'-goib	_____
18. daw'-mabe	(same)	_____

13. tay'-cho-gike	(same)	_____
14. vay'-foi-mub	zay'-foi-mub	_____
15. noi'-gaw-jeef	noi'-kaw-jeef	_____
16. chi'-fu-boke	chi'-fu-goke	_____

17. gee'-bo-zoit (short o)	(same)	_____
18. ree'-goi-tup	(same)	_____

For items 19-24, stress second syllable:

19. taw-moi'-fo-boke (1st o short)	(same)	_____
20. chay-hoi'-gee-fope	chay-hoi'-gee-fote	_____
21. zo-chee'-maw-dig (short o)	vo-chee'-maw-dig	_____
22. loi-ho'-fay-gike (short o)	(same)	_____
23. ni-go'-moi-fup (short o)	ni-bo'-moi-fup	_____
24. vay-fu'-gaw-chis	(same)	_____

For items 25-36, stress third syllable:

25. vo-cho-tay'-foi-deej (1st o short)	zo-cho-tay'-foi-deej	_____
26. loi-gee-zo'-tay-muk	(same)	_____
27. naw-fu-jie'-bo-chape (short o)	(same)	_____
28. doi-go-zay'-fu-bawsh (short o)	doi-go-zay'-fu-dawsh	_____
29. zay-moi-do'-cho-geef (1st o short)	zay-noi-do'-cho-geef	_____
30. voe-fu-tay'-bo-joog (short o)	(same)	_____
31. ree-jie-gaw'-chae-doi-fibe	(same)	_____
32. vay-chee-haw'-yi-fu-gois	thay-chee-haw'-yi-fu-gois (th as in 'thing')	_____
33. loi-jie-daw'-fay-gee-zos	loi-jie-baw'-fay-gee-zos	_____
34. tae-do-moi'-chi-fu-jope (short o)	tae-bo-moi'-chi-fu-jope	_____
35. ni-gee-faw'-zo-hoi-tabe	(same)	_____
36. do-zay-chee'-hoi-taw-gibe (short o)	(same)	_____

Number correct: _____

REFERENCES

Academic Therapy Publications. (2000). Expressive One-Word Picture Vocabulary Test. Novato, CA: Author.

Apthorp, H. (1995). Phonetic coding and reading in college students with and without learning disabilities. *Journal of Learning Disabilities, 28,* 342-352.

Baddeley, A.D. (1996). The concept of working memory. In S.E. Gathercole (Ed.) Models of short-term memory (pp. 1-27). East Sussex, UK: Psychology Press.

Baddeley, A.D. & Hitch, G. (1974). Working memory. In G.A. Bower (Ed.) The psychology of learning and motivation, Vol. 8, (pp. 47-89). New York: Academic Press.

Baddeley,A.D., Papagno, C., & Vallar, G. (1988). When long-term learning depends on short-term storage. *Journal of Memory & Language, 27*, 586-595.

Bishop, D.V.M. (2002). The role of genes in the etiology of specific language impairment. Journal of Communication Disorders, 35, 311-328.

Bishop, D.V.M., North, T., & Donlan, C. (1996). Nonword repetition as a behavioural marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 37,* 391-403.

Brady, S.A. (1991). The role of working memory in reading disability. In S. Brady & D. Shankweiler (Eds.) Phonological processes in literacy: A tribute to Isabelle Y. Liberman (pp. 129-151). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brady, S.A. (1997). Ability to encode phonological representations: An underlying difficulty of poor readers. In B. Blachman (Ed.) Foundations of Reading and Dyslexia: Implications for Early Intervention (pp. 21-46). Mahwah, NJ: Lawrence Erlbaum Associates.

Dollaghan, C., Biber, M, & Campbell, T. (1993). Constituent syllable effects in a nonsense-word repetition task. *Journal of Speech and Hearing Research, 36,* 1051-1054.

Dollaghan, C., Biber, M, & Campbell, T. (1995). Lexical influences on nonword

repetition. *Applied Psycholinguistics, 16,* 211-222.

Dollaghan, C., & Campbell, T. (1998). Nonword repetition and child language impairment. *Journal of Speech-Language & Hearing Research, 41,* 1136-1146.

Elbro, C. (1996). Early linguistic abilities and reading development: A review and hypothesis. *Reading and Writing: An Interdisciplinary Journal, 8,* 453-485.

