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Investigating Profiles of Lexical Quality in Preschool and their Contribution to First Grade Reading

--Manuscript Draft--

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Abstract:	This longitudinal study investigated profiles of lexical quality domains in preschool children and the extent to which profile membership predicted reading comprehension in first grade. A latent profile analysis (LPA) was conducted to classify 420 preschool children on lexical quality domains, including orthography, phonology, morphosyntax, and vocabulary. Regression analysis was used to determine whether profile membership was associated with first grade outcomes across reading comprehension and its components (i.e., listening comprehension and word recognition). Results revealed five profiles of lexical quality, which were predictive of all three outcomes in first grade. Children in low lexical quality profiles performed more poorly on the outcome measures than children in the higher lexical quality profiles. Additionally, profile membership did differentially predict later reading outcomes. These results suggest that lexical quality profiles are associated with reading and therefore may offer a means of early identification of children who are susceptible to future reading difficulties.
Response to Reviewers:	Dear Author, Below are two reviews on your paper and as you can see, one reviewer says accept and the other reviewer suggests to strengthen the discussion by highlighting more what unique findings by latent profile analyses (LPA). After my own reading of the paper, I agree with the reviewers and suggest you revise the paper according by conducting LPA and strengthening the discussion along with a detailed letter explaining how you have incorporated the suggestions of the reviewers in your revised version. We look forward for your revised submission and thank you for considering Reading and Writing for your professional needs.

Yours sincerely,
R. M. Joshi, Ph.D.
Professor and Editor

Reviewer #2:

In this study, there are measures of oral language, letter knowledge, and phonological awareness. These are not measures of lexical quality; they are measures of skills. Although it is possible that individuals with better lexical quality have better scores on these measures, it is not the case that higher scores are necessarily associated with better lexical quality. Consider the case of letter knowledge: By age 6 (or earlier), most children know all letter names and letter sounds. Performance is perfect. However, there is substantial variability between these individuals and between words within individual in terms of orthographic lexical quality depending on exposure to specific words as print and knowledge of each word's spelling (i.e., its orthographic representation). Conversely, it seems unlikely that many four-year-old children--even those with high levels of letter knowledge--have many words that are represented orthographically in their lexicon, and for those who have any words represented orthographically, a better indicator than letter knowledge would be their ability to "decode" or spell words.

Authors: While we agree that decoding and/or spelling may be a better indicator in older children, we note that measuring these skills in preschoolers would likely result in floor effects and limited variability.

The point here, I think, is that although the skill domains associated with reading and the domains by which words can be represented are similar (i.e., phonology, meaning, orthography), there has not been a relation established between the quality of lexical representations and the level of skills in specific domains. Therefore, measures of skills are not measures of lexical quality. Without measures of lexical quality, no test of the LQH can be conducted.

The authors claim (MS pp. 6-7) that "Children's abilities in the domains we measured should be related to similar properties of lexical quality. For example, individual differences in phonological awareness should be related to individual differences in phonological representation in the lexicon…" (in addition to be tautological) seems insufficient to establish a connection between measures of skills within a domain and the components of the LQH. What is the evidence for this claim? As noted above, there are logically derived exceptions to this claim generally and for the measures/population in this study. As noted in the prior review, the authors have measured components of an emergent literacy model (e.g., Lonigan, Schatschneider, & Westberg, 2008; Whitehurst & Lonigan, 1998). This is not the LQH.

Authors: We appreciate the reviewer’s concerns and thoughtful comments. We have added additional clarification on p. 7 that we are not attempting to test the LQH in this study. Instead, we are using a lexical quality framework to think about the skills that are related to reading comprehension. We have also elaborated on the issue of measurement in the discussion, p. 30-31.

It seems to me that what is novel here is the use of LPA as a way of examining the linkage between early literacy skills and later reading skills. However, the authors spend little time explaining what is to be gained by this approach beyond an approach that examines how scores on the measures that are used to create the profiles relate to the outcomes of interest. As written, the manuscript suggests that LPA is superior to '… approaches that use arbitrary cutoff scores on standardized tests" (MS p. 7); however, LPA makes use of a sample-optimized arbitrary cutoff scores to create profiles. Therefore, it is not entirely clear how LPA is superior (as opposed to different) than a multivariate prediction approach.

Authors: We thank the reviewer for pointing out this weakness in our discussion. We have now added more attention to this point on p. 29 and we have changed the wording in the introduction (p. 8) to indicate that LPA, as person-centered approach is

a supplement to (not superior to) multivariate prediction.

Beyond conceptual issues, the authors examined the linkages between profile membership and reading and reading-related outcomes in a multiple regression format. However, profile membership is not an all-or-none phenomenon. In a latent profile analysis, each individual has a posterior probability that reflects his or her "connectedness" to the individual's profile. The posterior probabilities are what the entropy metric is derived from. Conducting the analyses as regressions or ANOVAs treats the data as if entropy were 1.0 (i.e., profile membership is perfect); however, the posterior probabilities need to be taken into account. Otherwise, the results can be biased such that the profiles appear more related to outcomes than they actually are. There are several methods that can be used for these analyses. One of the more common approaches is the three-step approach (Vermunt, 2010), which allows monitoring of changes to profile membership when additional variables are included in the mixture model.

Authors: This is a good point. We agree that use of the three-step approach would be ideal and we address this on p. 31 of the discussion.

It is not entirely clear how the authors settled on the five-profile model. According to Nylund, Asparouhov, and Muthen (2007; in Structural Equation Modeling, 14, 535-569), the BIC and BLRT most often identify the correct profile solution. As noted by the authors, the BIC appears to favor the six-profile model, as does the LMRT (although there has been discussion that the first time LMRT becomes significant is the correct stopping point). As seems often to be the case, the BLRT identifies a k+1 solution. The authors note that they rejected the six-profile solution because it had relatively few participants (i.e., n = 16); however, if the profile can be described and differentiated from the other profiles in a sensible way, profile size is not a selection criteria in LPA. Importantly, much of the fuzziness of identifying the profile solution could be prevented if there was an a priori expectation of the profiles to be recovered. Regardless, the authors seem to select the five-class model on the basis of the one smaller profile and entropy values; however, entropy is not a fit statistic. Therefore, using entropy to determine the best model is not a correct strategy. It is also possible that because neither BIC nor BLRT reaches a minimum, the wrong mixture model is being used (see, for example, Mplus discussion board).

Authors: Again, we appreciate the reviewer’s thoughtful comments here. Selecting the optimal number of profiles is indeed complicated at times and open to interpretation. Although we note that entropy and class counts have been recommended as part of model fit strategy (Logan & Petscher, 2010; Logan & Pentimonti, 2016) we add clarification and expand upon the selection process on p. 18-19.

Would it make more sense to report the constant in the regressions as the constant rather than reporting the constant as the value for the profile left out in specific models (i.e., Tables 4-6)?

Authors: Respectfully, we chose to retain the original label in these tables. We will change them if the Editor wishes.

Beyond the conceptual and analytic issues, the study reports some interesting--albeit not surprising--findings. Early language skills are more associated with meaning-related outcomes than are early print-related skills. Early letter knowledge is more related to letter knowledge than it is to meaning-related skills. Given extant findings in the literature on these relations, it is not surprising that profiles defined by high or low skills in oral language, phonological awareness, or letter knowledge would show differential relations to code- versus meaning-focused outcomes. It seems to me that the authors could strengthen the discussion by highlighting more what unique findings an LPA approach yields (above the more typical multivariate prediction approach).

Authors: As mentioned, we have added more on this point in our discussion, p. 18-19.

	Authors: Each of the following typographical and reference errors have been corrected: READ-D-15-00138R1 Title: Investigating profiles of lexical quality in preschool and their contribution to First grade reading Title Page 1. add the running head with the term since the first title page 2. number the first title page as 1 Abstract Page 1. set the term “Keywords” as one word and indented at least five spaces 2. do not set the content of keywords italicized Article Page ***ERRORs throughout entire text NA Key: Page number, paragraph number, line number 20, 2, 14 the citation is not found in the references 30, 2, 5 the citation is not found in the references Reference Page ***ERRORs throughout entire text 1. do not set the term “References” bold 2. delete the issue numbers if the journal is not paginated by issues 3. give the journal title in full as “Reading and Writing: An Interdisciplinary Journal’ 4. revise as “Ed.” or “Eds.” Key: Page number, reference number, first author 32, 1, Authors the reference is not found in the text 32, 6, Catts give the volume and page number information 33, 17, Kim give the volume and page number information 34, 19, Leslie add the city information of the publisher 34, 20, Logan give in press within the parentheses, instead of year; update the book information as it is already available online 34, 22, MacGinitie give the publisher information 35, 35, Stothard revise the page number information Table/Figure 1. revise “Mean” as M and set it italicized 2. set the figure caption below each figure 3. revise as “Figure X.” and set it italicized, not bold —

Investigating Profiles of Lexical Quality in Preschool and their Contribution to First Grade Reading

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This paper was prepared by a Task Force of the Language and Reading Research Consortium (LARRC) consisting of Kimberly A. Murphy (Convener), Kate Cain, Hugh Catts, Laura Justice, Richard Lomax, and Jill Pentimonti, along with Kelly Farquharson. LARRC project sites and investigators are as follows:

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1. Jill Pentimonti is now at American Institutes for Research.

2. Stephen A. Petrill was a LARRC co-investigator from 2010-2013.

3. Hugh Catts is now at Florida State University.

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Amber Sherman, Shannon Tierney, Stephanie Williams, and Gloria Yeomans-Maldonado. The views presented in this work do not represent those of the federal government, nor do they endorse any products or findings presented herein.

