Phonological Working Memory and Preschool ESL Children: A Study and Review of the Literature
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Abstract
Using Baddeley’s (1990) theoretical framework of phonological representation in working memory, the following questions are addressed: Does a nonword repetition task differentiate “more rapid” from “less rapid” second language learners, thus being a potential predictor of second language learning in the preschool ESL population? And, if so, could nonword repetition ability be used as a potential screening tool for at-risk ESL children? To explore these questions, twenty-three ESL preschoolers were assessed for nonword repetition ability, followed by their ability to learn new English words, using naturalistic play sessions. Comprehension and production of new vocabulary, both immediate and recall, were then assessed. Correlations, multiple regressions, and ANCOVAs were used to determine if relationships exist between nonword repetition ability and ease of English word learning. Discussion centers on the continuing research that is being done and appropriateness of this measure for the ESL population.

Introduction
A current problem in schools is whether ESL children who are developing English in an atypical manner are simply delayed in their acquisition or experiencing a language learning disability. Though children appear to acquire language with ease, language learning is actually an immense undertaking, so much so that five-year-old children have been termed “linguistic geniuses”\(^1\) because of their prowess with language in comparison to their lack of ability in other areas (e.g., to tie shoes or tell time). This is even more true for second language learners due to effects of age, personality, and motivation; influences of the first language; and the often unequal status of the languages involved. Most children learn a second language (L2) quickly and with relative ease; others, though, learn less rapidly and with more of a struggle.

This difference in ease of acquisition raises the question of why individual differences exist in the ability to learn a second language (Skehan, 1989). Traditional explanations have involved different socio-emotional and environmental reasons, such as motivation, identity issues, amount and type of linguistic input, and status of the first language (L1) in relation to the target language. A different view is that of Baddeley’s (1986, 1990) theory of phonological working memory as a potential source of individual variation. Baddeley’s theory holds that when a word is perceived, a sequence of sounds

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\(^1\) Personal communication with Dr. Phil Connell, Spring 1994, based on course taught by Connell at Indiana University entitled Born to be a Genius.
(composing the word) is held in memory, first, long enough to be repeated back, and second, long enough and in stable enough representation to become part of the long-term store (i.e., the mental lexicon). This process is accomplished via a memory mechanism termed the “phonological loop”. The loop operates in the following manner: 1) incoming material is held in sound-based form, making a memory trace, which 2) starts to degrade/decay within two seconds, but which 3) can be refreshed by what is termed subvocal rehearsal. This cycle of activation, degradation, and reactivation, over time, and with enough repetitions and exposures, allows the sequence of sounds (i.e., the word) to be associated with meaning and become part of the long-term store. Finally, the word can be accessed either through semantic links or similar-sounding words.

The process of phonological working memory detailed above has been investigated in the population of monolingual English language learners regarding its potential to be used as a differential diagnostic measure with children suspected of language processing problems (Dolloghan & Campbell, 1998; Ellis Weismer, 1996; Montgomery, 1996). This raises the question of whether the same such unbiased measure might be appropriate for use with at-risk language delayed ESL children. The aims of the exploratory study that follows are: 1) to ascertain whether the framework of phonological working memory can explain individual differences in language learning in preschool ESL children, and 2) to determine whether nonword repetition ability, as a measure of phonological working memory, is a factor in the ease of second language learning, more specifically, vocabulary learning. In other words, can a memory process-dependent task such as nonword repetition act as a predictor of language learning and thus be a potential unbiased differential diagnostic tool to identify children at risk of being slower language learners in need of language-learning support? Such an unbiased diagnostic measure is needed for L2 populations due to differences between languages, cultures, and world knowledge which can negatively influence test results (Adler, 1991; Cheng, 1987; Cummins, 1985; Lidz & Pena, 1996; Mattes & Omark, 1991; Stockman, 1996), as well as potential problems involving inappropriate administration of assessments (Kayser, 1995), and/or the situation where the L1 may have stagnated or undergone attrition (Schiff-Myers, 1992).

