5-17-2019

Exploring Predictors of Reading Comprehension for Struggling Adult Readers: A Quantile Regression Approach

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EXPLORING PREDICTORS OF READING COMPREHENSION FOR STRUGGLING ADULT READERS: A QUANTILE REGRESSION APPROACH

by

AMANI TALWAR

Under the Direction of Daphne Greenberg

ABSTRACT

There is a paucity of research examining the skills that contribute to reading comprehension for adults who struggle with reading, which includes one in six adults in the United States (Organisation for Economic Co-operation and Development, 2013). The current studies addressed some of the gaps in this literature.

Study 1 explored the Simple View of Reading (SVR), which postulates that reading comprehension is predicted by two component skills: decoding and linguistic comprehension (Gough & Tunmer, 1986). Participants included 392 struggling adult readers who were native speakers of English. The dimensionality of the SVR components was examined using confirmatory factor analysis. For the decoding component, a parsimonious latent representation inclusive of phonic decoding and word recognition provided good fit to the data. With respect to linguistic comprehension, the subcomponents of oral vocabulary and listening comprehension emerged as separable yet highly related constructs. A structural equation model showed that decoding and listening comprehension made significant unique contributions to reading comprehension, whereas oral vocabulary did not emerge as a significant unique predictor.
Additionally, quantile regression analyses indicated that decoding, listening comprehension, and oral vocabulary exhibited significant unique effects on reading comprehension at low, average, and high levels of reading comprehension performance (.10, .50, and .90 quantiles), with decoding making the largest unique contributions.

Study 2 examined the influence of decoding, oral vocabulary, fluency, listening comprehension, background knowledge, and inferencing across different reading comprehension tests. Participants included 168 struggling adult readers who were native speakers of English. The explanatory effects of the predictors were estimated for three reading comprehension tests: WJ Passage Comprehension (WJ-PC), RISE Reading Comprehension (RISE-RC), and RAPID Reading Comprehension (RAPID-RC). Ordinary least squares regression analyses indicated that all predictors except for listening comprehension uniquely explained variance in WJ-PC scores, whereas significant unique predictors were limited to decoding and listening comprehension for RAPID-RC and only decoding for RISE-RC. Quantile regression analyses indicated that the effects of oral vocabulary and background knowledge differed across levels of WJ-PC performance, the effects of decoding and listening comprehension differed across levels of RAPID-RC performance, and the effect of decoding was stable across levels of RISE-RC performance.

INDEX WORDS: reading comprehension; struggling adult readers; adult literacy; quantile regression; Simple View of Reading
EXPLORING PREDICTORS OF READING COMPREHENSION FOR STRUGGLING ADULT READERS: A QUANTILE REGRESSION APPROACH

by

Amani Talwar

A Dissertation

Presented in Partial Fulfillment of Requirements for the Degree of Doctor in Philosophy in Educational Psychology in the Department of Learning Sciences in the College of Education and Human Development

Georgia State University

Atlanta, GA

2019
DEDICATION

To my parents, for the oceans of love and a lifetime of unconditional support.

To my siblings, for always being in my corner regardless of distances and circumstances.

And to my spouse, for the last five years and all that awaits.
ACKNOWLEDGMENTS

This undertaking would not have been possible without the guidance and efforts of several individuals. First and foremost, I would like to thank Dr. Daphne Greenberg. Daphne, thank you for your invaluable advice and support throughout my graduate training. It is difficult to express in words how much I value your mentorship. Ever since I emailed you as an undergraduate, you have been nothing but encouraging about my prospects, even when I had my doubts. I greatly appreciate the empathy, respect, and collegiality that you have always shown me. Thank you for being my guide as I completed the various stages of the PhD process and as I continue to navigate different facets of academia.

I am also extremely grateful to Dr. Elizabeth Tighe. Liz, thank you for your mentorship and friendship. I greatly value your encouragement and feedback on this dissertation and previous projects. Thank you for collaborating on my first publication as a graduate student and for encouraging me to target a premier journal. It is a privilege and a pleasure to work on innovative research with you and learn from your expertise. I look forward to our future collaboration.

I would like to express my gratitude to the other faculty members who served on my dissertation advisory committee. Dr. Hongli Li, thank you for giving me invaluable methodological feedback on this dissertation and previous papers, and for providing a strong statistical foundation in your SEM course. Dr. Ann Kruger, thank you for helping to shape the direction of this dissertation, and for skillfully supporting my writing and scholarly development in your courses.

I would also like to thank Dr. Katherine Binder. Kathy, thank you for introducing me to adult literacy research and quantitative methods. I deeply appreciate your mentorship and encouragement through all of these years. Your early vote of confidence in my writing and statistical abilities continues to mean the world to me. Thank you for advising me through various projects, including my undergraduate thesis and the resulting manuscript. I consider myself extremely lucky to have had the opportunity to work with you and learn from you.

Finally, I would like to extend a special thanks to all the research assistants who collected data for the Center for the Study of Adult Literacy. Thank you for putting in countless hours of testing, scoring, and data entry. You hard work has resulted in a unique, comprehensive dataset, which is a vital contribution to research on adults who struggle with reading.
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UNPACKING THE SIMPLE VIEW OF READING FOR STRUGGLING ADULT READERS

Review of the Literature

A recent estimate indicates that one in six adults in the United States has difficulty with understanding simple, everyday texts (Organisation for Economic Co-operation and Development, 2013). This process of translating text into mental representations is known as reading comprehension and has been recognized as the “ultimate goal of reading” (Keenan, 2016, p. 17). Unfortunately, there is dearth of research on struggling adult readers, and it is unclear how their reading comprehension subprocesses are organized in order to facilitate comprehension.

A useful framework for exploring reading comprehension subprocesses in this population is the Simple View of Reading, a widely used reading model introduced by Gough and Tunmer (1986). Originally, the SVR was proposed as a multiplicative model in which reading comprehension is predicted by the product (or interaction) of two components: decoding and linguistic comprehension. However, some studies have indicated that the product of decoding and linguistic comprehension does not always uniquely explain a statistically or practically significant proportion of variance in reading comprehension (Dreyer & Katz, 1992; Savage, 2006; Silverman, Speece, Harring, & Ritchey, 2013). Instead these investigations suggest that the SVR can be considered as an additive model in which decoding and linguistic comprehension make separate contributions to reading comprehension (Dreyer & Katz, 1992; Savage, 2006).

While the SVR may seem reductive, it provides a valuable perspective of the reading process (Kirby & Savage, 2010), especially for low-skilled readers. The focus of the SVR is on
the fundamental function of reading: the mapping of print to spoken language (Tunmer & Chapman, 2012). Across investigations with child, adolescent, and adult readers, decoding and linguistic comprehension have emerged as separable constructs that explain substantial variance in reading comprehension (Chen & Vellutino, 1997; Cutting & Scarborough, 2006; Kendeou et al., 2009; Sabatini, Sawaki, Shore, & Scarborough, 2010; Savage & Wolfforth, 2007; Vellutino, Tunmer, Jaccard, & Chen, 2007), even after controlling for other predictors (Silverman et al., 2013; Tilstra, McMaster, van den Broek, & Rapp, 2009). Furthermore, constructs that tap into decoding and linguistic comprehension have been included in more complex reading models (Cromley & Azevedo, 2007; Kim, 2017), which demonstrates the theoretical relevance of these skills to reading comprehension.

There is extensive empirical support for the SVR. The predictive utility of decoding and linguistic comprehension to reading comprehension has been established for students in the first grade through graduate school (Carver, 1998; Catts, Adlof, & Weismer, 2006; Chen & Vellutino, 1997; Hoover & Gough, 1990; Johnston & Kirby, 2006; Lonigan, Burgess, & Schatschneider, 2018; Savage, 2006; Savage & Wolfforth, 2007). Decoding and linguistic comprehension are such reliable predictors of reading comprehension that deficits in these skills can indicate specific profiles of reading difficulties (Catts, Hogan, & Fey, 2003; Catts et al., 2006). Moreover, the validity of the SVR extends beyond the English language context, as indicated by research involving languages with transparent orthographies, such as Spanish and Dutch (Florit & Cain, 2011).