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Investigating Profiles of Lexical Quality in Preschool and their Contribution to First Grade Reading

Abstract

This longitudinal study investigated profiles of lexical quality domains in preschool children and the extent to which profile membership predicted reading comprehension in first grade. A latent profile analysis (LPA) was conducted to classify 420 preschool children on lexical quality domains, including orthography, phonology, morphosyntax, and vocabulary. Regression analysis was used to determine whether profile membership was associated with first grade outcomes across reading comprehension and its components (i.e., listening comprehension and word recognition). Results revealed five profiles of lexical quality, which were predictive of all three outcomes in first grade. Children in low lexical quality profiles performed more poorly on the outcome measures than children in the higher lexical quality profiles. Additionally, profile membership did differentially predict later reading outcomes. These results suggest that lexical quality profiles are associated with reading and therefore may offer a means of early identification of children who are susceptible to future reading difficulties.

Keywords: early reading, early identification, lexical quality, latent profile analysis

Investigating Profiles of Lexical Quality in Preschool and their Contribution to First Grade Reading

Early weaknesses in reading achievement are important to identify as they indicate elevated risk for continued reading difficulties throughout the school years (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Juel, 1988). A large body of research has identified variables that predict future reading achievement but relatively few studies have examined reading outcomes from a person-centered approach. The present study aims to contribute to this research by using lexical quality domains to investigate the presence of preschool profiles and to explore how these profiles may relate to first grade reading outcomes.

Lexical quality is a framework for understanding individual differences in word knowledge and, subsequently, reading comprehension. According to the lexical quality hypothesis (Perfetti, 2007; Perfetti & Hart, 2002), word knowledge includes knowledge of a word's form (orthography, phonology, and grammar; the latter hereafter referred to as morphosyntax) and meaning (hereafter referred to as vocabulary). Lexical representations in these four domains are retrieved from memory to enable word identification during reading (or listening). Word identification then provides the meanings needed for comprehension.

According to the simple view of reading (Hoover & Gough, 1990), reading comprehension is the product of listening comprehension and word recognition. Listening comprehension refers to the ability to process and extract meaning from linguistic information. Word recognition refers to the process by which children apply knowledge of letter-sound relationships in order to accurately and fluently decode words,

and/or reading words by sight. Thus, lexical quality may be a source of individual differences in the process of reading comprehension (Richter, Isberner, Naumann, & Neeb, 2013). If so, lexical quality may serve as a sensitive and early means by which to earlier identify and intervene for children at risk for reading difficulties. With the simple view framework in mind, we hypothesize that preschool profiles of lexical quality will predict first grade achievement in reading comprehension and that differences in reading comprehension may be explained by listening comprehension and/or word recognition. Thus, we will examine children's outcomes across each of these reading domains.

Lexical Quality and Reading

The premise of the lexical quality hypothesis is that word knowledge (consisting of representations of the word's orthography, phonology, morphosyntax, and vocabulary), plays a central role in reading (Perfetti, 2007). Although Perfetti has theorized a critical role for lexical quality in reading development, he and colleagues have only examined this construct experimentally in adult readers. Other researchers have examined aspects of lexical quality as it relates to reading development. This work finds that skills within each of the four domains of lexical quality have been individually identified as important predictors of reading achievement (e.g., Catts, Nielsen, Bridges, & Liu, 2014; Kendeou, van den Broek, White, & Lynch, 2009; Muter, Hulme, Snowling, & Stevenson, 2004; National Early Literacy Panel, 2008), but few studies have investigated all domains simultaneously (examples of notable exceptions include Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Kim, Apel, & Al Otaiba, 2013).

To our knowledge, only one study has directly examined the construct of lexical quality as a predictor of reading comprehension in children. Richter and colleagues (2013) investigated the relationship between lexical quality and *concurrent* reading comprehension in a cross-sectional sample of 247 German children in grades 1 to 4. They found that lexical quality, measured by accuracy of knowledge across orthographic, phonological, and meaning domains, and speed of access to that knowledge, explained 57% of the variance in children's reading comprehension. The authors concluded that lexical representations are important for reading comprehension in developing readers and that the effects of accuracy were much larger than the effects of speed. However, the extent to which lexical quality may contribute to listening comprehension or word recognition was not examined; nor was the role of lexical quality in the longitudinal prediction of reading comprehension.

In a study using only vocabulary as an indicator of lexical quality, Verhoeven and van Leeuwe (2008) compared the prediction of reading comprehension using a lexical quality framework to the prediction of reading comprehension based on the simple view of reading. In their longitudinal study of Dutch children in grades 1 to 6, the authors tested three different structural models: one for lexical quality, one for the simple view, and one that combined the two. The lexical quality model contained word decoding, vocabulary, and reading comprehension. The simple view model contained word decoding, listening comprehension, and reading comprehension. The combined model contained all four components. All predictors were significant, and each model was empirically supported. The authors did not offer conclusions about whether any one model was preferable over another.

A single study of the contribution of lexical quality domains to early word decoding ability was conducted by Verhoeven, van Leeuwe, Irausquin, and Segers (2016). Examining the lexical quality abilities of Dutch kindergarteners, results of this study showed that two lexical quality measures, phonological awareness and lexical retrieval (specifically, rapid naming), explained significant variance in grapheme-phoneme correspondence at the beginning of kindergarten and word decoding at the end of kindergarten.

In summary, lexical quality is expected to contribute to reading skills in young children. Lexical quality may be a source of individual differences in both reading comprehension and word recognition (Richter et al., 2013; Verhoeven et al., 2016), as well as in listening comprehension, although only the phonological and meaning components of lexical quality would be expected to relate to listening comprehension (e.g., Florit, Roch, & Levorato, 2014; Kim, 2014). Therefore, in the present study we hypothesize that individual differences in preschool domains of lexical quality will relate to first grade differences in reading comprehension, listening comprehension, and word reading, and therefore may serve as a means for early identification of children at risk for reading difficulty. We use lexical quality as a framework for considering reading comprehension and how differences in early abilities may relate to later reading abilities.

For the purpose of the present study, we index lexical quality as knowledge across its four domains – orthography, phonology, morphosyntax, and vocabulary. We propose that these knowledge domains in children learning to read are precursors to ‘mature’ lexical quality, in which speed of access is increased as readers gain more experience and the lexical representations across domains become increasingly interconnected (Perfetti,

2007). Further, we hypothesize that the domains of lexical quality will differentially contribute to the components of reading comprehension – listening comprehension and word recognition. For instance, a child with a profile of weak orthographic skills but strong vocabulary may exhibit difficulty with word recognition and have average comprehension, whereas a child with an inverse profile may exhibit difficulty with comprehension.

Our conceptualization and measurement of lexical quality are an extension of the lexical quality hypothesis in that we have moved from a focus on words and their representations to measuring individual differences in skills that are related to lexical quality. Children's abilities in the domains we measured should be related to similar properties of lexical quality. For example, individual differences in phonological awareness should be related to individual differences in phonological representations in the lexicon, and individual differences in vocabulary are likely to be indicative of individual differences in semantic representations. Thus, our intention is to examine children's abilities in lexical quality domains and how these relate to reading outcomes, but not to explicitly test the LQH.

A Person-centered Approach

The majority of existing research on early predictors of reading is variable centered; that is, it explores relationships between predictor variables and reading comprehension. However, individual variables alone are not sufficiently predictive, especially for reading comprehension, to provide accurate early identification. For example, traditional methods used to identify reading comprehension difficulties often include a cut-point of at least 1 *SD* below the mean of an assessment. However, the early

language skills of poor comprehenders often do not fall below a clinical threshold (Catts, Adlof, & Ellis Weismer, 2006; Nation, Cocksey, Taylor, & Bishop, 2010), which makes it difficult to identify children at risk for reading comprehension difficulties.

A person-centered approach, such as latent profile analysis (LPA), can supplement traditional variable-centered methods of identifying risk. LPA is an empirically driven methodology that categorizes individuals into behavioral profiles based on their pattern of strengths and weaknesses across domains of interest. As such, LPA is a nuanced way of capturing the variability in a child's performance between different domains and therefore has the potential to identify individual differences in performance. This approach, then, could be used to aid earlier identification and is an alternative to approaches that use arbitrary cutoff scores on standardized tests (Logan & Pentimonti, 2016). In the present study, we use LPA to examine the relations among lexical quality domains within groups of children. We hypothesize that preschool children will vary in their lexical quality profiles and that profile membership will be predictive of first grade reading comprehension.

The Present Study

The primary aims of the present study were to empirically examine preschool children for the presence of profiles related to lexical quality domains and to determine the extent to which these profiles relate to reading comprehension in these same children in first grade. We hypothesized that there would be several empirically supported lexical quality profiles and that those profiles would be related to later reading skills. That is, children with profiles indicative of lower lexical quality were hypothesized to exhibit lower reading comprehension skills. To measure knowledge in lexical quality domains,

we used letter knowledge as an indicator of orthography and phonological awareness as an indicator of phonology. We used multiple measures of knowledge of the structure of words and sentences to create a latent variable for morphosyntax, and we used multiple measures of knowledge of word meanings (breadth) and relations amongst words (depth) to form a latent variable for vocabulary.

Our secondary research aim was to investigate the mechanism for potential differences in reading comprehension. Considered within the framework of the simple view of reading, we were interested in whether the lexical quality profiles are specifically related to listening comprehension and/or word recognition. For instance, children with lexical quality profiles that are weak in morphosyntax and vocabulary but strong in orthography are likely to exhibit difficulties with listening comprehension but not word recognition.