Review of Literature

Phonological working memory has been under exploration for over thirty years, with one of the earliest and most well-established multicomponent working memory models being that of Baddeley & Hitch (1974), more recently modified and extended by Baddeley (1986, 1990). More intense investigation into its impact on language learning has occurred during the past twenty years (see, for example, Baddeley, Gathercole, & Papagno, 1998; Hitch, Halliday, Schaal, & Heffernan, 1991; Hulme, Thomson, Muir, & Lawrence, 1984; Hulme & Tordoff, 1989). During this time, several researchers (e.g., Dollaghan & Campbell, 1998; Ellis Weismer, 1996; Gathercole & Baddeley, 1990a, 1990b, 1993; Gaulin & Campbell, 1994; Gillam & van Kleeck, 1996; Montgomery,
1996) have investigated the use of nonword repetition ability, as a measure of phonological working memory, in normal and language impaired children, in particularly, children with Specific Language Impairment (SLI). SLI, a language learning impairment, affects approximately 7% of the preschool population (Leonard, 1998) with its key characteristic being problems with the morphological system. (For more information on this language learning disorder, see Genesee, Paradis, & Crago, 2004; Levy & Schaeffer, 2003; and Watkins & Rice, 1994. For a fuller overview of phonological working memory and classic studies in the area involving young children, see Pearson, 1999, 2000a, 2000b; and in adults, see Pearson, 2000c.)

This line of research has found that phonological working memory is involved in long-term vocabulary acquisition in both L1 and L2 contexts. Additionally, there appears to be a reciprocal relationship between phonological working memory and long-term memory specifically related to vocabulary acquisition (Gathercole, Willis, Emslie, & Baddeley, 1992). This relationship, however, appears to change over time, with initial heavy reliance on phonological working memory until a large store of words are built in long-term memory, at which time more reliance is shifted to phonologically similar words and semantic links (Gathercole & Baddeley, 1993). This is thought to occur by the age of seven years. The exception to this shift, though, is thought to be foreign language learning (Gathercole et al., 1992). In this situation, because of a) unfamiliar phonological sequences due to different phonotactic patterns and b) little support from the existing (L1) lexicon for sustaining memory representations, there is a decrease in the ease of long-term learning. Two studies have specifically investigated this issue: Service (1992) and Cheung (1996).

Service (1992) studied students ages nine to twelve years in an English-as-a-Foreign-Language (EFL) context. The forty-four students in the study spoke Finnish as their L1 and were tracked over a period of three years. Students were first tested on their nonword repetition ability; the following three assessments, at yearly intervals, included teacher ratings and test scores on their second language learning. Service found that nonword repetition ability (as a measure of phonological working memory) and language learning were significantly correlated.

Cheung (1996) also explored the relationship of nonword repetition ability in an EFL context, working with 7th grade students in Hong Kong. Focusing on vocabulary acquisition, Cheung found that nonword repetition ability predicted second language vocabulary learning. However, these results held only for those students of limited English proficiency (LEP). This is interesting in that it ties into the above-cited work done with monolingual English-speaking children, where a shift occurs by age seven: first, early heavy reliance on phonological working memory, followed by less reliance once a store of vocabulary items are firmly in the long-term mental lexicon. It appears that a similar process is at work in second language learning. (For a discussion of the
possible interaction between phonological working memory and long-term memory, see Gathercole, Hitch, Service, and Martin, 1997.)

Though this line of inquiry is burgeoning, several areas remain unexplored. First, there are no studies involving preschool-aged children learning a second language. Service (1992) and Cheung (1996) both investigated learners in upper elementary and middle school, presumably proficient in reading. Second, the existing studies on children learning another language involve an EFL context, not an ESL context (foreign language learning vs. second language acquisition). And third, the studies by Service and Cheung involved formal classroom learning and/or testing rather than naturalistic play sessions in which language would presumably be acquired in comparison to being learned (see Krashen (1982, 1985) for a discussion of the acquired/learned distinction). It is to these gaps in the literature that the following exploratory study seeks to provide insight.

**Research Question**

In light of the above, the following research question was addressed: In ESL preschool children, is there a relationship between nonword repetition ability and English (L2) new word learning, both production and comprehension, during naturalistic play sessions designed to simulate real-world vocabulary acquisition? That is, does nonword repetition ability differentiate faster vs. slower L2 learners?