Past research also indicates that the relative importance of decoding and linguistic comprehension may change as a function of reading skill level. It has been reported that decoding is a stronger correlate of reading comprehension than linguistic comprehension at the
beginning of elementary education, but that this relation declines as children advance through the elementary grades (Carver, 1998; Hoover & Gough, 1990; Kendeou et al., 2009). This pattern is also seen in terms of contributions to reading comprehension variance. Cross-sectional research with children has demonstrated that as grade level increases, the predictive utility of linguistic comprehension to reading comprehension increases and that of decoding decreases (Tilstra et al., 2009; Lonigan et al., 2018; Vellutino et al., 2007). For poor readers in high school and university, linguistic comprehension is not the dominant predictor of reading comprehension; in fact, decoding and linguistic comprehension appear to be correlated with reading comprehension at similar magnitudes for such samples (Savage, 2006; Savage & Wolforth, 2007). Overall, these results suggest that as readers become more proficient, reading comprehension is more heavily influenced by linguistic comprehension than by decoding. This observed trend may be explained by Perfetti’s (1985) verbal efficiency theory, which posits that lower-level processes (e.g., decoding) become automatized for advanced readers. This automatization frees up cognitive resources for higher-level skills (e.g., linguistic comprehension).

Despite the rich history of research with the SVR, there are multiple unanswered questions regarding the SVR for struggling adult readers, which were explored in the current study. Before turning to the current study, a literature review is presented that focuses on the gaps in the SVR literature requiring further investigation, especially with the struggling adult reader population.

**Components of the Simple View of Reading**

**Decoding.** Gough and Tunmer (1986) conceptualized decoding as phonological analysis, noting their reluctance “to equate decoding with word recognition” (p. 7). They proposed that assessments of this component should require the pronunciation of pseudowords (e.g., clard).
This ability to apply the knowledge of letter-sound correspondence rules to pronounce nonsense words is known as phonic decoding (Kilpatrick, 2015). Despite Gough and Tunmer’s (1986) characterization of decoding, several subsequent investigations of the SVR included real word recognition tests in their assessment of the decoding component (e.g., Adlof, Catts, & Little, 2006; Carver, 1993; Dreyer & Katz, 1992; Kendeou et al., 2009; Oulette & Beers, 2010).

Notably, Johnston and Kirby (2006) demonstrated with children in the elementary grades that the SVR explained a greater proportion of reading comprehension variance when the decoding component was represented by word recognition rather than phonic decoding. This finding suggests that comprehension is better predicted by a word processing ability that taps into the awareness of grapheme-phoneme relationships as well as the retrieval of familiar lexical subunits.

The issue of whether decoding should be interpreted as word recognition or phonic decoding has not been explored with adults who struggle with reading. This issue can be addressed by answering the question: do word recognition and phonic decoding tap into the same underlying ability for struggling adult readers? If the answer is yes, then it would make sense to refer to this underlying ability as decoding and conclude that the decoding component involves word recognition. However, if real word recognition and phonic decoding appear to be separable skills, then it would be prudent to treat the phonological ability (i.e., phonic decoding) as solely representative of the decoding component in Gough and Tunmer’s (1986) original framework. The current literature with struggling adult readers presents mixed findings regarding this question: word recognition and phonic decoding tests loaded onto the same latent factor for some samples of struggling adult readers (Nanda, Greenberg, & Morris, 2010; Sabatini et al., 2010; Tighe et al., 2018) but not for others (MacArthur, Konold, Glutting, & Alamprese, 2010;
Mellard, Woods, Desa, & Vuyk, 2015). Further research is clearly needed to explore the decoding component with struggling adult readers.

**Linguistic Comprehension.** The SVR component of linguistic comprehension is defined as the ability to derive meaning from spoken words, sentences, and discourses (Gough & Tunmer, 1986; Hoover & Gough, 1990). This complex meaning-making process indicates the involvement of oral vocabulary knowledge at the word level and listening comprehension at the sentence and discourse level (Kirby & Savage, 2008; Tunmer & Chapman, 2012). Although these two aspects of linguistic comprehension are widely accepted, the question remains as to whether they should be considered separate skills. Some past research with children suggests that these subcomponents tap into a shared latent ability (Silverman et al., 2013; Tunmer & Chapman, 2012) although this is not a unanimous finding (Lonigan et al., 2018). With struggling adult readers, Braze et al. (2016) found support for a unidimensional linguistic comprehension construct, but Sabatini et al. (2010) reported an improvement in model fit when oral vocabulary and listening comprehension were represented as separated factors. To arrive at a more conclusive answer, competing factor models involving these constructs should be compared.

**Quantile Regression Models of the Simple View of Reading**

The SVR literature indicates the changing roles of decoding and linguistic comprehension as children advance their reading skills (Hoover & Gough, 1990; Tilstra et al., 2009; Vellutino et al., 2007). In recent years, a handful of investigations have examined the stability of these predictors across reading proficiency levels using quantile regression, a methodology that was initially used in econometrics research (Koenker & Basset, 1978) and eventually adopted by other disciplines (Cade & Noon, 2003; Petscher & Logan, 2014). Quantiles refer to levels or “cut points” of a score distribution that are closely related to
percentiles (Petscher & Logan, 2014). Quantile regression analyzes the effect of independent variables at multiple quantiles in the distribution of a dependent variable (Davino, Furno, & Vistocco, 2014; Koenker & Basset, 1978; Koenker & Hallock, 2001). Each effect is estimated by utilizing data from the entire sample and appropriately assigning weights to different data points (Petscher & Logan, 2014). This allows researchers to explore the relation between the independent and dependent variables across the full range of skill level.

Past SVR research using quantile regression is limited to child samples. Lonigan et al. (2018) observed that the unique effect of decoding was relatively stable across different quantiles of reading comprehension performance, whereas the unique effect of oral vocabulary appeared to be greater at higher quantiles. Because tests of between-quantile slopes were not reported, it cannot be determined whether the apparent increase in the importance of vocabulary for higher-level comprehenders was statistically significant.

Hua and Keenan (2017) explored the importance of word recognition and listening comprehension on five reading comprehension tests with two age groups of readers. For children eight through 10 years old, the unique effect of word recognition significantly declined between the .10 and .50 quantiles and between the .50 and .90 quantiles of the Woodcock Johnson III Passage Comprehension subtest (Woodcock, McGrew, & Mather, 2001). There was no statistically significant difference in the unique effects of listening comprehension for any reading comprehension test. For older readers who were between the ages of 10 and 18 years, no between-quantile differences were found in the unique effects of word recognition and listening comprehension on any of the five reading comprehension tests.

Another quantile regression study relevant to the SVR was conducted by the Language and Reading Research Consortium (LARRC) and Logan (2017) with a sample of third grade
students. Although word reading and higher-level language exhibited approximately similar effects on reading comprehension for third graders at the .20 quantile of reading comprehension, the effect of word reading was significantly smaller at the .80 quantile whereas the effect of higher-level language remained stable across all quantiles. This finding, coupled with Hua and Keenan’s results for younger readers on the WJ Passage Comprehension subtest, supports the previously reported trend regarding the declining importance of decoding for more proficient readers in elementary school (Carver, 1998; Hoover & Gough, 1990).

**Gaps in Research with the Simple View of Reading for Struggling Adult Readers**

For struggling adult readers, reading comprehension is moderately to strongly correlated with both decoding and linguistic comprehension (Barnes, Kim, Tighe, & Vorstius, 2017; Braze, Tabor, Shankweiler, & Menel, 2007; Fracasso, Bangs, & Binder, 2016; Herman, Cote, Reilly, & Binder, 2013; Mellard, Fall, & Woods, 2010; Mellard & Fall, 2012; Sabatini et al., 2010; Tighe & Binder, 2015; To, Tighe, & Binder, 2016). A few investigations have explicitly analyzed the SVR framework in the adult literacy context. In these studies, decoding and linguistic comprehension accounted for the majority of variance in reading comprehension for adults whose reading skills were below the seventh grade level (Sabatini et al., 2010), between the first and tenth grade levels (Barnes et al., 2017), and between the first and twelfth grade levels (Mellard et al., 2010), as well as for young adults in different educational programs whose reading skill levels were not reported (Braze et al., 2007; Braze et al., 2016).