The specific research questions of this study are: (1) To what extent do reliable profiles of lexical quality domains in preschoolers exist? (2) To what extent is profile membership predictive of first grade reading comprehension? and (3) What is the mechanism for potential differences in reading comprehension (i.e., how are the profiles of lexical quality related to listening comprehension and word recognition)? In answering these questions, we seek to gain a more nuanced understanding of children's susceptibility to reading difficulties. Children with profiles of low lexical quality may experience such susceptibility and could therefore be identified for early intervention.

Method

The data for this study come from a five year, multi-state, longitudinal research study investigating the language processes underlying reading comprehension and its

development from preschool to third grade. The study used a longitudinal cohort design in which a cohort of children from each grade was followed longitudinally until third grade. A sample of children was recruited from partnering schools in four states in the Midwest and Southwest. Recruitment began with obtaining permission from school districts and schools, and then all teachers in the appropriate grades in each school were invited to participate. Children were then recruited from each participating teacher's classroom. Once caregiver permission was obtained, children were eligible for the study if they understood and spoke English fluently and did not have severe or profound disabilities that would prevent them from appropriately participating in the assessment battery. Additionally, for the preschool cohort, only children who were expected to matriculate into kindergarten the following year were accepted into the study. From those eligible, approximately 100 preschool and 120 K-3 children per site were randomly selected to receive the full battery of language and reading assessments. Data were collected in the spring of each school year, between the months of January and May, beginning in 2010. For additional details on recruitment and study procedures, see Authors (2016).

Participants

The participants in the current study were a subsample of children, specifically, the preschool cohort (n = 420) who were enrolled in the first year of the larger study. The children, 41% of whom were female, had a mean age of 60 months (SD = 4.35) and nonverbal intelligence within the average range (standard score M = 101.68, SD = 12.37), as measured by the Matrices subtest of the *Kaufman Brief Intelligence Test, 2nd edition* (KBIT; Kaufman & Kaufman, 1997). Demographic information was collected from

parent questionnaires. It was reported that 89% of the children spoke English as their first language, 84% were Caucasian, and 7% reported Hispanic or Latino ethnicity (10% missing data). The highest level of education obtained by the mother or female guardian was reported as follows: 2% did not have a high school diploma, 11% had a high school diploma but no college, 19% had some college but no degree, 37% had a 2- or 4-year college degree, and 21% had a graduate degree (10% missing data). Regarding income status, 11% of families reported income of less than or equal to $30,000; 23% reported $30,001 - $60,000; 21% reported $60,001 - $85, 001; 33% reported income greater than $85,001; and 14% of children qualified for free or reduced price lunch (11% missing data). The mean family income was $60,001-$65,000. In Year 3 of the study, 340 of the children remained in the study and were in first grade. Two of the children were not able to be assessed, however, so the sample size in first grade was 338.

Procedures

Between January and May each year, trained field assessors administered all measures individually to children at their schools, local university site, community center, or home. To ensure fidelity, assessors across sites received the same thorough training in measurement administration and scoring. Training included completion of on-line training modules with quizzes and direct observations by supervising assessors. At two sites, the assessments were conducted in one-hour blocks during the school day, and at the other two sites assessments took place on the weekend in 3-6 hour blocks with frequent breaks provided to the children.

Measures

Measures used for the purpose of the present study included preschool assessments representing each domain of lexical quality (orthography, phonology, morphosyntax, and vocabulary) and first grade assessments of reading comprehension and its components, listening comprehension and word recognition. Multiple measures were available from the larger study for all constructs except orthography and phonology. This is discussed further in our limitations section. A description of each of the measures is provided below. See Table 1 for the internal consistency reliability coefficients for our sample.

Orthography. As an indicator of orthography, letter knowledge was assessed using the Letter Identification subtest of the *Woodcock Reading Mastery Tests-Revised: Normative Update* (WRMT; Woodcock, 1998). For this subtest, children were asked to name letters of the alphabet presented in isolation in a variety of fonts and styles. Split-half reliability is reported in the test manual at .94 (for first grade).

Phonology. As an indicator of phonology, phonological awareness was assessed using the Phonological Awareness subtest of the *Test of Preschool Early Literacy* (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007). On this measure, children were asked to perform two types of auditory tasks. The first, elision, required children to delete a segment of the word (e.g., syllables or phonemes) and then say what was left over. The second, blending, required children to listen to word segments (e.g., syllables or phonemes) and blend them together to form a complete word. The reliability coefficient (Cronbach's alpha) reported in the test manual is .86 for four-year olds.

Morphosyntax. Morphosyntax was assessed using four different measures. A modified version of the Word Structure subtest of the *Clinical Evaluation of Language*

Fundamentals, 4th edition (CELF-4; Semel, Wiig, & Secord, 2003) was administered to assess children's ability to use morphology to mark inflections, derivations, and comparison, and also to select and use appropriate pronouns. Test authors report split-half reliability of .83 and Cronbach's alpha of .82. The CELF-4 was developed to assess children aged five and older, but was administered to preschool children in our study so that the same measure could be given to children across all grades. We modified the Word Structure subtest to include a discontinue rule (8 consecutive incorrect responses), in order to decrease the length of the assessment and to decrease potential frustration for preschoolers.

Two probes from the *Test of Early Grammatical Impairment* (TEGI; Rice & Wexler, 2001) were administered. The Past Tense probe measured children's use of regular and irregular past tense verb forms. Children were shown a picture of a child completing an action and given a verbal description of the action using the present participle of the verb. The children were then asked to tell what the child in the picture did, using the past tense form of the verb (e.g., when presented with a picture and the prompt "*Here the boy paints. Now he is done. Tell me what he did"*, the response would be "*painted"*). Test-retest reliability reported in the TEGI manual is .82. The Third Person Singular probe of the TEGI evaluated children's use of the third person singular morpheme (/s/ or /z/) in a picture elicitation task. Children were presented with the picture and name of a person with a specific job and asked to tell what the person does (e.g., when shown a teacher, the response would be "*teaches*"). Test-retest reliability reported in the manual is .92.

The *Test for Reception of Grammar, 2nd edition* (TROG; Bishop, 2003) was administered to assess children's understanding of grammatical contrasts marked by inflections, function, words, and word order as well as grammatical comprehension. Children were shown four pictures and asked to choose the one that matched the word, phrase, or sentence spoken by the examiner. The test is comprised of 20 blocks, each with four items that measure a specific grammatical construct. The total score is the number of blocks in which all four items were correct. Split-half reliability reported in the manual is .88.

A modified version of the Recalling Sentences subtest of the CELF-4 was administered to assess children's ability to listen to spoken sentences of increasing length and complexity and repeat the sentences verbatim. Children's responses were audio recorded and later scored by trained personnel (inter-rater reliability .99). This subtest was modified for use with preschool children by inserting the first two items from the Recalling Sentences subtest of the *CELF-Preschool, 2nd edition* (Wiig, Secord, & Semel, 2004) as the first two items on this version of the test. Test-reliability is reported in the CELF-4 manual as .90 for six-year olds.

Vocabulary. Vocabulary was assessed with two measures of breadth and one measure of depth. Receptive vocabulary breadth was assessed using the *Peabody Picture Vocabulary Test, 4th edition* (PPVT; Dunn & Dunn, 2007). Children selected one out of four pictures that represented the meaning of a word spoken by the examiner. The split-half reliability is reported in the manual as .95. Expressive vocabulary breadth was assessed using the *Expressive Vocabulary Test, 2nd edition* (EVT; Williams, 2007).

Children are asked to label pictures or provide synonyms for target words that are orally presented. The reliability coefficient is reported at .95 for four-year olds.

Receptive and expressive vocabulary depth were assessed using the Word Classes subtest of the CELF-4. This subtest measured children's ability to understand and express relationships between words. The target words are related based on semantic class features. For the receptive portion of Word Classes subtest, children were presented with three or four pictures and asked which two belong together. Subsequently, for the expressive portion of the test, children were asked to explain the relation between the two words they chose. Children's responses to the expressive portion were audio recorded and later scored by trained research assistants (inter-rater reliability .99). The internal consistency reliability for five-year olds is reported in the test manual at .84 for the receptive portion of the test and .87 for the expressive portion.

First grade reading comprehension. Three measures of reading comprehension were administered. The Passage Comprehension subtest of the *Woodcock Reading Mastery Tests-Revised: Normative Update* (WRMT; Woodcock, 1998) employed a multiple choice format to assess children's ability to identify the missing word(s) in a short passage that they read. Split-half reliability reported in the manual is .94 for first grade. The Comprehension subtest of the *Gates-MacGinitie Reading Test* (GMRT; MacGinitie, MacGinitie, Maria, & Dreyer, 2000) required children to read short texts and select the correct picture from a panel of three that illustrated each segment of the text. Each text contained 3-4 segments. Children were given 35 minutes to read and respond to as many of the 11 texts as they could. Internal consistency reliability for this test is reported as .92. Finally, an experimental measure of reading comprehension was

administered. The *Reading Comprehension Measure* (RCM) was adapted from the *Qualitative Reading Inventory-5th edition* (QRI-5; Leslie & Caldwell, 2010). It assessed children's ability to comprehend narrative and expository texts. Children read one expository and two narrative passages and answered questions asked by the examiner after each passage. Responses were audio recorded and later scored by trained personnel (inter-rater reliability .94).

First grade listening comprehension. Two measures of listening comprehension were administered. The receptive portion of the *Test of Narrative Language* (TNL; Gillam & Pearson, 2004) required children to listen to three passages read aloud by the examiner and then answer open-ended questions asked by the examiner. Responses were audio recorded and later scored by trained personnel (inter-rater reliability .97). Internal consistency across grades, as reported in the test manual is .87. An experimental measure of listening comprehension was also administered. The *Listening Comprehension Measure* (LCM), like the RCM, was adapted from the QRI-5. Children listened to one expository and two narrative passages and then answered questions asked by the examiner. Again, responses were audio recorded and later scored to trained personnel (inter-rater reliability .89).