**Method**

*Participants*

Twenty-three ESL preschoolers, aged 3;1 – 6;6 years, participated in this study. All were sequential language learners. First language backgrounds included: Korean (9), Slovak (1), Japanese (2), Uzbek (2), Farsi (1), Russian (3), Finnish (1), ‘Chinese’ (1), Arabic (2), and Icelandic (1). All children were identified through preschools and kindergarten programs in a Midwestern university town. The preschools included university-affiliated programs and HeadStart centers. The kindergarten program was associated with the elementary school that services the university community. At the time of testing, all children had spent a minimum of three months to a maximum of 24 months in an English-speaking school environment. In all aspects of the study, the children were worked with individually.

*Procedure*

*Screening Procedures*

Children were screened for nonverbal analytical reasoning ability using the matrices subtest of the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990). All children scored above -1 sd of the mean, indicating analytical reasoning ability within the average range. A portable hearing screening unit was used to determine normal hearing acuity. Normal hearing was defined as the ability to hear the test tones at 25 dB
(level set due to ambient noise) or less at 500, 1000, 2000, 3000, 4000, and 6000 Hz. For general level of English language skill, the Preschool Language Assessment Scale (Duncan & De Avila, 1986) was used in order to assess each child’s level of English language development. This test has the advantage of providing labels according to a set criteria (e.g., Limited English Proficient). Both receptive and expressive English skills were assessed, since both comprehension and production of newly learned words were involved in the learning tasks. Finally, the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1969) was given in order to assess each child’s phonemic inventory in English, as well as to provide information needed in the task analyses regarding systematic misarticulations (Gathercole & Adams, 1993). These substitution patterns were needed for scoring each child’s productions during both the nonword repetition and experimental tasks in order to compensate for issues of normal phonological developmental at the preschool age, as well as L2 transfer issues. However, due to many of the children’s limited English proficiency, the testing format of the Goldman-Fristoe was changed to imitation, rather than elicitation.

Pre-test and Post-test Procedures

Before the learning/play sessions, children were pre-tested for comprehension using a set of 40 potential English target words, all concrete nouns. All potential target words were two syllables in length, composed of five phonemes, with primary stress on the first syllable. Selection of 12 unknown words were individually selected for each child, with all efforts made to select items that a) contained a minimum of fricatives and affricates, known to be perceptually demanding for children (Miller & Nicoly, 1955), and b) involved three food items and three cooking utensil items for each play session.

Following the learning/play sessions, once the children were more comfortable with the investigator, a modified version of The Children’s Test of Nonword Repetition (CNRep) (Gathercole, Willis, Baddeley, & Emslie, 1994) was given to assess phonological repetition ability as a measure of phonological representation in working memory. As the test was designed for children speaking British English, minor modifications were made to better adapt it to children learning American English. The CNRep was presented in an audiotaped format, so that children could not rely on visual lip-reading cues. The children’s responses on screening and pre- and post-testing were recorded so that all material could be reanalyzed multiple times.

Word Teaching Procedures

The experimental task consisted of two 10-minute naturalistic play sessions, during which six new English vocabulary (target) words were used and assessed at each session. Materials for the learning tasks were typical play kitchen equipment, including manipulables, with the theme of cooking for and feeding toy dinosaur puppet/stuffed animals. Food items were actual foods sealed in small, clear plastic bags. Target words were presented ten times each, in a naturalistic conversational style during the ten-minute play sessions, at times of joint attention. Immediately following each play
session, the children were assessed for comprehension and production knowledge of the new words using a pointing game format. The six target items were presented, along with four other items (foils) that were also played with during the session, for a total of ten items. Additionally, the children were reassessed for retention of the new words, both comprehension and production, within 24-48 hours, a time delay considered long-term for this age group (Fazio, 1997; Gathercole & Baddeley, 1990a).

Scoring

All answers were recorded on scoring sheets. Production data was scored on-line as well as audiotaped and rescored within 12 hours in order to recheck for intra-judge reliability (set at 95%). In contrast to existing studies which score in a binary manner (100% correct or wrong), the CNRep and scoring of target words in this study were measured in three ways: 1) number of words/nonwords totally correct (traditional scoring method); 2) number of syllables correct; and 3) number of phonemes in appropriate sequential order correct. This system of scoring sought to more closely assess the degree of representation in phonological working memory, an issue not previously addressed. In order to address developmental and transfer issues, systematic misarticulations were scored as correct if the same substitutions were also used on the Goldman-Fristoe Test of Articulation. See Appendix A for a list of assessment areas scored for each child.