Past SVR research with struggling adult readers has not established whether the decoding component should be conceptualized as word recognition or more narrowly as phonic decoding (Hoover & Gough, 1990; Johnston & Kirby, 2006; MacArthur et al., 2010; Mellard et al., 2015; Nanda et al., 2010; Sabatini et al., 2010). It is also unclear whether the subcomponents of
linguistic comprehension component – listening comprehension and oral vocabulary – should be treated as separate abilities within the structure of the SVR (Braze et al., 2016; Sabatini et al., 2010; Silverman et al., 2013; Tunmer & Chapman, 2012). Additionally, there have been mixed findings regarding the relative contributions of each of the SVR predictors to reading comprehension. Barnes et al. (2017) and Braze et al. (2007, 2016) found that linguistic comprehension had a relatively larger effect on reading comprehension, while Mellard et al. (2010) found that the effect of decoding on reading comprehension was relatively larger. In contrast to these trends, Sabatini et al. (2010) found that both decoding and linguistic comprehension exhibited similar effects on reading comprehension. As mentioned previously in this section, these samples differed in terms of reading skill levels.

As children get older and become more proficient readers, the foundational skill of decoding decreases in importance whereas the complex skill of linguistic comprehension increases in importance (Carver, 1998; Hoover & Gough, 1990; Kendeou et al., 2009; Lonigan et al., 2018; Tilstra et al., 2009; Vellutino et al., 2007). It is currently unknown whether a similar finding can be observed with struggling adult readers who demonstrate lower and higher levels of reading comprehension performance. Studies investigating the SVR model with struggling adult readers include samples with a very wide range of reading grade levels (Barnes et al., 2017; Mellard et al., 2010) or unreported reading levels (Braze et al., 2007; Braze et al., 2016). There is some evidence that the literacy skill sets found in this population do not necessarily reflect constructs and trends reported in developmental research (Binder & Lee, 2012; Greenberg, Ehri, & Perin, 1997, 2002; Nanda et al., 2010).
The Current Study

The current study focused on evaluating the SVR with a sample of struggling adult readers with two main goals. The first goal was to explore the dimensionality of the decoding and linguistic comprehension constructs for struggling adult readers. The second goal was to systematically examine the unique contributions of decoding and linguistic comprehension as reading skill changes by estimating their effects at different reading comprehension quantiles (Hua & Keenan, 2017; LARRC & Logan, 2017; Lonigan et al., 2018). Quantile regression has been successfully applied with struggling adult readers in a previous study (Tighe & Schatschneider, 2016). Three research questions were addressed in this exploratory study.

1. For struggling adult readers, what is the dimensionality of the predictive components of the Simple View of Reading: decoding and linguistic comprehension?
   a. Do listening comprehension and oral vocabulary tap into a common latent ability?
   b. Do word recognition and phonic decoding tap into a common latent ability?

2. What proportions of reading comprehension variance in the sample are jointly and uniquely explained by decoding and linguistic comprehension?

3. What are the effects of the SVR predictors at low, average, and high levels of reading comprehension performance?

Method

Participants

This study utilized data collected at the Center for the Study of Adult Literacy (CSAL). The participants in this study were 392 individuals who were native speakers of English and were enrolled in adult literacy classes targeting adults who read at the third through seventh grade levels in literacy programs in the United States (56.6%) or Canada (43.4%). The mean age
of the sample was 36.99 years (SD = 14.85). The majority of the participants (61.5%) were women. Over two-thirds of the participants (69.9%) were of African descent and almost one-fourth (23.7%) were White. More detailed demographic information is reported in Table 1.1.

Table 1.1

<table>
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**Procedure**

Participants provided informed consent prior to testing and were financially compensated at the rate of $10 per hour. Those who were younger than 18 years provided informed assent as
well as parental consent. Testing was conducted one-on-one by trained research assistants at the participants’ adult literacy programs.

Measures

Ten assessments from the CSAL project were included in this study. The items on all of these measures gradually increase in difficulty. Demographic data were also collected.

Reading Comprehension.

WJ Passage Comprehension. In the Passage Comprehension subtest of the Woodcock Johnson (WJ) III Normative Update (Woodcock, McGrew, & Mather, 2007), the items were connected texts consisting of one or two sentences with missing words indicated by blanks. The participant silently read each item and filled in the blank by speaking the missing word out loud. Administration started at Item 14. Following the ceiling rule, items were administered by complete pages in the testing booklet until the participant received a score of zero on six consecutive items. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .73 to .96 (McGrew, Schrank, & Woodcock, 2007).

Word Recognition.

WJ Letter-Word Identification. In the WJ Letter-Word Identification subtest, the participant read real words out loud. Administration started at Item 33. Following the ceiling rule, items were administered by complete pages in the testing booklet until the participant received a score of zero on six consecutive items. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .88 to .99 (McGrew et al., 2007).
**Test of Irregular Word Reading.** In the Test of Irregular Word Reading (TIWRE; Reynolds & Kamphaus, 2007a), the participant was presented with a list of irregularly spelled words and read out loud as many as possible. Administration started with the first word item. Following the ceiling rule, administration was discontinued after the participant received a zero score on four consecutive items. This measure was standardized on individuals 3 to 94 years old and the internal consistency reliability estimates ranged from .88 to .96 (Reynolds & Kamphaus, 2007b).

**Phonic Decoding.**

*WJ Word Attack.* In the WJ Word Attack subtest, the participant read aloud pseudowords. Administration started at Item 4. Following the ceiling rule, items were administered by complete pages in the testing booklet until the participant received a score of zero on six consecutive items. This measure was standardized on individuals 4 years old to over 80 years old and the internal consistency reliability estimates ranged from .78 to .94 (McGrew et al., 2007).

**Listening Comprehension.**

*WJ Story Recall.* In the WJ Story Recall subtest, the examiner played audio recordings of very short stories and the participant retold each story out loud as accurately as possible. Administration started at Story 5. Following the ceiling rule, stories were administered in sets and administration was discontinued if a certain threshold of points was not reached on a set of stories. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .56 to .90 (McGrew et al., 2007).

*WJ Understanding Directions.* In the WJ Understanding Directions subtest, the examiner played audio recordings instructing participants how to point to different parts of an
accompanying picture. The participant carried out each set of instructions. Administration started at Picture 2. Following the ceiling rule, pictures were administered in sets and administration was discontinued if a certain threshold of points (determined by the test manual) was not reached on a set of pictures. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .62 to .93 (McGrew et al., 2007).

**CELF Understanding Spoken Paragraphs.** In the Understanding Spoken Paragraphs subtest of the Clinical Evaluation of Language Fundamentals IV (CELF; Semel, Wiig, & Secord, 2003a), the examiner read aloud very short stories and the participant answered questions about the content of the stories. Administration started at Item 1 of Set 1. Following the ceiling rule, if the participant received a score of zero on any item, administration was discontinued after that set was completed. This measure was standardized on individuals 5 to 21 years old and the internal consistency reliability estimates ranged from .54 to .81 (Semel, Wiig, & Secord, 2003b).

**Oral Vocabulary.**

**CELF Word Classes.** In the Word Classes subtest of the Clinical Evaluation of Language Fundamentals IV (CELF; Semel, Wiig, & Secord, 2003a), the examiner read four words out loud for each item. The participant selected two words that were related and then explained their relationship. Administration started at Item 1. Following the ceiling rule, administration was discontinued after the participant received a zero score on five consecutive items. This measure was standardized on individuals 5 to 21 years old and the internal consistency reliability estimates ranged from .83 to .94 (Semel, Wiig, & Secord, 2003b).

**CELF Word Definitions.** In the CELF Word Definitions subtest, the examiner read out a word and used it in a sentence for each item. The participant orally provided a definition of the word. Administration started at Item 1. Following the ceiling rule, administration was
discontinued after the participant received a zero score on seven consecutive items. This measure was standardized on individuals 10 to 21 years old and the internal consistency reliability estimates ranged from .85 to .89 (Semel et al., 2003b).

**WJ Picture Vocabulary.** In the WJ Picture Vocabulary subtest, the participant named objects or actions depicted in pictures. Administration started at Item 15. Following the ceiling rule, items were administered by complete pages in the testing booklet until the participant received a score of zero on six consecutive items. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .70 to .93 (McGrew et al., 2007).

**Demographic Survey.** A demographic survey was administered, which included questions about the participant’s age, gender, and race (see Table 1.1).

**Data Analysis Strategy**

Before addressing the research questions, the missingness and distribution of the data were examined. Approximately 20% of participants had missing data on at least one measure. Little’s test indicated that these data were missing completely at random ($p > .05$). In addition, a total of 33 univariate outliers were identified and brought within the limits of ± two interquartile ranges. Data on each measure exhibited a normal distribution, as indicated by univariate skewness and kurtosis values between ±1.