First grade word recognition. Word recognition accuracy was measured using two subtests of the WRMT. For the Word Identification subtest, children were required to read aloud a list of words ordered in increasing difficulty. Split-half reliability for first grade, as reported in the test manual, is .98. For the Word Attack subtest, children read a list of pseudowords (pronounceable nonwords). Split-half reliability for first grade is .94. Word recognition fluency was measured using the *Test of Word Reading Efficiency, 2nd*

edition (TOWRE; Torgesen, Wagner, & Rashotte, 2012). The Sight Word Efficiency subtest required children to read aloud as many real words as they could in 45 seconds. Average internal consistency reliability is reported as .93. The Phonemic Decoding Efficiency subtest required children to read aloud as many pseudowords as they could in 45 seconds. Average internal consistency reliability is .94.

Control variables. Mother's education and children's nonverbal intelligence were included as control variables in this study since there is indication from prior research that they may have some influence on children's reading achievement. Mother's education level was determined via a questionnaire completed by caregivers at the beginning of the study. Children's nonverbal intelligence was measured in preschool using the Matrices subtest of the Kaufman Brief Intelligence Test.

Results

The primary aims of this study were to investigate lexical quality in preschoolers using a person-centered approach and to determine the extent to which profile membership predicted first grade reading comprehension. The secondary aim explored the relations between profile membership and both listening comprehension and word recognition. Descriptive statistics for each of the preschool and first grade variables are reported in Table 1 and correlations for the preschool variables are presented in Table 2. For subsequent analyses, which were conducted using MPlus 7 (Muthén & Muthén, 2012), all raw scores and factor scores were converted to *z*-scores ($M = 0$; $SD = 1$) for the LPA and to facilitate interpretation across measures.

[TABLE 1 ABOUT HERE]

[TABLE 2 ABOUT HERE]

Lexical Quality Profiles

To address our first research question regarding the extent to which profiles of lexical quality exist, exploratory latent profile analysis (LPA) was conducted using four domains of lexical quality. Orthography and phonology were measured through single measures – letter knowledge and phonological awareness, respectively. Factor scores were used for morphosyntax and vocabulary. Measures included in the morphosyntax factor were CELF-4 Word Structure, TEGI, TROG, and CELF-4 Recalling Sentences. Measures included in the vocabulary factor were PPVT, EVT, and CELF-4 Word Classes receptive and expressive. To determine the ideal number of profiles, we fit a series of models with an increasing number of groups, from two to seven. Absolute and comparative model fit indices were used to evaluate each model and to identify which model provided the best fit to the data. The specific indices examined included the Log likelihood (-2LL), Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and entropy. The -2LL, AIC, and BIC are comparative fit indices which allow for comparison of competing models (e.g., the 2- vs. 3-profile models). Smaller numbers indicate better fit; -2LL and BIC are considered to be the most accurate comparative fit indicators (Nylund, Asparouhov, & Muthén, 2007). The Lo-Mendell-Rubin Likelihood Ratio Test (LMRT) and the Bootstrapped Likelihood Ratio Test (BLRT) each determine whether the model being tested fits better than the previous model with one less profile. Finally, entropy is an index of how distinct the identified profiles are from each other, with values > .80 considered to indicate good fit (Celeux & Soromenho, 1996).

Results of the model fit indices are presented in Table 3. As is often the case in LPA, selecting the optimal number of profiles was not straightforward. The comparative

fit indices, 2LL, AIC and BIC, all decreased as the number of profiles increased. The decrease in BIC was greatest between the 2- and 3-profile models but entropy was not acceptable in either of these models. BIC flattened after the 5-profile model. The LMRT index was significant for the 6-profile model but not the 4- or 5- profile models. The BLRT, however, was significant for all models. Thus, the BIC indicated a 5- profile solution was better whereas the LMRT pointed to a 6-profile solution. To resolve this ambiguity, both models were further examined for conceptual merit, specifically, class counts and interpretability of the profiles (Lawson & Masyn, 2015; Logan & Pentimonti, 2016). Examining class counts, the 6-profile solution was found to have one profile with a very small group of children (n =16; 3.8% of the sample), smaller than the 5% recommended by Logan & Pentimonti (2016). The smallest class size in the 5-profile solution, however, was 50 (12%). With all of this information in mind, and in consideration of parsimony, the 5-profile solution was selected.

[TABLE 3 ABOUT HERE]

As expected, children showed variability in their lexical quality. The mean scores across lexical quality domains for each of the five groups are depicted in Figure 1. Group means are presented as *z*-scores (M = 0, SD = 1), therefore enabling comparison between groups based on *SD* units. It is notable that there was little within-profile variability across the language-related domains of lexical quality – phonology, morphosyntax and vocabulary – for three of the profiles. The only within-profile variability occurred for two 'inconsistent' profiles (described in the following paragraph) that showed differences between language-related skills and orthography (letter knowledge).

[FIGURE 1 ABOUT HERE]

Profile 1: Low (n = 50; 12%). This group of children performed very low on all four lexical quality domains as compared to other children in our sample, scoring approximately 1.5 *SD* below the mean. *Profile 2: Low Letter (n = 56; 13%).* Children in this profile performed close to the mean for our sample across the language-related domains (phonology, morphosyntax, and vocabulary), but scored very low (1.5 *SD* below the mean) on orthography. *Profile 3: Low Language (n = 68; 16%).* This profile is the opposite of Profile 2; children's scores were low on the language-related domains as compared to other children in this sample (1 *SD* below the mean) but close to the mean for orthography. *Profile 4: Average (n = 181; 43%).* This profile is characterized by average performance across the four lexical quality domains. As expected, this was the profile with the largest number of children. *Profile 5: High (n = 65; 16%).* These children had high scores across all four domains as compared to other children in our sample, with morphosyntax and vocabulary a little higher than orthography and phonology. To summarize, three profiles (*High, Average, Low)* demonstrated consistent performance across lexical quality domains and two profiles (*Low Letter, Low Language)* demonstrated inconsistent performance.

Predicting First Grade Outcomes

To address our second and third research questions, regarding the prediction of first grade outcomes from profile membership, we first created factor scores for the three outcomes. The reading comprehension factor consisted of the Paragraph Comprehension subtest of WRMT, the Comprehension subtest of GMRT, and the RCM. The listening comprehension factor consisted of the TNL and LCM, and the word recognition factor

consisted of the Word Identification and Word Attack subtests of the WRMT, and the Sight Word Efficiency and Phonemic Decoding Efficiency subtests of the TOWRE. The reading comprehension factor was highly correlated with the listening comprehension factor (r = .729) and very highly correlated with the word recognition factor (r = .956).[1] Listening comprehension and word recognition were moderately correlated (r = .548). The very high correlation between reading comprehension and word recognition indicates these are essentially a single construct in our sample of first grade children. This finding is in line with previous research showing that early reading comprehension is highly dependent upon word recognition skill (e.g., Authors, 2015). The mean scores for each profile on each outcome are depicted in Figure 2.

[FIGURE 2 ABOUT HERE]

Next, a series of linear regressions were run using IBM SPSS Statistics (version 21) to predict each outcome from profile membership and to compare group performance across outcomes. Two control variables were originally included – nonverbal intelligence and mother's education – but mother's education was not a significant predictor in any of the models and it had missing data for several children; thus it was removed from the models. The categorical variable for profile membership was dummy coded such that we were able to analyze the significance of the regression weight for each profile. With dummy coding, one level of a categorical predictor (in our case, one profile) is omitted from the regression and is therefore the constant, or the reference from which to compare other levels of the category (other profiles). We ran separate regressions with each profile

[1] Given this high correlation, we tested a two-factor confirmatory factor analysis with reading (all measures) and listening comprehension. Model fit was worse than for the three-factor model; thus we retained the three factors.

serving as the reference, allowing us to determine the degree to which each profile was uniquely related to each outcome. Results of these regression analyses are described next. Tables 4 to 6 provide the regression weights for a profile in the four instances in which one of the other profiles was excluded. The reported values for the excluded profile refer to the constant.

Reading comprehension. Profile membership, while controlling for nonverbal intelligence, significantly predicted reading comprehension in first grade $F(5, 330) = 47.391$, $p < .001$ and explained 40.9% (R^2_{adj}) of the variance. Nonverbal intelligence was a significant predictor but contributed negligibly to the prediction (with nonverbal intelligence removed from the model, profile membership on its own predicted 39.6% of the variance).

As hypothesized, differences in reading comprehension were evident across profiles (see Figure 2). Children who had been in profiles characterized by consistent lexical quality – High, Average, and Low – performed high, average, and low, respectively, on reading comprehension as compared to other children in our sample. Results from regression analyses indicated that these differences between high, average, and low profiles were significant (Table 4); with each of these three profiles serving as the reference, each of the other profiles were significant predictors. However, children who had been in the profiles characterized by inconsistent lexical quality – *Low Letter* and *Low Language* – performed similarly to each other on reading comprehension (i.e., the *Low Language* profile was not a significant predictor when the *Low Letter* profile was the reference, and vice versa). Specifically, children in both of these profiles demonstrated reading comprehension in the low average range (approximately -0.5 *SD*),

despite having started out with different strengths and weaknesses in lexical quality domains in preschool.