Analyses

An exploratory data analysis is needed in order to identify patterns during the preliminary stages of a new research area, in the following two situations: 1) when there is “not sufficient information to make precise predictions or formulate testable models” (Kirk, 1995, p. 118), and 2) when flexibility is important in “probing data and responding to patterns uncovered during successive stages of analysis” (Kirk, 1995, p. 119; see also Perry, 2005.) This was the situation encountered with this study, as no previous work has been done in this area with ESL preschool-aged children. For these reasons, several different types of statistical analyses were run, including bivariate correlations, multiple regressions, and ANCOVAs. Due to the small number of children in the study and the artificial division of scores when no naturally-occurring gaps appeared for grouping, the bivariate correlations and multiple regressions were the analysis methods of choice, with the more tenuous ANCOVAs (in this situation) used to corroborate and support obtained results.

Bivariate Correlations

Correlations were run between the following variables, in order to determine if any relationships existed, and, if so, in what direction: chronological age, nonverbal IQ, amount of school, degree of English proficiency, nonword repetition ability (scored three ways), immediate and recall production of new words (scored three ways), and immediate and recall comprehension of new words.
Multiple Regressions

Multiple regressions were run in order to better determine the interaction patterns of the variables, as well as to see if similarities existed across analyses (Kirk, 1995). Variables were the same as listed under bivariate correlations, with the dependent variables being immediate and recall production of words (each scored three ways) and immediate and recall comprehension of words.

ANCOVAs

Due to the above stated situation, ANCOVAs were used to support the bivariate correlations and multiple regressions. The between group (independent) variable was nonword repetition ability, as assessed by the CNRep. The within group (dependent) variables were: number of new words learned, productively, under the immediate condition, scored in three different ways; number of new words learned, productively, under the recall condition, scored in three different ways; and number of new words learned, based on comprehension, both immediate and recall. The effects of several covariates were also explored in the analyses, again to corroborate results obtained in the bivariate correlations and multiple regressions. These included: age, nonverbal IQ, and amount of school. Alpha levels were set at the .05 level; however, due to the exploratory nature of this study, trends were also noted, utilizing Tukey’s (1991) view of “leaning” towards significance.

Results

Significant results from the bivariate correlations, multiple regressions, and ANOVAs follow, along with an overall summary of results. Summaries of relevant statistical tests can be found in Appendices B and C. For full results and complete statistical tables, see Pearson (2000a).

Bivariate Correlations

As expected, significant correlations were obtained between the three scoring methods of the nonword repetition task, notably CNRep word and phoneme levels ($r=.751**$) and CNRep syllable and phoneme levels ($r=.538**$). Also, as expected, all eight target conditions (production and comprehension, both immediate and recall) were significantly correlated with each other at the .01 alpha level, with correlations ranging from $.548$ to $.995$. Additionally, the following significant correlations were found: 1) immediate production of target word conditions and English language proficiency ($r=.563**$, $.447*$, $.469*$, respectively), chronological age ($r=.463*$, $.483*$, $.495*$, respectively), and amount of school experience ($r=.683**$, $.544**$, $.553**$, respectively); 2) immediate comprehension of target words and English language proficiency ($r=.487*$)

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2 Tukey (1991) uses the word “lean” to make the point that significance is a continuum and that the .05 alpha level is not a magical number. Alpha levels between .05 and .15 are termed “leaning” to signify that even though not traditionally significant, they are worthy of investigation and consideration, especially in exploratory research. See also Abelson (1995).

3 As customary, alpha levels at .05 are notated by one asterisk, while alpha levels at .01 are notated by two asterisks.
and chronological age (r=.476*); and 3) recall production of target word conditions and 
English proficiency levels (r=.580**, .556**, .505*, respectively) and amount of school 
experience (r=.538**, .518*, .462*). Recall comprehension of words did not significantly 
correrate with other variables.  

**Multiple Regressions**

Overall models for the three ways of scoring nonword repetition ability were all 
significant, though not due to any significant influence of nonword repetition ability 
itslf. Instead, age was the most significant variable for the immediate production 
conditions, while nonverbal IQ exerted the most influence under the recall production 
conditions. Amount of school experience was also an important factor at the immediate 
word level. Immediate comprehension involved a complexity of interacting factors, 
including age, nonverbal IQ, English proficiency level, and amount of school experience. 
Select multiple regression results can be found in Appendix B.  