Confirmatory factor analysis (CFA) and structural equation modeling (SEM) were used to address the first two research questions. To handle missing data, full information maximum likelihood (ML) was used as the estimation method (Enders & Bandalos, 2001). Model fit indices were evaluated using Hu and Bentler’s (1999) recommendations for ML-based models, which suggest that good fit is indicated by Comparative Fit Index (CFI) and Tucker-Lewis Index.
(TLI) values greater than .95, Root Mean Square Error of Approximation (RMSEA) values less than .06, and Standardized Root Mean Square Residual (SRMR) values less than .08.

Quantile regression was used to address the third research question. Low, average, and high levels of reading comprehension performance were respectively operationalized as the .10, .50, and .90 quantiles of performance on the WJ Passage Comprehension subtest (Hua & Keenan, 2017).

**Results**

Participants’ performance on all measures is reported in Table 1.2, including raw scores, age-based standard scores, and grade equivalents, where available. Pearson’s correlations across measures ranged from .11 to .83, as reported in Table 1.3.

**Research Question 1: For struggling adult readers, what is the dimensionality of decoding and linguistic comprehension?**

To answer the first research question, a series of CFA models were analyzed in the R statistical environment (R Core Team, 2018) using the lavaan package (Rosseel, 2012). The fit indices for all models in the current study are reported in Table 1.4. In Model 1, all measures of decoding and linguistic comprehension were loaded on a single latent factor (see Figure 1.1). All factor loadings were significant ($p$s < .001) and standardized estimates ranged from .52 to .73. This model exhibited a poor fit to the data ($\chi^2(27) = 654.2$, $p < .001$, CFI = .616, TLI = .488, RMSEA = .243, SRMR = .185, AIC = 8449, and BIC = 8556), which suggests that these measures tap into more than one underlying ability. No attempts were made to improve the model fit because past research supports the separability of decoding and oral language skills (Chen & Vellutino, 1997; Cutting & Scarborough, 2006; Kendeou et al., 2009). The dimensionality of the separate components was examined next.
Table 1.2

Performance on Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Raw Scores</th>
<th>Mean Grade Equivalent</th>
<th>Age-Based Standard Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Age</td>
</tr>
<tr>
<td>WJPC</td>
<td>29.33</td>
<td>4.41</td>
<td>16 - 42</td>
</tr>
<tr>
<td>WJLWI</td>
<td>55.00</td>
<td>8.51</td>
<td>33 - 72</td>
</tr>
<tr>
<td>TIWRE</td>
<td>37.99</td>
<td>5.07</td>
<td>20 - 48</td>
</tr>
<tr>
<td>WJWA</td>
<td>16.49</td>
<td>7.63</td>
<td>1 - 31</td>
</tr>
<tr>
<td>WJSR</td>
<td>38.60</td>
<td>12.42</td>
<td>10 - 78</td>
</tr>
<tr>
<td>WJUD</td>
<td>38.76</td>
<td>7.04</td>
<td>14 - 56</td>
</tr>
<tr>
<td>CUSP</td>
<td>7.70</td>
<td>3.89</td>
<td>0 - 40</td>
</tr>
<tr>
<td>CWC</td>
<td>23.36</td>
<td>7.47</td>
<td>0 - 43</td>
</tr>
<tr>
<td>CWD</td>
<td>19.07</td>
<td>8.22</td>
<td>0 - 44</td>
</tr>
</tbody>
</table>

Note. The standardization scale for the WJ subtests and the TIWRE has a mean of 100 and standard deviation of 15. Age-based norms on the CELF subtests are not available for individuals older than 21 years. Grade equivalents are not available for the CELF subtests and two WJ subtests that consist of multiple item sets. WJPC = WJ Passage Comprehension; WJLWI = WJ Letter-Word Identification; TIWRE = Test of Irregular Word Reading Efficiency; WJWA = WJ Word Attack; WJSR = WJ Story Recall; WJUD = WJ Understanding Directions; CUSP = CELF Understanding Spoken Paragraphs; CWC = CELF Word Classes; CWD = CELF Word Definitions; WJPV = WJ Picture Vocabulary.
Table 1.3

*Correlations Across Measures*

<table>
<thead>
<tr>
<th></th>
<th>WJPC</th>
<th>WJLWI</th>
<th>TIWRE</th>
<th>WJWA</th>
<th>WJSR</th>
<th>WJUD</th>
<th>CUSP</th>
<th>CWC</th>
<th>CWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>WJPC</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJLWI</td>
<td>.603***</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIWRE</td>
<td>.602***</td>
<td>.828***</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJWA</td>
<td>.452***</td>
<td>.770***</td>
<td>.704***</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJSR</td>
<td>.420***</td>
<td>.143***</td>
<td>.120*</td>
<td>.117*</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJUD</td>
<td>.564***</td>
<td>.265***</td>
<td>.290***</td>
<td>.300***</td>
<td>.411***</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUSP</td>
<td>.352***</td>
<td>.133*</td>
<td>.122*</td>
<td>.105*</td>
<td>.497***</td>
<td>.423***</td>
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<td>CWC</td>
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<td>.405***</td>
<td>.336***</td>
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<td>.408***</td>
<td>.490***</td>
<td>.400***</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>CWD</td>
<td>.494***</td>
<td>.328***</td>
<td>.261***</td>
<td>.242***</td>
<td>.447***</td>
<td>.401***</td>
<td>.378***</td>
<td>.596***</td>
<td>---</td>
</tr>
<tr>
<td>WJPV</td>
<td>.588***</td>
<td>.337***</td>
<td>.368***</td>
<td>.269***</td>
<td>.452***</td>
<td>.447***</td>
<td>.385***</td>
<td>.558***</td>
<td>.613***</td>
</tr>
</tbody>
</table>

*Note.*** p < .001; * p < .05. WJPC = WJ Passage Comprehension; WJLWI = WJ Letter-Word Identification; TIWRE = Test of Irregular Word Reading Efficiency; WJWA = WJ Word Attack; WJSR = WJ Story Recall; WJUD = WJ Understanding Directions; CUSP = CELF Understanding Spoken Paragraphs; CWC = CELF Word Classes; CWD = CELF Word Definitions; WJPV = WJ Picture Vocabulary.*
Table 1.4
*Fit Indices for Models*

<table>
<thead>
<tr>
<th>Model Description</th>
<th>$\chi^2$(df)</th>
<th>$p$</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA (90% CI)</th>
<th>SRMR</th>
<th>AIC</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CFAs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Unidimensional</td>
<td>654.2(27)</td>
<td>&lt;.001</td>
<td>.616</td>
<td>.488</td>
<td>.243 (.227 - .260)</td>
<td>.185</td>
<td>8449</td>
<td>8556</td>
</tr>
<tr>
<td>2. Linguistic comprehension</td>
<td>40.7(9)</td>
<td>&lt;.001</td>
<td>.959</td>
<td>.931</td>
<td>.095 (.066 - .125)</td>
<td>.037</td>
<td>5575</td>
<td>5647</td>
</tr>
<tr>
<td>3. Listening comprehension and oral vocabulary</td>
<td>15.8(8)</td>
<td>.045</td>
<td>.990</td>
<td>.981</td>
<td>.05 (.007 - .086)</td>
<td>.022</td>
<td>5552</td>
<td>5628</td>
</tr>
<tr>
<td>4. Decoding, listening comprehension, and oral vocabulary</td>
<td>59.6(24)</td>
<td>&lt;.001</td>
<td>.978</td>
<td>.967</td>
<td>.062 (.042 - .081)</td>
<td>.040</td>
<td>7860</td>
<td>7980</td>
</tr>
<tr>
<td>5. Word recognition, WJ Word Attack, listening comprehension, and oral vocabulary</td>
<td>56.2(22)</td>
<td>&lt;.001</td>
<td>.979</td>
<td>.966</td>
<td>.063 (.043 - .084)</td>
<td>.039</td>
<td>7861</td>
<td>7988</td>
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<tr>
<td><strong>SEMs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reading comprehension predicted by decoding, listening comprehension, and oral vocabulary</td>
<td>98.0(30)</td>
<td>&lt;.001</td>
<td>.966</td>
<td>.949</td>
<td>.076 (.060 - .093)</td>
<td>.040</td>
<td>8589</td>
<td>8728</td>
</tr>
<tr>
<td>2. Reading comprehension predicted by word recognition, listening comprehension, oral vocabulary, and WJ Word Attack</td>
<td>80.5(27)</td>
<td>&lt;.001</td>
<td>.974</td>
<td>.956</td>
<td>.071 (.054 - .089)</td>
<td>.037</td>
<td>8578</td>
<td>8729</td>
</tr>
</tbody>
</table>

*Note.* $\chi^2$ = Chi square statistic. $df$ = degrees of freedom. CFI = Comparative Fit Index; TLI = Tucker-Lewis Index. RMSEA = Root Mean Square Error of Approximation. CI = confidence interval. SRMR = Standardized Root Mean Square Residual. AIC = Akaike Information Criterion. BIC = Bayesian Information Criterion.
Figure 1.1. Unidimensional CFA model for the Simple View of Reading. Standardized estimates are reported.
Research Question 1a: Do listening comprehension and oral vocabulary tap into a common latent ability?