[TABLE 4 ABOUT HERE]

Listening comprehension and word recognition. Profile membership, while controlling for nonverbal intelligence, significantly predicted both listening comprehension $F(5, 330) = 46.764$, $p < .001$ and word recognition $F(5, 330) = 32.248$, $p < .001$. Total variance accounted for (R^2_{adj}) was 40.6% for listening comprehension and 31.8% for word recognition. Nonverbal intelligence was a significant predictor of listening comprehension although, again, the amount of variance explained changed minimally when it was removed (listening comprehension on its own explained 35.2% of the variance). Nonverbal intelligence was not a significant predictor of word recognition.

Performance in listening comprehension and word recognition varied between profiles (see Figure 2). As with the reading comprehension outcome, children who had been in the *High*, *Average*, and *Low* lexical quality profiles performed high, average, and low in listening comprehension and word recognition. These differences between high, average, and low profiles were significant for both listening comprehension (Table 5) and word recognition (Table 6); with each of these three profiles serving as the reference, each of the other profiles was a significant predictor.

[TABLE 5 ABOUT HERE]

[TABLE 6 ABOUT HERE]

In contrast, children in the *Low Letter* and *Low Language* profiles showed differences between skills. Children in the *Low Letter* profile scored near the mean (-0.16 *SD*) on listening comprehension but low average (-0.55 *SD*) on word recognition.

Children in the *Low Language* profile scored lower on listening comprehension (-0.70 *SD*) than on word recognition (-0.33 *SD*). Visual inspection of the mean scores indicated that children in these two inconsistent profiles differed from each other on listening comprehension, with the *Low Language* children scoring lower, but they did not differ on word recognition. Both groups scored in the low average range on word recognition, at approximately the same level as their reading comprehension. These comparisons were supported by the results of the regression analyses (Tables 5 and 6); with the *Low Language* profile as the reference, the *Low Letter* profile was a significant predictor in the listening comprehension model but not in the word recognition model.

Discussion

The goals of the present study were to determine the extent to which reliable profiles of lexical quality exist in preschool children and the extent to which profile membership was related to first grade outcomes across reading comprehension and its components (i.e., listening comprehension and word recognition).

The Profiles

Results of the current investigation revealed three main findings. First, preschool children were characterized by five unique profiles of lexical quality, ranging from low skill across all domains (orthography, phonology, morphosyntax, and vocabulary) to high skill across all domains. The majority of children (43% of the sample) belonged to the *Average* profile, demonstrating average performance across all domains of lexical quality. Children in the *High* profile (16% of the sample) displayed higher lexical quality than children in the other profiles, with scores on morphosyntax and vocabulary being strongest. The remaining three profiles (*Low*, *Low Language*, *Low Letter*), representing

41% of the sample, were characterized by low performance on at least one of the lexical quality domains and therefore may be at risk for difficulties in reading comprehension.

Within three of the five profiles, consistency was found across all four domains of lexical quality. For instance, a child who scored low in one domain, such as phonology, also scored low in all other domains. The two profiles that showed inconsistencies within their profiles were the *Low Language* and *Low Letter* profiles. The *Low Language* profile was comprised of children whose language skills (i.e., phonology, morphosyntax, and vocabulary) were low but whose orthography skills were average. In other words, these children appear delayed in their language development but have age-appropriate letter knowledge. In contrast, children in the *Low Letter* profile exhibited average language skills but low orthography skills. Thus, they appear to have normal language development but may have had limited exposure to alphabet learning opportunities. Children in these two inconsistent profiles provide an interesting opportunity to explore differences in reading comprehension, given that they display different patterns in the domains of lexical quality.

Predicting Reading Comprehension

Our second main finding was that profile membership significantly predicted a substantial amount of variance in first grade reading comprehension while controlling for nonverbal intelligence. Children who had been in the *High*, *Average*, and *Low* lexical quality profiles maintained their consistent pattern and scored high, average, and low, respectively, on reading comprehension. Children within profiles that had inconsistent patterns of performance (i.e., *Low Language* and *Low Letter* profiles) exhibited lower reading comprehension skills. Interestingly, the two groups did not differ from each other

on reading comprehension performance. Thus, regardless of which lexical quality domain was weaker in preschool, reading comprehension performance was also weaker. We explored this further by examining two primary components of reading comprehension – listening comprehension and word recognition – as per the simple view of reading.

Predicting Listening Comprehension and Word Recognition

Our third main finding was in regard to the prediction of the components of reading comprehension (i.e., listening comprehension and word recognition). To capture a more fine-grained analysis of reading comprehension skills, all preschool profiles were examined with regards to performance on first grade measures of listening comprehension and word recognition. Profile membership significantly predicted a substantial amount of variance in both outcomes when nonverbal intelligence was controlled. Again, consistency was maintained for the *High*, *Average*, and *Low* preschool profiles; each group performed high, average, or low, respectively, on first grade listening comprehension and word recognition. The two profiles with inconsistent performance across lexical quality domains also exhibited inconsistent performance across listening comprehension and word recognition. Not surprisingly, children in the *Low Letter* profile exhibited average listening comprehension but low average word recognition. Children in the *Low Language* profile exhibited low listening comprehension and low average word recognition.

This finding is useful for considering the role of lexical quality domains early in language and literacy development. In particular, the *Low Letter* and *Low Language* profiles indicate that, although first grade reading comprehension may look similar between these groups of children, a more in-depth analysis of their skills revealed

weaknesses related to the components of reading comprehension. Early difficulties in letter knowledge resulted in later difficulties with word recognition; early difficulties with language-based skills (for our purposes, phonology, morphosyntax, and vocabulary) resulted in later difficulties with listening comprehension.

Taken together, the results of both the reading comprehension analyses and the listening comprehension and word recognition analyses reveal some compelling patterns. First, children who had been in the *Low Letter* profile eventually demonstrated the same level of performance for word recognition as children in the *Low Language* profile, despite scoring much lower on letter knowledge in preschool. This suggests that formal instruction between preschool and first grade may have helped to bridge the gap in performance on letter knowledge, albeit a constrained skill, for those children who started school with good language skills but weak letter knowledge. Note, however, that children who demonstrated low lexical quality across all four domains in preschool did not seem to benefit in the same way – their word recognition performance was low. It may be the case that good language skills act as a protective factor against early deficits in letter knowledge (Snowling, Gallagher, & Frith, 2003).

Second, children in the *Low Letter* and *Low Language* profiles obtained similar scores in word recognition and reading comprehension. This is likely due to the nature of reading comprehension assessments in first grade. Previous research has indicated that many assessments are comprised of short texts or cloze tasks that rely more on decoding ability than on true comprehension (Keenan, Betjemann, & Olson, 2008). Thus, if a child is able to decode key words, or rely on visual supports, s/he may be able to answer the majority of the comprehension questions. Finally, those children who started out with low

language in preschool (*Low* and *Low Language* profiles) did more poorly on listening comprehension in first grade compared to children in the other three profiles. This may indicate that for unconstrained skills, such as listening comprehension, formal schooling did not yet bridge the gap for these children. We expand upon this idea, and the importance of language skills below.

It is not entirely surprising that early weaknesses in language skills are related to later difficulties with comprehension-based tasks. Much of what is required during comprehension is related to language – understanding the meanings of words, processing grammatical structure and morphological endings, and inferencing meaning from a passage or story. Certainly, previous work has supported the connection between language and reading comprehension. For instance, Nation and Snowling (2004) noted that school-aged children with poor language skills will exhibit weaknesses with reading comprehension. In a longitudinal study, Stothard, Snowling, Bishop, Chipchase, and Kaplan (1998) found that adolescents with a history of preschool language impairment continued to exhibit weaknesses in phonological processing and literacy skills compared to age-matched peers who had remediated their language-based difficulties by the age of 5. Children who persisted with language impairments past age 5 evidenced continued deficits in written and spoken language at age 15. Although this study did not consider the variables of interest within the lexical quality or simple view of reading frameworks, the results are similar. Another primary difference between the Stothard et al. (1998) study and the present investigation is that the latter employed a person-centered approach to analysis as opposed to a variable-centered approach. By avoiding arbitrary cut points, like many variable-centered approaches, a latent profile analysis examines children's

pattern of responses across multiple measures and therefore takes variability across skills into account. Additionally, person-centered approaches such as latent profile analysis account for heterogeneity in the sample – they assume that there are underlying groups of people rather than a single homogenous sample. Therefore, examining these patterns allows for a nuanced evaluation of variability in skills across multiple measures which provides an alternative means of identifying risk.

It is important to note here that, although our analyses have enabled us to make between-profile comparisons, person-centered methodology may be most appropriate for identifying gaps across skills *within* profiles rather than absolute differences in skills *between* profiles. For instance, the profile characterized by low letter knowledge coupled with average language skills correctly predicted a gap between listening comprehension and word recognition, and not necessarily a deficit in word recognition per se.

When considering the application of these results to clinical practice, the implications are clear. It is necessary to fully assess lexical quality domains early in development to capture the nuances in language and literacy skills, particularly for children at risk for language and literacy impairments. The latent profile analysis allowed for a sensitive examination of five unique profiles and how those children grew to become good or poor at reading comprehension. The identification of these unique profiles highlights, again, the benefits of using a person-centered approach, as it allows for examination of variability in children's skills across multiple measures and, in turn, a sophisticated understanding of children's unique needs across a range of skills. Thus, for early intervention purposes, preventative treatment can be tailored towards the individual needs of the child. For instance, a preschool child exhibiting weakness in orthography

(e.g., letter knowledge) is at risk for later deficits in word recognition. A deficit in word recognition will also result in overall weakness with reading comprehension (at least in first grade). For this particular profile, treatment can intensively target letter knowledge skills, which is likely to support the primary area of need for that child. In providing early identification as well as targeted early intervention, we may prevent the "snowball" effect by which children with deficits in one or more domains of lexical quality become children with deficits in one or more components of reading comprehension.