**ANCOVAs**

Due to the unequal number of subjects in the ANCOVA cells, tests of 
homogeneity of variance were deemed especially important. Results indicated that no 
problems existed with this group of subjects; that is, all tests for homogeneity of variance 
were nonsignificant. All ANCOVA models were run twice. The first time the covariates 
of age, nonverbal IQ, and amount of school were entered. Any nonsignificant covariate 
was then removed and the model run a second time. 

Using the traditional binary scoring system, nonword repetition ability was 
nonsignificant. Under the immediate production conditions, age was significant, while 
under the recall production conditions, nonverbal IQ was significant. Using a syllable 
scoring system, a similar pattern was found with nonword repetition ability 
nonsignificant, age and nonverbal IQ significant under the immediate production 
conditions, and nonverbal IQ significant under the recall production conditions. Finally, 
under a phoneme scoring system, nonword repetition ability was significant at the word 
and syllable levels and also accounted for the greatest amount of variance. Nonword 
repetition ability also showed a trend at the immediate phoneme level and with 
immediate comprehension. Using this scoring system, age exerted less of an effect 
under the immediate production conditions and nonverbal IQ exerted less of an effect 
under the recall conditions. See Appendix C for relevant ANCOVA tables.  

**Overall Summary of Results**

Findings from correlations and multiple regressions, and supported by 
ANCOVAs, were as follows:

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4 See Pearson, 2000a, for full bivariate correlation matrix.  
5 See Pearson, 2000a, for full multiple regression tables.  
6 See Pearson, 2000a, for full ANCOVA tables.
1) Nonword repetition ability, using traditional scoring, was nonsignificant in predicting acquisition of new English vocabulary; instead, age accounted for most of the variance under immediate production conditions while nonverbal IQ accounted for most of the variance under recall production conditions.

2) Nonword repetition ability, scored under the phoneme condition—in order to assess degree of stability of representation in working memory—was significant in predicting acquisition of new words under immediate production of words and syllables, but only for the lower English proficiency children. Additionally, nonword repetition ability showed a trend towards significance for immediate production of target words at the phoneme level—again, in lower English proficiency children only—and immediate comprehension of target words.

3) Current English proficiency level was nonsignificant on ability to learn new words at the lower proficiency levels, but significant with immediate learning in the higher English proficiency children.

Discussion

The purpose of this study was to determine if, in ESL preschool children, a relationship exists between nonword repetition ability and L2 new word learning, under both production and comprehension conditions, as well as immediate and recall conditions. In other words, does nonword repetition ability differentiate faster vs. slower second language learning in preschoolers, thus being a potential unbiased differential diagnostic measure in this population?

The above findings indicate that there are similarities in the use of phonological working memory in both monolingual and L2 English learners. That said, however, results of this study do not support all that is known about nonword repetition ability as a predictor of language learning in monolingual children, nor of work by Service (1992) and Cheung (1996) with L2 learning in EFL contexts. With very young children—in an ESL context—there may be too many additional factors exerting an effect on their second language acquisition, thus causing nonword repetition ability to play a less significant role. In other words, the “pie” is being cut into too many pieces for nonword repetition ability to reach statistical significance. This should not be surprising in that second language acquisition is a much more complex situation than monolingual language acquisition.

One issue that can complicate the situation is that of “wordlikeness”, that is, how similar or dissimilar nonwords are to real words. This is currently being explored in the monolingual population by researchers such as Edwards, Beckman, and Munson (2004); Munson, Swenson, and Manthei (2005); and Roy and Chiat (2004). “Wordlikeness” becomes an even more complex issue when two languages are involved; not only is there the issue of similarity/dissimilarity of the nonwords to the new vocabulary (L2), but the
L1 phonemic inventory and phonotactic constraints must also be considered (Pearson, 2000a, 2002). This has serious potential consequences for type of nonword test being used. The CNRep used in this study uses the same phonemic inventory and phonotactic constraints as does English. This may bias results based on the degree of difference between the L1 and L2 being investigated. Other nonword repetition tests, such as the Nonword Repetition Test (Dollaghan & Campbell, 1998) have a more basic syllable structure (CVCV) which could be less biased depending on the L1 when such tests are used as differential diagnostic measures. (See Archibald & Gathercole (2006) and Pearson (2000a, 2002) for fuller discussions of bias in nonword repetition tests.)