Fowler, A.E. (1991). How early phonological development might set the stage for phoneme awareness. In S. Brady & D. Shankweiler (Eds.) Phonological processes in literacy: A tribute to Isabelle Y. Liberman (pp. 97-117). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gathercole, S., & Baddeley, A. (1989). Evaluation of the role of STM in the development of vocabulary of children: A longitudinal study. *Journal of Memory & Language, 28,* 200-213.

Gathercole, S., & Baddeley, A. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology, 81*, 439-454.

Gathercole, S., Service, E., Hitch, G., Adams, A., Martin, A. (1999). Phonological short-term memory and vocabulary development: Further evidence on the nature of the relationship. Applied Cognitive Psychology, 13, 65-77.

Gathercole, S., Willis, C., Baddeley, A., & Emslie, H. (1994). The Children's Test of Nonword Repetition: A test of phonological working memory. *Memory, 2,* 103-127.

Gathercole, S., Willis, C., Emslie, H., & Baddeley, A. (1992). Phonological memory and vocabulary development during the early school years: A longitudinal study. *Developmental Psychology, 28,* 887-898.

Hoff, Erika. (2000). Language development (2nd ed.). Belmont, CA: Wadsworth.

Hulme, C., Maughan, S., & Brown, G. (1991). Memory for familiar and unfamiliar words: evidence for a long-term memory contribution to short-term memory span. *Journal of Memory & Language, 30,* 685-701.

Hulme, C., and Snowling, M. (1992). Deficits in output phonology: An explanation of reading failure? *Cognitive Neuropsychology, 9,* 47-72.

Liberman, I.Y., Shankweiler, D., & Liberman, A.M. (1989). The alphabetic principle and learning to read. In D. Shankweiler & I.G. Liberman (Eds.) Phonology and reading disability (pp. 1-33). Ann Arbor: University of Michigan Press.

Masoura, E., and Gathercole, S. (1999). Phonological short-term memory and foreign

language learning. *International Journal of Psychology, 34,* 383-388.

Muter, V. and Snowling, M. (1998). Concurrent and longitudinal predictors of reading: The role of metalinguistic and short-term memory skills. *Reading Research Quarterly, 33,* 320-337.

Perfetti, C.A. (1985). *Reading Ability*. New York: Oxford University Press.

Shriberg, L.D., & Kent, R.D. (1995). *Clinical phonetics* (2nd ed.). Needham Heights, MA: Macmillan Publishing Company.

Snowling, M., Goulandris, N., Bowlby, M., & Howell, P. (1986). Segmentation and speech perception in relation to reading skill: A developmental analysis. *Journal of Experimental Child Psychology, 41*, 489-507.

Stembach, G. & Williams, W.B. (1988). Word Express: The First 2,500 Words of Spoken English. Novato, CA: Academic Therapy Publications.

Stone, B. and Brady, S. (1995). Evidence for phonological processing deficits in less-skilled readers. *Annals of Dyslexia, 45,* 51-78.

Torgesen, J.K. (1985). Memory processes in reading disabled children. *Journal of Learning Disabilities, 18*, 350-357.

Torgesen, J.K. (1988). Studies of children with learning disabilities who perform poorly on memory span tasks. *Journal of Learning Disabilities, 21*, 605-612.

Torgesen, J.K. (1999). Reading disabilities. In R. Gallimore, L. Bernheimer, D. MacMillan, D. Speece, & S. Vaughn. (Eds.) Developmental perspectives on children with high incidence disabilities (pp. 157-181). Mahwah, NJ: Lawrence Erlbaum.

Torgesen, J.K., Wagner, R.K., & Rashotte, C.A. (1999). *Test of Word Reading Efficiency*. Austin, TX: Pro-Ed.

Treiman, R. (1985). Onsets and rimes as units of spoken syllables: Evidence from children. *Journal of Experimental Child Psychology, 39,* 161-181.

Treiman, R., Goswami, U., & Bruck, M. (1990). Not all nonwords are alike: Implications for reading development and theory. *Memory & Cognition, 18,* 559-567.

Wagner, R., & Torgesen, J. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192-212.

Wagner, R., Torgesen, J., & Rashotte, C. (1999). *Comprehensive Test of Phonological Processing.* Austin, TX: Pro-Ed.

Woodcock R.W., McGrew, K.S., & Mather, N. (2001). *Woodcock-Johnson III Tests of Achievement*. Itasca, IL: Riverside.

BIOGRAPHICAL SKETCH

Andrea Muse was born in Massachusetts in 1975. She attended Westfield State College, where she majored in psychology. She worked as an undergraduate research assistant for Dr. Horace Marchant and Dr. Linda Albright-Malloy. She received the Academic Excellence in Psychology award and graduated with honors in 1997.

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