Limitations and Conclusion

Key limitations of this study include how lexical quality was defined and measured. Because of the age of our sample, we could not directly assess the quality of orthographic representations of words, because children would have performed at or near floor limiting our ability to capture variance in this skill. Instead we used letter knowledge as a measure of orthographic knowledge suitable for this age group. Similarly, like other studies of lexical quality (Richter et al., 2013; Verhoeven et al., 2016), we used a measure of phonological knowledge (i.e., a phonological awareness task) to index phonological representations. Future concurrent and longitudinal work is needed to confirm the predictive validity of such measures for real word orthographic and phonological representations to extend our understanding of the foundations and development of lexical quality.

Also related to measurement, we used indicators of *knowledge* in the four lexical quality domains – orthography, phonology, morphosyntax, and vocabulary – but did not take into account the broader construct of lexical quality that includes speed and efficiency of access. Future research should endeavor to include measurement of

response time. Of note, however, is evidence suggesting that accuracy of lexical representations may be more important than speed of access for reading comprehension (Richter et al., 2013). In addition, we had only single indicators of the orthography and phonology domains of lexical quality. It would be preferable to have multiple measures in order to create latent variables, as we did with the morphosyntax and vocabulary domains.

Another limitation is our attempt to examine reading comprehension and word recognition separately when they may be tapping a single construct at this early point in reading development. Although we tested the model with reading comprehension and word recognition as a single factor and found it to result in a slightly worse fit, we acknowledge that the high correlation between these two latent variables is problematic. Differences in how the profiles relate to reading comprehension and word recognition can occur only within a very small amount of unique variance (9%). Nevertheless, we feel that this study offers a valuable look at the relationship between lexical quality domains and early reading. In future work, it would be beneficial to follow children into later grades when reading comprehension is less dependent on word recognition.

A methodological limitation of this study is that using regression analyses to predict outcomes from profile membership fails to account for the fact that profile membership is not perfect. Classification into profiles is based on the probability of belonging in a given profile and this involves error (i.e., probabilities < 100%). Treating the data as if classification were perfect can lead to biased estimates of the association between the profiles and the outcomes. Future work could overcome this limitation using a modified three-step approach (e.g., Vermunt, 2010). A final note with regards to the

limitations of our study is that the sample was representative of mid- to high-socioeconomic status and therefore our results may not be generalizable to the population as a whole.

The results of this study point to additional future research directions. One important avenue for future research is to investigate whether the association between lexical quality and reading changes across grades. Since the relative contribution of listening comprehension and word recognition to reading comprehension changes over time (e.g., Authors, 2015), it is possible that the prediction of these skills from lexical quality may also change. Additionally, our use of a person-centered approach allowed us to gain insight into individual level differences between young children in regard to their lexical quality skills. Future research should investigate whether lexical quality profiles are replicable in preschool (particularly considering the ambiguity in the optimal number of profiles in our data), and whether meaningful profiles exist across other grades as well. Stability of profile membership over time would also be of interest, to determine whether children remain in the same profile or if their pattern of skills changes over time, as has been found in previous work (Tambyraja, Schmitt, Farquharson, & Justice, 2015). Finally, it may be productive in future research to conduct an exploratory factor analysis to determine whether the assessments load onto the lexical quality domains as we assumed a priori in this study.

In conclusion, we have offered a preliminary investigation of preschool children's knowledge across lexical quality domains as a predictor of later reading comprehension. Our results revealed that preschool children could be reliably placed into five profiles based on their lexical quality skills and that these profiles significantly predicted reading

comprehension as well as its components (i.e., listening comprehension and word recognition). To summarize, profiles of low lexical quality in preschool children were indicative of susceptibility to later reading difficulties. Children who had low indicators of lexical quality in preschool performed low average or below average on at least one of the outcomes in first grade. This work provides preliminary support for the validity of examining domains of lexical quality as a framework for investigating early reading. Additional work is needed to further explore the validity and utility of this framework and how it may contribute to efforts in early identification of reading difficulties.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

Authors (2015).

Authors (2016).

Apel, K., Wilson-Fowler, E. B., Brimo, D., & Perrin, N. A. (2012). Metalinguistic contributions to reading and spelling in second and third grade students. *Reading and Writing: An Interdisciplinary Journal, 25*(6), 1283-1305. doi:10.1007/s11145-011-9317-8

Bishop, D. V. M. (2003). *Test for reception of grammar* (2nd ed.). Minneapolis, MN: Pearson.

Catts, H. W., Adlof, S. M., & Ellis Weismer, S. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research, 49*(2), 278-293. doi:10.1044/1092-4388(2006/023)

Catts, H. W., Nielsen, D. C., Bridges, M. S., & Liu, Y.-S. (2014). Early identification of reading comprehension difficulties. *Journal of Learning Disabilities*. doi:10.1177/0022219414556121

Celeux, G., & Soromenho, G. (1996). An entropy criterion for assessing the number of clusters in a mixture model. *Journal of Classification, 13*(2), 195-212. doi:10.1007/BF01246098

Dunn, L. M., & Dunn, D. M. (2007). *Peabody picture vocabulary test* (4th ed.). Minneapolis, MN: Pearson.

Florit, E., Roch, M., & Levorato, M. C. (2014). Listening text comprehension in preschoolers: A longitudinal study on the role of semantic components. *Reading*

and Writing: An Interdisciplinary Journal, 27(5), 793-817. doi:10.1007/s11145-013-9464-1

Francis, D. J., Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Fletcher, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology, 88*(1), 3-17. doi:10.1037/0022-0663.88.1.3

Gillam, R. B., & Pearson, N. A. (2004). *Test of narrative language*. Austin: TX: Pro-Ed.

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal, 2*(2), 127-160. doi:10.1007/BF00401799

Juel, C. (1988). Learning to read and write. *Journal of Educational Psychology, 80*(4), 437-447. doi:10.1037//0022-0663.80.4.437

Kaufman, A. S., & Kaufman, N. L. (1997). *Kaufman brief intelligence test* (2nd ed.). Minneapolis, MN: Pearson.

Keenan, J. M., Betjemann, R. S., & Olson, R. K. (2008). Reading comprehension tests vary in the skills they assess: Differential dependence on decoding and oral comprehension. *Scientific Studies of Reading, 12*(3), 281-300. doi:10.1080/10888430802132279

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school. *Journal of Educational Psychology, 101*(4), 765-778. doi:10.1037/a0015956

Kim, Y.-S. (2014). Language and cognitive predictors of text comprehension: Evidence from multivariate analysis. *Child Development, 86*(1), 128-144. doi:10.1111/cdev.12293

Kim, Y.-S., Apel, K., & Al Otaiba, S. (2013). The relation of linguistic awareness and vocabulary to word reading and spelling for first-grade students participating in response to intervention. *Language, Speech, and Hearing Services in Schools, 44*(4), 337-347. doi:10.1044/0161-1461(2013/12-0013)

Lawson, M. A., & Masyn, K. E. (2015). Analyzing profiles and predictors of students' social-ecological engagement. *AERA Open, 1*(4). doi:10.1177/2332858415615856

Leslie, L., & Caldwell, J. (2010). *Qualitative reading inventory* (5th ed.). Boston, MA: Pearson.

Logan, R. J. A., & Pentimonti, M. J. (2016). Introduction to latent class analysis for reading fluency research. In D. K. Cummings & Y. Petscher (Eds.), *The fluency construct: Curriculum-based measurement concepts and applications* (pp. 309-332). New York, NY: Springer New York.

Lonigan, C. J., Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (2007). *Test of preschool early literacy*. Austin, TX: Pro-Ed.

MacGinitie, W. H., MacGinitie, R. K., Maria, K., & Dreyer, L. G. (2000). *Gates-MacGinitie reading tests (4th ed.)*. Itasca, IL: Riverside Publishing.

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*(5), 665-681. doi:10.1037/0012-1649.40.5.665

Muthén, L. K., & Muthén, B. O. (2012). *MPlus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nation, K., Cocksey, J., Taylor, J. S. H., & Bishop, D. V. M. (2010). A longitudinal investigation of early reading and language skills in children with poor reading comprehension. *Journal of Child Psychology and Psychiatry, 51*(9), 1031-1039. doi:10.1111/j.1469-7610.2010.02254.x

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading, 27*(4), 342-356. doi:10.1111/j.1467-9817.2004.00238.x

National Early Literacy Panel. (2008). *Developing early literacy: Report of the national early literacy panel*. Washington, D.C.: National Institute for Literacy.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(4), 535-569. doi:10.1080/10705510701575396

Perfetti, C. A. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading, 11*(4), 357-383. doi:10.1080/10888430701530730

Perfetti, C. A., & Hart, L. (2002). The lexical quality hypothesis. *Precursors of functional literacy, 11*, 67-86.

Rice, M. L., & Wexler, K. (2001). *Rice/wexler test of early grammatical impairment*. San Antonia, TX: The Psychological Corporation.

Richter, T., Isberner, M.-B., Naumann, J., & Neeb, Y. (2013). Lexical quality and reading comprehension in primary school children. *Scientific Studies of Reading, 17*(6), 415-434. doi:10.1080/10888438.2013.764879

Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical evaluation of language fundamentals (4th ed.)*. Bloomington, MN: Pearson.