Other findings also deserve discussion. First, the findings of this study (see #2 above in the overall summary of results regarding degree of representation) support the importance of assessing nonword repetition ability and new word learning in a more controlled manner that takes into account the degree of stability in the representation held in memory. This is in contrast to the traditional all-or-nothing (binary) approach that has taken place in previous studies. Gathercole, Frankish, Pickering, and Peaker (1999) used a three prong scoring system, but gave no operational definition of how this was done, so their system remains ambiguous, making a comparison between studies impossible.

Second, findings of this study support Cheung’s (1996) findings that nonword repetition ability is only significant at less proficient stages of L2 acquisition. Note that in point #2 of the overall summary of results, significance of nonword repetition ability was shown only for those children of lower English proficiency. Further, in point # 3 of the summary of results, it was found that English proficiency level was nonsignificant at the lower levels of proficiency, but exerted an effect at higher English proficiency levels. This pattern, where nonword repetition ability has a greater influence at lower proficiency levels while current English (L2) proficiency has a greater influence on new word learning at higher proficiency levels, supports earlier studies on monolingual children where a shift takes place by approximately age seven years. That is, initially, phonological working memory plays a stronger role in language acquisition, but as language proficiency develops, long-term memory and other factors begin to exert a stronger influence and the role of phonological working memory becomes weaker.

Conclusion

Nonword repetition ability, as a measure of phonological working memory, has been a rich line of inquiry over the past forty years, with continuing research being done in many areas. Clinical populations are being studied, most notably SLI (Archibald & Gathercole, 2006; Chiat & Roy, 2007; Estes, Evans, & Else-Quest, 2007; Munson, Edwards, & Beckman, 2005; Munson, Kurtz, & Windsor, 2005; Thal, Miller, Carlson, & Vega, 2005), though other clinical areas also are being explored, such as deafness (Dillon, Burkholder, Cleary, & Pisoni, 2004; Miller, 2004) and Down syndrome (Laws,
The effect of nonword repetition ability on reading ability is also being investigated with interesting results (Maridaki-Kassotaki, 2002; Masterson, Laxon, Carnegie, Wright, & Horslen, 2005; Wagner & Torgeson, 1987). Exploration into the use of nonword repetition as a nonbiased predictor also continues with multicultural populations and second dialect speakers (Ellis Weismer, Tomblin, Zhang, Buckwalter, Chynoweth, & Jones, 2000), with learners of lower socioeconomic status (Engel, Santos, & Gathercole, 2008), and with L2 learners in EFL contexts (Masoura & Gathercole, 2005; Stokes, Wong, Fletcher, & Leonard, 2006).

Can nonword repetition ability, though, differentiate faster vs. slower language learning in preschool-aged L2 learners and thus be a potential unbiased differential diagnostic measure in this population? Though promising, at this point, it is too soon to tell whether nonword repetition ability will prove fruitful as a unbiased assessment in the population of ESL preschoolers. First, there are still many unknowns and problematic areas even with the monolingual population, and second, the situation with ESL children is even more complicated due to a) the “wordlikeness” issues revolving around both the L1 and L2, and b) the exponentially larger number of interacting variables in a second language situation making for a far more complex situation.

This study has contributed to the existing knowledge base by exploring previous gaps, specifically, a) a younger (preschool) L2 population vs. school-aged children; b) second language acquisition vs. foreign language learning (ESL vs. EFL); and c) naturalistic play sessions vs. formal classroom learning. Additionally, an argument has been made that the degree of representation in working memory needs to be accounted for by measuring nonword repetition ability and new word learning more narrowly, that is, at the phoneme level rather than the whole word level. However, more work still needs to be done in order to definitively answer the question of whether this type of assessment truly is nonbiased and can be used as a differential diagnostic measure with the very young ESL population.