Model 2 focused on the linguistic comprehension component of the SVR. All six measures of linguistic comprehension were loaded on one latent factor (see Figure 1.2). All factor loadings were significant ($p < .001$) and standardized estimates ranged from .60 to .75. This model exhibited acceptable fit to the data ($\chi^2(9) = 40.7$, $p < .001$, $CFI = .959$, $TLI = .931$, $RMSEA = .095$, $SRMR = .0.37$, $AIC = 5575$, and $BIC = 5647$). Since the RMSEA and TLI values did not meet Hu and Bentler’s (1998) criteria, an alternative model was estimated next.

In Model 3, a two-factor CFA was estimated for linguistic comprehension. The three listening comprehension measures and the three oral vocabulary measures were loaded on separate factors (see Figure 1.3). All factor loadings were significant ($ps < .001$) and standardized estimates ranged from .65 to .78. This model exhibited excellent fit ($\chi^2(8) = 15.8$, $p = .045$, $CFI = .990$, $TLI = .981$, $RMSEA = .05$, $SRMR = .022$, $AIC = 5552$, and $BIC = 5628$). Moreover, a chi-square different test indicated that this two-factor model for linguistic comprehension provided a significant better fit to the data than the one-factor model, ($\chi^2(1) = 24.9$, $p < .001$). Thus, this representation of linguistic comprehension was retained for subsequent analyses.

Research Question 1b: Do word recognition and phonic decoding tap into a common latent ability?

Model 4 included both the decoding and linguistic comprehension components of the SVR. A three-factor CFA was estimated, with decoding measures, listening comprehension measures, and oral vocabulary measures loaded on separate factors (see Figure 1.4). All factor loadings were significant ($ps < .001$) and standardized estimates ranged from .65 to .94. The
Figure 1.2. One-factor CFA model for linguistic comprehension. Standardized estimates are reported.
Figure 1.3. Two-factor CFA model for listening comprehension and oral vocabulary. Standardized estimates are reported.
Figure 1.4. Three-factor CFA model for decoding, listening comprehension, and oral vocabulary. Standardized estimates are reported.
model provided a good fit to the data ($\chi^2(24) = 59.6, p < .001$, CFI = .978, TLI = .967, RMSEA = .062, SRMR = .040, AIC = 7860, and BIC = 7980).

To test whether separating phonic decoding from word recognition improves model fit, a final CFA was estimated in Model 5. This model was identical to Model 4, with the exception that the phonic decoding measure, WJ Word Attack, was not loaded on the same factor as the two word recognition measures (see Figure 1.5). All factor loadings were significant ($ps < .001$) and standardized estimates ranged from .65 to .94. The model provided a good fit to the data ($\chi^2(22) = 56.2, p < .001$, CFI = .979, TLI = .966, RMSEA = .063, SRMR = .039, AIC = 7861, and BIC = 7988).

Models 4 and 5 exhibited nearly identical fit to the data. The parsimony principle states that the simplest model that adequately explains the data is the best model (McClave & Sincich, 2006). Therefore, Model 4 was selected as the preferred latent representation of the SVR predictors. However, given the paucity of research on word recognition and phonic decoding in the adult literacy context, Model 5 was also retained for the next research question.

**Research Question 2: What proportions of reading comprehension variance in the sample are jointly and uniquely explained by decoding and linguistic comprehension?**

To answer the second research question, two SEMs were estimated where the criterion was reading comprehension as represented by the WJ Passage Comprehension subtest.

**First SEM.** In the first SEM, the measurement structure of Model 4 was retained (see Figure 1.6). The predictors in this model were the latent factors of decoding, listening comprehension, and oral vocabulary. The fit indices for this SEM are reported in Table 1.4.

The results for this first SEM showed that decoding and listening comprehension had significant unique effects on reading comprehension ($ps < .01$), but the unique effect of oral
Figure 1.5. Three-factor CFA model for word recognition, listening comprehension, and oral vocabulary, with a phonic decoding measure separated out. Standardized estimates are reported.
Figure 1.6. SEM for reading comprehension with decoding, listening comprehension, and oral vocabulary as predictors. Standardized estimates are reported. *** $p < .001$; ** $p < .01$. 
vocabulary was not significant (\(p > .05\)). Overall, this model accounted for 67.5% of the variance in reading comprehension scores. Approximately 12.6% of the variance in reading comprehension was uniquely explained by decoding and 3.4% was uniquely explained by listening comprehension.

**Second SEM.** In the second SEM, the measurement structure of Model 5 was retained (see Figure 1.7). The predictors in this model were the latent factors of word recognition, listening comprehension, and oral vocabulary, as well as the observed variable of WJ Word Attack performance. The fit indices for this SEM are reported in Table 1.4.

The SEM results showed that word recognition, WJ Word Attack, and listening comprehension had significant unique effects on reading comprehension (\(ps < .01\)). The unique effect of oral vocabulary was not significant (\(p > .05\)). Overall, this model accounted for 71.5% of the variance in reading comprehension scores. Approximately 12.6% of the variance in reading comprehension was uniquely explained by word recognition, 2.2% was uniquely explained by WJ Word Attack performance, and 5.2% was uniquely explained by listening comprehension.

Interestingly, the unique effect of WJ Word Attack on WJ Passage Comprehension had a negative coefficient, which implies that an increase in phonic decoding score was associated with a decrease in reading comprehension score after controlling for word recognition, listening comprehension, and oral vocabulary. This is an unexpected finding, given the moderate positive correlation between the two measures (\(r = .45\)). This negative beta coefficient could possibly be attributed to the multicollinearity among the three decoding measures.
Figure 1.7. SEM for reading comprehension with word recognition, WJ Word Attack, listening comprehension, and oral vocabulary as predictors. Standardized estimates are reported. *** $p < .001$; ** $p < .01$. 

Research Question 3: What are the effects of the Simple View of Reading predictors at low, average, and high levels of reading comprehension performance?

To answer the third research question, a quantile regression model was estimated using the quantreg package in R (Koenker, 2018). Predictors were selected based on the structure of Model 4, because it was the more parsimonious model and because Model 5 presented a problematic negative beta weight. Following the composition of the latent factors in Model 4, composites were computed for decoding, listening comprehension, and oral vocabulary by taking the mean of z-scores on the relevant measures. For example, the decoding composite was the mean of z-scores on WJ Letter-Word Identification, TIWRE, and WJ Word Attack. All composites are reported in Table 1.5.

The decoding, listening comprehension, and oral vocabulary composites served as the predictors in the quantile regression. The criterion was reading comprehension as indexed by WJ Passage Comprehension. To examine the effects of predictors at low, average, and high levels of reading comprehension performance, the model parameters were estimated at the .10, .50, and .90 quantiles of the WJ Passage Comprehension score distribution. The estimates are reported in Table 1.6.