Snowling, M. J., Gallagher, A., & Frith, U. (2003). Family risk of dyslexia is continuous: Individual differences in the precursors of reading skill. *Child Development, 74*(2), 358-373. doi:10.2307/3696318

Stothard, S. E., Snowling, M. J., Bishop, D. V. M., Chipchase, B. B., & Kaplan, C. A. (1998). Language-impaired preschoolers: A follow-up into adolescence. *Journal of Speech, Language, and Hearing Research, 41*(2), 407-418. doi:10.1044/jslhr.4102.407

Tambyraja, S. R., Schmitt, M. B., Farquharson, K., & Justice, L. M. (2015). Stability of language and literacy profiles of children with language impairment in the public schools. *Journal of Speech, Language, and Hearing Research, 58*(4), 1167-1181. doi:10.1044/2015_JSLHR-L-14-0197

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (2012). *Test of word reading efficiency* (2nd ed.). Austin, TX: Pro-Ed.

Verhoeven, L., & van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology, 22*(3), 407-423. doi:10.1002/acp.1414

Verhoeven, L., van Leeuwe, J., Irausquin, R., & Segers, E. (2016). The unique role of lexical accessibility in predicting kindergarten emergent literacy. *Reading and Writing, 29*(4), 591-608. doi:10.1007/s11145-015-9614-8

Vermunt, J. K. (2010). Latent class modeling with covariates: Two improved +three-step approaches. *Political Analysis, 18*(4), 450-469. doi:10.1093/pan/mpq025

Wiig, E. H., Secord, W., & Semel, E. M. (2004). *Clinical evaluation of language fundamentals: Preschool (2nd ed.)*. San Antonio, TX: Psychological Corporation.

Williams, K. T. (2007). *Expressive vocabulary test* (2nd ed.). Bloomington, MN: Pearson.

Woodcock, R. W. (1998). *Woodcock reading mastery tests-revised: Normative update*. Circle Pines, MN: American Guidance Service/Pearson Assessments.

Table 1

Descriptive Statistics and Reliabilities for Preschool and First Grade Measures

	M	***SD***	***Reliability***
Preschool measures			
WRMT Letter identification	22.84	9.965	0.95
TOPEL Phonological Awareness	18.48	5.490	0.88
CELF Word Structure	15.59	5.557	0.83
TEGI Third Person	7.00	2.932	0.85
TEGI Past Tense	8.55	4.319	0.86
Test for Reception of Grammar	6.25	3.757	0.84
CELF Recalling Sentences	32.15	13.993	0.92
Peabody Picture Vocabulary Test-4	93.80	19.293	0.96
Expressive Vocabulary Test-2	70.06	13.777	0.94
CELF Word Classes-receptive	14.30	4.437	0.88
CELF Word Classes-expressive	7.81	4.539	0.85
First grade measures			
Reading Comprehension			
WRMT Passage comprehension	24.05	8.159	0.91
Gates-MacGinitie	29.02	7.312	0.89
Reading Comprehension Measure	10.02	3.275	0.77
Listening Comprehension			
Test of Narrative Language	27.05	4.504	0.69
Listening Comprehension Measure	11.77	2.811	0.65
Word recognition			
WRMT Word Identification	48.23	13.799	0.96
WRMT Word Attack	20.87	9.123	0.92
TOWRE Sight Word*	44.54	15.122	--
TOWRE Phonemic Decoding*	19.86	9.977	--

Note. All means represent raw scores. WRMT = Woodcock Reading Mastery Tests-Revised: Normative Update; TOPEL = Test of Preschool Early Literacy; CELF = Clinical Evaluation of Language Fundamentals-4th ed.; TEGI = Test of Early Grammatical Impairment; TOWRE = Test of Word Reading Efficiency-2nd ed. All reliabilities are Cronbach's alpha from the study data.
* Cronbach's alpha for the TOWRE cannot be calculated since it is a timed measure.

Table 2

Correlations Amongst Preschool Lexical Quality Variables

	1	*2*	*3*	*4*	5	*6*	*7*	*8*	*9*	*10*	*11*
1. LK	1										
2. PA	.516**	1									
3. PPVT	.334**	.501**	1								
4. EVT	.447**	.584**	.706**	1							
5. WCR	.317**	.343**	.432**	.448**	1						
6. WCE	.416**	.469**	.515**	.578**	.775**	1					
7. WS	.328**	.507**	.617**	.595**	.372**	.509**	1				
8. TEGS	.259**	.414**	.436**	.451**	.298**	.392**	.533**	1			
9. TEGT	.304**	.389**	.365**	.429**	.171**	.244**	.420**	.456**	1		
10.TROG	.314**	.428**	.553**	.514**	.405**	.540**	.469**	.305**	.322**	1	
11. RS	.380**	.592**	.586**	.665**	.412**	.583**	.646**	.513**	.434**	.521**	1

Note. LK = Woodcock Reading Mastery Test-Letter Identification; PA = Test of Preschool Early Literacy-Phonological Awareness; PPVT = Peabody Picture Vocabulary Test-4; EVT = Expressive Vocabulary Test-2; WCR = Clinical Evaluation of Language Fundamentals (CELF-4)-Word Classes Receptive; WCE = CELF-4 Word Classes Expressive; WS = CELF-4 Word Structure; TEGS = Test of Early Grammatical Impairment (TEGI)-Third Person Singular; TEGT = TEGI-Past Tense; TROG = Test for Reception of Grammar; RS = CELF-4 Recalling Sentences.

**$p < .01$.

Table 3

Model Fit Indices for the Six Tested Latent Profile Models

Number of Classes	-2LL	Free Parameters	AIC	BIC	Entropy	LMRT	BLRT
2	-2130.043	13	4286.086	4338.609	0.788	< 0.001	<0.001
3	-2041.449	18	4118.897	4191.622	0.793	0.007	<0.001
4	-2002.466	23	4050.932	4143.858	0.822	0.428	<0.001
5	-1955.768	28	3967.537	4080.664	0.818	0.068	<0.001
6	-1926.097	33	3918.194	4051.522	0.832	0.001	<0.001
7	-1909.152	38	3894.305	4047.835	0.83	0.115	<0.001

Note. -2LL = -2 Log Likelihood, AIC = Akaike Information Criteria, BIC = Bayesian Information Criteria, LMRT = Lo-Mendell-Rubin Likelihood Ratio Test, BLRT = Bootstrapped Likelihood Ratio Test.

Table 4

Lexical Quality Profiles as Predictors of Reading Comprehension

Variable	Profile 1 as reference	Profile 2 as reference	Profile 3 as reference	Profile 4 as reference	Profile 5 as reference
	B (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value
NVIQ	0.012	0.012	0.012	0.012	0.012
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	.001	.001	.001	.001	.001
Profile 1:	-1.243	-0.741	-0.854	-1.515	-1.988
Low	(0.137)	(0.178)	(0.171)	(0.152)	(0.174)
	< .001	< .001	< .001	< .001	< .001
Profile 2:	0.741	-0.502	-0.114	-0.774	-1.247
Low Letter	(0.178)	(0.115)	(0.156)	(0.132)	(0.155)
	< .001	< .001	.469	< .001	< .001
Profile 3:	0.854	0.114	-0.389	-0.661	-1.134
Low Language	(0.171)	(0.156)	(0.107)	(0.126)	(0.151)
	< .001	.469	< .001	< .001	< .001
Profile 4:	1.515	0.774	0.661	0.272	-0.473
Average	(0.152)	(0.132)	(0.126)	(0.064)	(0.119)
	< .001	< .001	< .001	< .001	< .001
Profile 5:	1.988	1.247	1.134	0.473	0.745
High	(0.174)	(0.155)	(0.151)	(0.119)	(0.102)
	< .001	< .001	< .001	< .001	< .001

Note. All coefficients are unstandardized. NVIQ = nonverbal intelligence. Where each profile serves as the reference, the values shown for that profile represent the constant.

Table 5

Lexical Quality Profiles as Predictors of Listening Comprehension

	Profile 1 as reference	Profile 2 as reference	Profile 3 as reference	Profile 4 as reference	Profile 5 as reference
Variable	B (*SE*) *p*-value	B (*SE*) *p*-value	B (*SE*) *p*-value	B (*SE*) *p*-value	B (*SE*) *p*-value
NVIQ	0.020	0.020	0.020	0.020	0.020
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	< .001	< .001	< .001	< .001	< .001
Profile 1:	-1.036	-.910	-0.423	-1.246	-1.716
Low	(0.137)	(0.178)	(0.172)	(0.153)	(0.175)
	< .001	< .001	.014	< .001	< .001
Profile 2:	0.910	-0.126	0.486	-0.336	-0.807
Low Letter	(0.178)	(0.115)	(0.157)	(0.132)	(0.155)
	< .001	.276	.002	.012	< .001
Profile 3:	0.423	-0.486	-0.612	-0.822	-1.293
Low Language	(0.172)	(0.157)	(0.107)	(0.126)	(0.151)
	.014	.002	< .001	< .001	< .001
Profile 4:	1.246	0.336	0.822	0.210	-0.470
Average	(0.153)	(0.132)	(0.126)	(0.064)	(0.120)
	< .001	< .012	< .001	.001	< .001
Profile 5:	1.716	0.807	1.293	0.470	0.681
High	(0.175)	(0.155)	(0.151)	(0.120)	(0.102)
	< .001	< .001	< .001	< .011	< .001

Note. All coefficients are unstandardized. NVIQ = nonverbal intelligence. Where each profile serves as the reference, the values shown for that profile represent the constant.