Author Note

Christen M. Pearson, Associate Professor, English Linguistics and TESOL, Grand Valley State University. The author would like to acknowledge the children who so eagerly participated in this study; the parents, teachers, and schools for their permission to work with the children during school hours; and Drs. Rachel Anderson, Barb Fazio, and Phil Connell for their valuable input on this project. Correspondence concerning this article should be addressed to Christen M. Pearson (pearsonc@gvsu.edu).
References


Appendix A
Assessment Areas Scored for Each Child

Children’s Test of Nonword Repetition (CNRep)
  # words totally correct
  # syllables correct
  # phonemes correct (in order)
Target Words (new learning)
  Immediately after task               Production  # words totally correct
  # syllables correct
  # phonemes correct
  Comprehension  # correct
  Recall (24-48 hrs. later)           Production  # words totally correct
  # syllables correct
  # phonemes correct
  Comprehension  # correct
### Appendix B

#### Summary Chart of Multiple Regressions

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<th>Model</th>
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<th>Variance</th>
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</tr>
<tr>
<td>Immediate Production of Phonemes</td>
<td>.007</td>
<td>age</td>
<td>.012</td>
</tr>
<tr>
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<td>.032</td>
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<td>-</td>
</tr>
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<td>.020</td>
<td>nIQ</td>
<td>.054</td>
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<tr>
<td>Recall Production of Syllables</td>
<td>.015</td>
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<td>.036</td>
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<tr>
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</tr>
<tr>
<td>Recall Comprehension</td>
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<td>-</td>
</tr>
</tbody>
</table>

**Legend:**

- Model = Significance level of overall model
- Significant = Variable(s) significant independent of overall model
- Variance = Significance of variance of independent variable
- age = chronological age
- nIQ = nonverbal analytical reasoning ability
- school = amount of time in school
- ns = not significant
Appendix C
Summary Charts of ANCOVA Results

<table>
<thead>
<tr>
<th>CNRep ability (assessed @ word level)</th>
<th>covariate</th>
<th>1st analysis</th>
<th>2nd analysis</th>
<th>model</th>
<th>sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate production – word level</td>
<td>Age</td>
<td>.046</td>
<td>.164</td>
<td>.144</td>
<td>ns</td>
</tr>
<tr>
<td>Immediate production – syllable level</td>
<td>Age</td>
<td>.024</td>
<td>.080</td>
<td>.095</td>
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<tr>
<td>Immediate production – phoneme level</td>
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<td>.101</td>
<td>.109</td>
<td>ns</td>
</tr>
<tr>
<td>Immediate comprehension</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.250</td>
<td>ns</td>
</tr>
</tbody>
</table>

| Recall production – word level       | nIQ       | .035         | .074         | .150  | ns    |
| Recall production – syllable level   | nIQ       | .019         | .069         | .152  | ns    |
| Recall production – phoneme level    | nIQ       | .015         | .057         | .127  | ns    |
| Recall comprehension                  | -         | -            | -            | .705  | ns    |

Nonword Repetition Ability (assessed at word level) x Degree of New Vocabulary Learned
Immediate and Recall
Production and Comprehension

<table>
<thead>
<tr>
<th>CNRep ability (assessed at syllable level)</th>
<th>covariate</th>
<th>1st analysis</th>
<th>2nd analysis</th>
<th>model</th>
<th>sign.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Immediate production – syllable level</td>
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<td>.131</td>
<td>.203</td>
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<td>.047</td>
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<td>.214</td>
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<tr>
<td>Immediate comprehension</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.150</td>
<td>ns</td>
</tr>
</tbody>
</table>

| Recall production – word level           | nIQ       | .015         | .031         | .066  | ns    |
| Recall production – syllable level       | nIQ       | .013         | .048         | .106  | ns    |
| Recall production – phoneme level        | nIQ       | .008         | .034         | .073  | ns    |
| Recall comprehension                      | -         | -            | -            | .709  | ns    |

Nonword Repetition Ability (assessed at syllable level) x Degree of New Vocabulary Learned
Immediate and Recall
Production and Comprehension

<table>
<thead>
<tr>
<th>CNRep ability (assessed at phoneme level)</th>
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<th>1st analysis</th>
<th>2nd analysis</th>
<th>model</th>
<th>sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate production – word level</td>
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<tr>
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<td>.128</td>
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<td>Recall production – word level</td>
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</table>

Nonword Repetition Ability (assessed at phoneme level) x Degree of New Vocabulary Learned
Immediate and Recall Production and Comprehension

Legend: ns = not significant  * = significant at the .05 alpha level