All three predictors exhibited unique significant effects on reading comprehension at the .10, .50, and .90 quantiles (ps < .01). At the .10 quantile, the model explained 49% of the variance in reading comprehension. Decoding uniquely contributed 15% of the variance, listening comprehension uniquely contributed 3% of the variance, and oral vocabulary uniquely contributed 7% of the variance. At the .50 quantile, the model explained 46% of the variance in reading comprehension. Decoding uniquely contributed 10% of the variance, listening comprehension uniquely contributed 4% of the variance, and oral vocabulary uniquely contributed 4% of the variance.
Table 1.5
**Composites of Z-Scores**

<table>
<thead>
<tr>
<th>Composite</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding</td>
<td>0.022</td>
<td>0.901</td>
<td>-2.068 - 1.674</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.008</td>
<td>0.764</td>
<td>-2.202 - 2.517</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.007</td>
<td>0.849</td>
<td>-1.986 - 2.428</td>
</tr>
</tbody>
</table>

Table 1.6
**Quantile Regression Parameter Estimates for Reading Comprehension**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>SE</th>
<th>t</th>
<th>Unique Pseudo $R^2$</th>
<th>Total Pseudo $R^2$</th>
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<tbody>
<tr>
<td>.10 Quantile (Intercept)</td>
<td>-0.797</td>
<td>0.060</td>
<td>-13.173***</td>
<td>.489</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.455</td>
<td>0.097</td>
<td>4.674***</td>
<td>.149</td>
<td></td>
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<tr>
<td>Listening Comprehension</td>
<td>0.261</td>
<td>0.082</td>
<td>3.172**</td>
<td>.033</td>
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<tr>
<td>Oral Vocabulary</td>
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<td>0.102</td>
<td>4.706***</td>
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<td>.50 Quantile (Intercept)</td>
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<td>5.599***</td>
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<td>Listening Comprehension</td>
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<td>5.799***</td>
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<td>Oral Vocabulary</td>
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<td>0.073</td>
<td>5.717***</td>
<td>.061</td>
<td></td>
</tr>
<tr>
<td>.90 Quantile (Intercept)</td>
<td>0.727</td>
<td>0.063</td>
<td>11.494***</td>
<td>.461</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.333</td>
<td>0.072</td>
<td>4.596***</td>
<td>.092</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.437</td>
<td>0.099</td>
<td>4.437***</td>
<td>.051</td>
<td></td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>0.361</td>
<td>0.078</td>
<td>4.643***</td>
<td>.060</td>
<td></td>
</tr>
</tbody>
</table>

contributed 6% of the variance. At the .90 quantile, the model explained 46% of the variance in reading comprehension. Decoding uniquely contributed 9% of the variance, listening comprehension uniquely contributed 5% of the variance, and oral vocabulary uniquely contributed 6% of the variance.

Between-quantile slope comparisons were conducted across the .10, .50, and .90 quantiles. No significant differences were found (see Table 1.7 for \( p \)-values). This indicates that the unique effects of decoding, listening comprehension, and oral vocabulary were stable across low, average, and high levels of reading comprehension performance for this sample of struggling adult readers. Figures 1.8, 1.9, and 1.10 show the unique slope estimates of each independent variable at nine equidistant quantiles of the WJ Passage Comprehension score distribution.

**Discussion**

The SVR has been widely used to model comprehension process for readers of varying ages and across different languages (Florit & Cain, 2011; Savage & Wolforth, 2007; Silverman et al., 2013; Vellutino et al., 2007). The main aim of the current study was to unravel the intricacies of the SVR for struggling adult readers who are native English speakers and read approximately between the third and eighth grade levels. The results indicate that the SVR component of decoding can be represented by both word recognition and phonic decoding tasks. Additionally, oral vocabulary and listening comprehension emerged as highly related yet separate constructs that fall under the umbrella of the SVR component of linguistic comprehension. Furthermore, as latent variables, decoding and listening comprehension uniquely explained variation in the reading comprehension performance of the sample, whereas oral vocabulary was not uniquely significant in this regard. In contrast, quantile regression analyses
Table 1.7
Comparisons of Quantile Regression Coefficients for Reading Comprehension

<table>
<thead>
<tr>
<th>Predictor</th>
<th>p-value of Between-Quantile Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.10 vs. .50</td>
</tr>
<tr>
<td>Decoding</td>
<td>.28</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>.32</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>.52</td>
</tr>
</tbody>
</table>

Figure 1.8. Quantile regression plot for the relation between decoding and reading comprehension after controlling for listening comprehension and oral vocabulary. Error bars indicate 95% confidence intervals.
Figure 1.9. Quantile regression plot for the relation between listening comprehension and reading comprehension after controlling for decoding and oral vocabulary. Error bars indicate 95% confidence intervals.

Figure 1.10. Quantile regression plot for the relation between oral vocabulary and reading comprehension after controlling for decoding and listening comprehension. Error bars indicate 95% confidence intervals.
with observed variable composites showed that all three predictors exerted significant effects on reading comprehension when separately focusing on the low, average, high levels of performance.

**The Factor Structure of Decoding and Linguistic Comprehension**

The structure of decoding in the parsimonious model (see Figure 1.4) echoes the sparse previous findings indicating that word recognition and phonic decoding are aspects of the same underlying ability for struggling adult readers (Nanda et al., 2010; Sabatini et al., 2010; Tighe et al., 2018). Even when a measure of phonic decoding was separated out (see Figure 1.5), it was strongly related to the word recognition latent factor. Thus, both models suggest a connection between pronouncing real words and pseudowords. These results can be interpreted as support for the dual route model of word reading (Coltheart, 2006), which posits that the reader engages in one of two processes to pronounce a printed word. If the word is known to the reader, it can be visually recognized and retrieved from the mental lexicon. If the word is unknown, it can be analyzed phonetically and pronounced using grapheme-phoneme correspondence rules. Furthermore, past research indicates that struggling adult readers rely on orthographic (visual) knowledge of words to compensate for deficient phonological processing skills (Greenberg et al., 1997). Thus, it is not surprising that word recognition and phonic decoding emerged as intertwined abilities for this sample.

In terms of the linguistic comprehension component, separating the oral vocabulary and listening comprehension factors significantly improved model fit for the current sample. While this finding is similar to Sabatini et al.’s (2010) results for adult literacy students reading below the seventh grade level, it contrasts with Braze et al.’s (2016) unidimensional structure of linguistic comprehension for individuals with unreported reading levels enrolled in adult
education programs, high school, and community college. Perhaps this difference can be attributed to the inclusion of high school students in Braze et al.’s sample; the integration of oral language skills observed with school-age readers (e.g., Tunmer & Chapman, 2012) would not necessarily apply to the struggling adult reader population (Nanda et al., 2010).

**Explaining Variance in Reading Comprehension**

In the first SEM (see Figure 1.6), the SVR components accounted for approximately two-thirds of the total variance (67.5%) in reading comprehension for the current sample. This is in line with previous studies reporting the variance explained by SVR models (58-69%) with struggling adult readers (Braze et al., 2016; Sabatini et al., 2010). The total variance explained in the second SEM (see Figure 1.7) was only slightly greater (71.5%).

In terms of decoding, the differences between the two SEMs warrant further consideration. As indicators of a latent factor, WJ Letter-Word Identification and TIWRE made a similar unique contribution to reading comprehension variance (12.6%) regardless of whether WJ Word Attack was a co-indicator of the same factor or separated out as an observed variable. This does not necessarily mean that the SVR component of decoding should be reduced to word recognition, because doing so can inflate the effect of word recognition on reading comprehension, as indicated by the large beta coefficient in Figure 1.7. The second SEM also demonstrates the problematic consequences of including word recognition and phonic decoding as separate predictors in the same model. Measures of these abilities exhibited undeniable multicollinearity ($r_s > .70$), which may be responsible for the surprising negative effect of WJ Word Attack on reading comprehension. Overall, the SEM results point to a need for fully latent CFA models that account for method effects, which is discussed further as a direction for future research.
With regard to linguistic comprehension, the results were similar across both SEMs. Listening comprehension had a significant unique effect on reading comprehension whereas oral vocabulary did not, which is similar to Sabatini et al.’s (2010) latent SVR model. Perhaps the unique influence of oral vocabulary was suppressed due to the high correlation with listening comprehension ($r > .80$) in both the current study and Sabatini et al.’s investigation. It is also possible that the association between oral vocabulary and reading comprehension is, in fact, an indirect relationship that is mediated by decoding (Tunmer & Chapman, 2012).

The quantile regression analyses showed that decoding constantly exerted the largest unique effect on reading comprehension across low, average, and high levels of reading comprehension performance. Thus, the adults in the current sample appear to be similar to young readers in elementary school for whom reading comprehension is more strongly related to decoding than to oral language skills (Hoover & Gough, 1990; Kendeou et al., 2009; Lonigan et al., 2018). It is likely that their word-level processes consume considerable cognitive resources (Perfetti, 1985) and, therefore, differences in word reading skill largely predict how well a text passage is understood.