Table 6

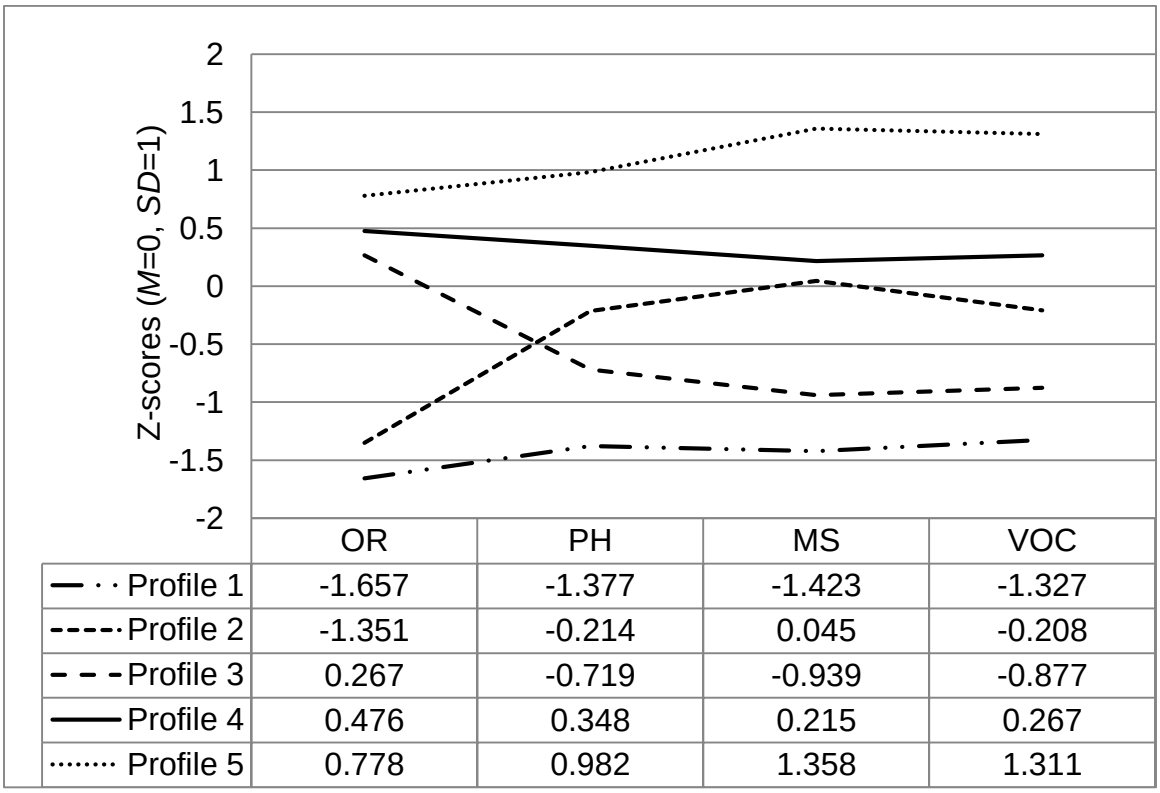
Lexical Quality Profiles as Predictors of Word Recognition

	Profile 1 as reference	Profile 2 as reference	Profile 3 as reference	Profile 4 as reference	Profile 5 as reference
Variable	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value	*B* (*SE*) *p*-value
NVIQ	0.007	0.007	0.007	0.007	0.007
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	.091	.091	.091	.091	.091
Profile 1:	-1.143	-0.603	-0.842	-1.399	-1.826
Low	(0.147)	(0.191)	(0.184)	(0.163)	(0.187)
	< .001	.002	< .001	< .001	< .001
Profile 2:	0.603	-0.540	-0.238	-0.796	-1.222
Low Letter	(0.191)	(0.123)	(0.168)	(0.142)	(0.166)
	.002	< .001	.157	< .001	< .001
Profile 3:	0.842	0.238	-0.302	-0.558	-0.984
Low Language	(0.184)	(0.168)	(0.115)	(0.135)	(0.162)
	< .001	.157	.009	< .001	< .001
Profile 4:	1.399	0.796	0.558	0.256	-0.426
Average	(0.163)	(0.142)	(0.135)	(0.069)	(0.128)
	< .001	< .001	< .001	< .001	.001
Profile 5:	1.826	1.222	0.984	0.426	0.682
High	(0.187)	(0.166)	(0.162)	(0.128)	(0.110)
	< .001	< .001	< .001	.001	< .001

Note. All coefficients are unstandardized. NVIQ = nonverbal intelligence. Where each profile serves as the reference, the values shown for that profile represent the constant.

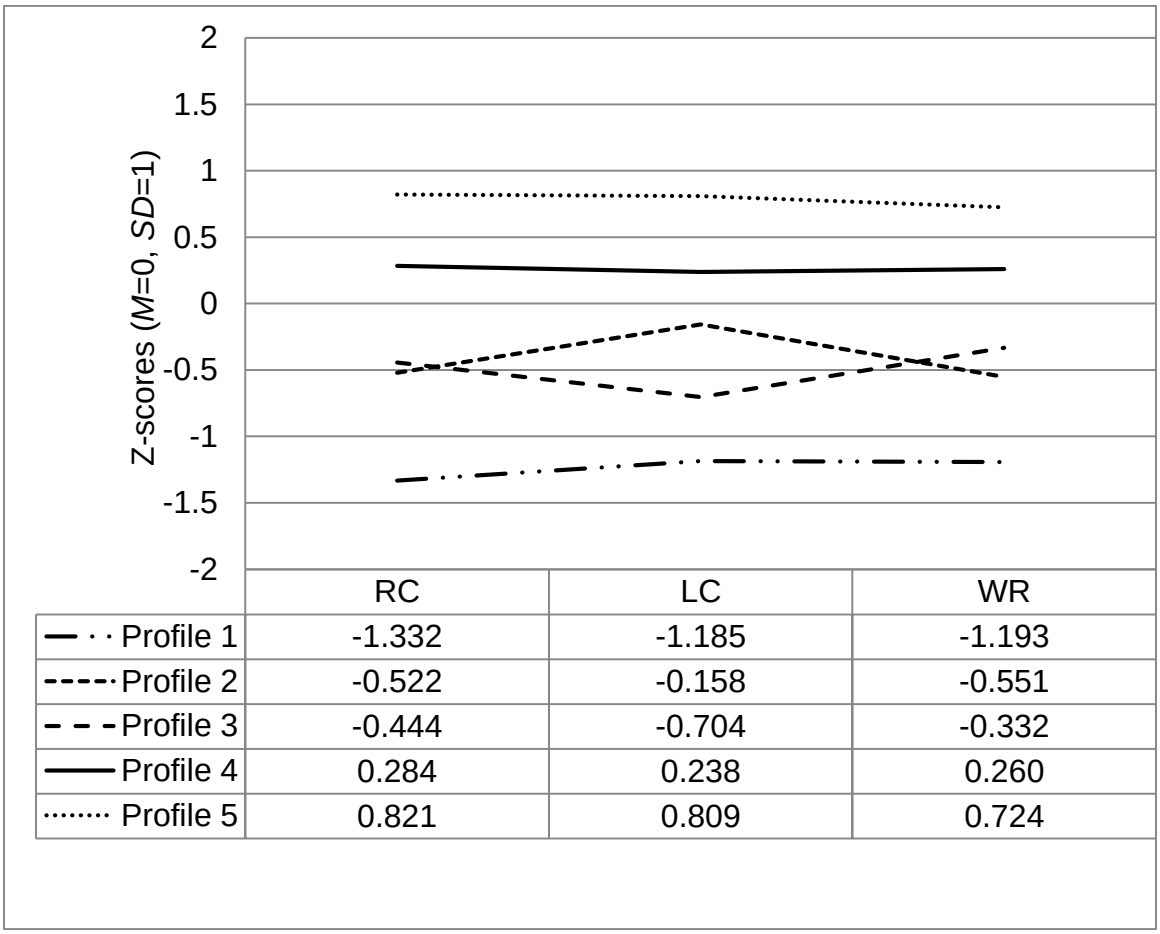
Figure 1. Latent profiles of lexical quality domains in preschool. Profile 1: Low (12%); Profile 2: Low Letter (13%); Profile 3: Low Language (16%); Profile 4: Average (43%); Profile 5: High (16%). OR = orthography; PH = phonology; MS = morphosyntax; VOC = vocabulary

Figure 2. Mean scores on first grade outcomes for each of the preschool lexical quality profiles. RC = reading comprehension; LC = listening comprehension; WR = word recognition



	OR	PH	MS	VOC
Profile 1	-1.657	-1.377	-1.423	-1.327
Profile 2	-1.351	-0.214	0.045	-0.208
Profile 3	0.267	-0.719	-0.939	-0.877
Profile 4	0.476	0.348	0.215	0.267
Profile 5	0.778	0.982	1.358	1.311

Figure 1. Latent profiles of lexical quality domains in preschool. Profile 1: Low (12%); Profile 2: Low Letter (13%); Profile 3: Low Language (16%); Profile 4: Average (43%); Profile 5: High (16%). OR = orthography; PH = phonology; MS = morphosyntax; VOC = vocabulary



	RC	LC	WR
Profile 1	-1.332	-1.185	-1.193
Profile 2	-0.522	-0.158	-0.551
Profile 3	-0.444	-0.704	-0.332
Profile 4	0.284	0.238	0.260
Profile 5	0.821	0.809	0.724

Figure 2. Mean scores on first grade outcomes for each of the preschool lexical quality profiles. RC = reading comprehension; LC = listening comprehension; WR = word recognition

April 20, 2016

Dear Dr. Joshi,

Thank you for the opportunity to further revise our manuscript READ-D-15-00138, *Investigating Profiles of Lexical Quality in Preschool and their Contribution to First Grade Reading* for publication in Reading and Writing: An Interdisciplinary Journal. We appreciate the thoughtful feedback provided and we believe that the manuscript has greatly improved as a result of the reviews.

In the remainder of this letter, we discuss how we carried out the necessary corrections to receive final acceptance for publication. Please let me know if further questions or need for clarification arise.

Sincerely,

Kimberly Murphy (corresponding author)