**Implications for Adult Literacy Instruction**

The importance of decoding uncovered in the SEMs and quantile regression model demonstrates the need to build decoding skills in adult literacy classes. Evidence from multi-site adult literacy interventions indicates that some struggling adult readers are responsive to curricula that include an intensive decoding component. Alamprese, MacArthur, Price, and Knight (2011) delivered a structured decoding curriculum called Making Sense of Decoding and Spelling, and found that this treatment led to gains on letter-sound knowledge and phonic decoding, especially for native speakers of English. More recently, Greenberg and colleagues
administered the multicomponent Adult PHAST PACES program, which includes instruction in decoding, vocabulary, and comprehension strategies (Center for the Study of Adult Literacy, n.d.). Preliminary results suggest that this intervention can improve letter-sound knowledge and decoding and may be most beneficial for adult learners with relatively lower decoding skills (Greenberg et al., 2019).

The skills encompassed by the linguistic comprehension component also emerged as significant predictors of reading comprehension across analyses. Linguistic comprehension can be improved by building oral vocabulary knowledge. Interventions targeting vocabulary have yielded large effect sizes with children (Scammacca, Roberts, Vaughn, & Stuebing, 2015) and may be similarly helpful for struggling adult readers. Curtis (2006) emphasizes different instructional strategies to build vocabulary in the adult classroom, such as analyzing contextual cues, decomposing words into roots and affixes, and eliciting definitions for particularly difficult words. Additionally, a specific focus on academic vocabulary may address an important gap in adult learners’ lexicon (Pae, Greenberg, & Williams, 2012; Strucker, 2013).

Limitations and Future Research

In line with past investigations, the current study represented the SVR as an additive model (Dreyer & Katz, 1992; Savage, 2006; Silverman et al., 2013). However, in their original postulation of the SVR, Gough and Tunmer (1986) characterized reading comprehension as the product of decoding and linguistic comprehension, which implies that the two components interact with one another. Future research with struggling adult readers should explore interactive models of the SVR, which will indicate whether the contributions of each SVR component to reading comprehension should be characterized as direct or indirect effects for this population.
Another caveat to note is that the current sample of adult readers represents a limited range of reading skills. A similar quantile regression approach can be applied to an adult sample that includes much more variability in reading comprehension performance. The effects of predictors can be thus explored across the continuum of adult reading ability. This will allow researchers to identify differences between low-skilled, intermediate, and proficient readers.

Additionally, the WJ Passage Comprehension subtest, which was the only measure of reading comprehension in this study, has been critiqued in the past as being too heavily influenced by word reading skills (Keenan, Betjemann, & Olson, 2008). This test property may partially explain the prominence of decoding in predicting comprehension for this sample. Future attempts to model the SVR with struggling adult readers should endeavor to include multiple reading comprehension measures. This will circumvent the drawbacks of any particular test and provide further insight into the predictors of comprehension across different assessment methods (Cutting & Scarborough, 2006; Mellard et al., 2015; Tighe, Johnson, & McNamara, 2017).

Further limitations should be noted with respect to the treatment of the decoding component in the current study. First, the WJ Letter-Word Identification subtest was considered a measure of word recognition because all items are real words. It is important to acknowledge, though, that phonic decoding could also be used to pronounce many of these words. This contrasts with the TIWRE on which all of the items were irregularly spelled words that had to be recognized as sight words by the examinee. Second, since WJ Letter-Word Identification and WJ Word Attack are subtests of the same assessment battery, the strong correlation between the two measures could perhaps be partially attributed to a method effect. Third, it was not possible to analyze a CFA model with only the three decoding measures, because three observed variables are not sufficient for latent modeling (Kline, 2011). Future investigations with struggling adult
readers could address all of these issues by collecting data on several different types of decoding measures from multiple test batteries. This might allow researchers to estimate multiple-indicator CFA models that minimize the influence of method effects and examine varying dimensions of the decoding construct, including purely orthographic sight word recognition versus phonic decoding.

Finally, adult literacy is a worldwide issue that extends beyond English-speaking cultures (Organisation for Economic Co-operation and Development, 2013). The current sample consisted exclusively of native English speakers and all assessments were administered in English. Since the SVR framework has been successfully applied to text written in non-English languages (Florit & Cain, 2011) and the dimensionality of the SVR components may be different for speakers of other languages (Nanda et al., 2010), it would be valuable to examine the structure of the SVR for struggling adult readers across different linguistic contexts.
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USING QUANTILE REGRESSION TO EXAMINE STRUGGLING ADULT READERS’ PERFORMANCE ACROSS READING COMPREHENSION TESTS

Review of the Literature

A common refrain in reading research is that there is no complete theory of reading comprehension (McNamara & Magliano, 2009; Perfetti & Stafura, 2014; Rayner & Reichle, 2010). Instead, the field is guided by prominent ideas conceptualized in broad theoretical frameworks (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; van den Broek, Young, Tzeng, & Linderholm, 1999) and testable component models (Cromley & Azevedo, 2007; Gough & Tunmer, 1986; Kim, 2017). These various attempts to explain the complexities of reading comprehension have been likened to “blind men feeling an elephant” (Rayner & Reichle, 2010, p. 7), with each account capturing only some subprocesses of comprehension and missing others.

Among these text comprehension frameworks, Kintsch’s (1988) construction-integration (CI) theory is widely considered the most influential and thorough (McNamara & Magliano, 2009; Rayner & Reichle, 2010). The CI theory posits that the reader forms a mental representation of the text at three main levels: the surface level refers to words and their relationships within sentences; the textbase refers to a collection of simple, literal propositions gleaned from the sentences in the connected text; and the situation model refers to the cohesive meaning of the text content, which is enriched by the reader’s prior knowledge, inferences, and conclusions (Graesser et al., 1994). Deep comprehension of the text involves all three levels, which points to the importance of basic print processing skills as well as complex language and reasoning abilities.
Because a major goal of reading research is to bolster academic success (National Reading Panel [NRP], 2000), the literature on the underlying skills of reading comprehension largely pertains to students in the K-12 grades and postsecondary programs. For example, Aaron, Joshi, Gooden, & Bentum (2008) utilized a comprehension model to identify areas of reading difficulty for students in the elementary grades with learning disabilities and implemented a multi-year intervention to address their deficits. As another example, McNamara (2004) demonstrated that instruction on using an innovative self-explanation strategy while processing scientific texts can improve comprehension performance for undergraduates and even compensate for poor prior knowledge. Such investigations are clearly advantageous for readers in schools and universities, but this line of work has historically ignored the unique challenges and needs of one in six adults in the United States who read at or below elementary levels (Organisation for Economic Co-operation and Development, 2013).

In recent years, there has been growth in research with adults who read below the high school level (hereafter referred to as struggling adult readers). Notably, researchers have reported on the relations between reading comprehension and component skills including decoding, oral vocabulary knowledge, reading fluency, and listening comprehension (e.g., Barnes, Kim, Tighe, & Vorstius, 2017; Braze, Tabor, Shankweiler, & Mencl, 2007; Braze et al., 2016; Fracasso, Bangs, & Binder, 2016; Greenberg et al., 2010; Herman, Cote, Reilly, & Binder, 2013; MacArthur, Konold, Glutting, & Alamprese, 2010; Mellard, Fall, & Woods, 2010; Sabatini, Sawaki, Shore, & Scarborough, 2010; Tighe et al., 2018; Tighe & Binder, 2015; To, Tighe, & Binder, 2016). However, certain domains that have emerged as important predictors of comprehension for typical readers, like background knowledge (Ozuru, Dempsey, & McNamara,
2009) and inference generation (Cain & Oakhill, 1999), remain understudied in the adult literacy context (Greenberg, Ginsburg, & Wrigley, 2017).

The current study addresses the gaps in the adult literacy literature regarding predictors of reading comprehension by specifically examining the explanatory effects of predictors across different reading comprehension tests and performance levels. Before turning to the current study, a literature review will follow on the reading-related competencies of struggling adult readers and the differences among reading comprehension assessments.

**Reading-Related Competencies of Struggling Adult Readers**

**Decoding.** Decoding refers to the ability to pronounce isolated written words. According to the dual route model of word reading, familiar print words are processed automatically through visual recognition, whereas unknown words require phonetic analysis (Coltheart, 2006). Theoretically, decoding can be considered primary to other subprocesses of reading. Failure to process words within sentences prevents the formation of the textbase and situation model (Kintsch, 1988). In other words, if the reader cannot translate print words into spoken language, no meaning can be constructed from the text. Likewise, strong decoding supports other reading components: Perfetti’s (1985) verbal efficiency theory postulates that rapid word processing allows more cognitive resources to be dedicated to higher-level activities, which improves the reader’s efficiency.

In research with struggling adult readers, decoding has been measured by asking participants to read aloud real English words or pseudowords that follow English grapheme-phoneme correspondences (e.g., Nanda, Greenberg, & Morris, 2010; Sabatini et al., 2010; Tighe & Binder, 2015). Overall, moderate to strong correlations have been reported between decoding and reading comprehension (Barnes et al., 2017; Braze et al., 2007; Braze et al., 2016; Fracasso
et al., 2016; Herman et al., 2013; MacArthur et al., 2010; Mellard et al., 2010; Sabatini et al., 2010; Tighe et al., 2018; Tighe & Binder, 2015; To et al., 2016). Researchers have found that decoding uniquely contributed to reading comprehension variance after controlling for other skills, such as listening comprehension, oral vocabulary, and reading fluency (Barnes et al., 2017; Braze et al., 2007; Braze et al., 2016; Fracasso et al., 2016; Mellard et al., 2010; Sabatini et al., 2010; Tighe et al., 2018; Taylor, Greenberg, Laures-Gore, & Wise, 2012).

**Oral vocabulary.** Oral vocabulary refers to an individual’s verbal knowledge of words and their meanings (NRP, 2000). This word knowledge allows the reader to derive propositions from the surface code to build the textbase (Kintsch, 1988; Rayner & Reichle, 2010). It is, of course, difficult to understand sentences in a connected text if the meanings of individual words are unknown. More specifically, according to Perfetti’s (2007) lexical quality hypothesis, when the reader does not have precise knowledge about a word’s possible meanings, incorrect concepts can be activated, which leads to comprehension failure.

With struggling adult readers, researchers have administered vocabulary measures that assess the ability to understand spoken words or produce words from picture cues (e.g., Fracasso et al., 2016; Hall, Greenberg, Laures-Gore, & Pae, 2014). Oral vocabulary has demonstrated moderate to strong correlations with reading comprehension (Braze et al., 2007; Fracasso et al., 2016; Hall et al., 2014; Herman et al., 2013; Mellard et al., 2010; Mellard & Fall, 2012; Nanda et al., 2010; Sabatini et al., 2010; Tighe et al., 2018; Tighe & Schatschneider, 2016). Across studies, oral vocabulary accounted for a significant proportion of variance in comprehension beyond the contributions of other skills, such as decoding, fluency, and morphological awareness (Braze et al., 2007; Fracasso et al., 2016; Greenberg et al., 2010; Hall et al., 2014; Mellard et al.,
In fact, this effect appears to increase at higher levels of reading comprehension (Tighe & Schatschneider, 2016).

**Fluency.** Reading fluency refers to the ability to read text quickly and correctly (NRP, 2000). This complex ability necessitates rapid and reliable lower-level skills: the reader must be able to automatically decode word forms and retrieve the appropriate meanings, which emphasizes the importance of word representations (Perfetti & Stafura, 2014). Efficient reading of texts strengthens processes and connections at all levels of meaning-making, thereby increasing the likelihood of deep comprehension (McNamara & Magliano, 2009; Rayner & Reichle, 2010).

Adult literacy researchers have administered fluency assessments that require participants to read connected texts quickly and accurately (e.g., Greenberg et al., 2010). Like the other component skills discussed so far, fluency appears to be moderately to strongly correlated with reading comprehension (Barnes et al., 2017; Greenberg et al., 2010; MacArthur et al., 2010; Mellard et al., 2010; Mellard, Woods, & Desa, 2012; Mellard & Fall, 2012; Nanda et al., 2010; Sabatani et al., 2010; Taylor et al., 2012). Fluency also exhibited a significant direct effect on reading comprehension when controlling for predictors like decoding and vocabulary (Greenberg et al., 2010; Taylor et al., 2012). Furthermore, explorations of subgroups have identified that less fluent readers performed poorly on reading comprehension measures (Barnes et al., 2017; Mellard, Woods, Desa, & Vuyk, 2015).

**Listening comprehension.** Listening comprehension is the ability to derive meaning from oral language discourse (Tunmer & Chapman, 2012). In text processing, the reader’s language proficiency drives the creation of propositions and, in turn, the textbase (Kintsch, 1988). Consider the example of a monolingual English reader faced with a connected text written
in Turkish. Since both languages use the Latin script, the reader could potentially decode most words in the text using letter-sound correspondence rules. However, without the ability to understand spoken Turkish, the reader would not be able to create a meaningful interpretation of the text.

In studies with struggling adult readers, listening comprehension has been assessed with measures that require participants to listen to auditory linguistic stimuli and demonstrate that they have understood the content (e.g., Barnes et al., 2017; Mellard et al, 2010). Across studies, listening comprehension has exhibited moderate to strong correlations with reading comprehension (Barnes et al., 2017, Braze et al., 2007, Fracasso et al., 2016, Mellard et al., 2010, Mellard & Fall, 2012; Sabatini et al., 2010). Moreover, the unique contributions of listening comprehension to reading comprehension have been reported in models controlling for decoding, fluency, and vocabulary (Barnes et al., 2017; Braze et al., 2007; Mellard et al., 2010; Sabatini et al., 2010).

**Background knowledge.** Also known as prior topic knowledge, background knowledge refers to the generic and specific knowledge encoded in an individual’s long-term memory (Graesser et al., 1994). During the formation of the textbase, the content of propositions triggers the activation of relevant background knowledge, which in turn improves the situation model (Kintsch, 1988). This suggests that when the reader recalls useful information and makes connections between what is known and what is being learned, a more meaningful understanding of the text is achieved.

Research with children and college students demonstrates the importance of background knowledge to reading comprehension. For example, undergraduates with strong scientific knowledge have been found to be more successful at understanding academic biology texts
compared to less knowledgeable peers (Ozuru et al., 2009). As another example, children in fifth grade who received instruction in background knowledge had higher comprehension scores than peers in a control condition (Dole, Valencia, Greer, & Wardrop, 1991). Studies have shown that for students in secondary and postsecondary settings, background knowledge exhibits a direct effect on comprehension beyond the contributions of skills like decoding and vocabulary (Ahmed et al., 2016; Cromley & Azevedo, 2007; Cromley, Snyder-Hogan, & Luciw-Dubas, 2010).

Very little is known about the relation between background knowledge and reading comprehension for struggling adult readers. To measure background knowledge with this population, researchers have administered oral assessments of knowledge in domains such as science, social studies, literature, and general information (Strucker & Davidson, 2003; Talwar, Tighe, & Greenberg, 2018). Findings have indicated that adults who struggle with reading also tend to have deficits in background knowledge (Strucker & Davidson, 2003; Strucker, 2013; Talwar et al., 2018). Additionally, background knowledge appears to be strongly correlated with reading comprehension and exhibits unique predictive utility to reading comprehension after controlling for the effects of decoding, listening comprehension, and oral vocabulary (Talwar et al., 2018).

**Inference.** Inferencing refers to the skill of understanding implicit clues and connections within a discourse (Kintsch, 1988). After the formation of the textbase, the reader makes inferences based on knowledge and logic to increase the cohesion of the situation model (McNamara & Magliano, 2009). In the context of narrative texts, inferences are often made regarding characters’ goals and intentions, the causes of events, and the overall message or “moral” of a story (Graesser et al., 1994). For example, consider the following short text: “As
soon as the lasagna was ready, John opened the oven door and took it out. He immediately reached for his fork and took a large bite of the lasagna. With tears in his eyes, he gulped down a tall glass of ice-cold water.” In addition to strong print processing skills, background knowledge and inferencing are required to conclude that John was possibly impatient and hungry, that the hot food burned John’s mouth, and that this story illustrates the importance of patience.

The influence of inference on reading comprehension has been examined with readers of different ages. Children who have difficulty generating inferences tend to be poor comprehenders, with inference performance uniquely explaining variance in reading comprehension scores (Cain & Oakhill, 1999; Cain, Oakill, Barnes, & Bryant, 2001). A recent meta-analysis suggests that providing instruction in inference-making can improve children’s reading comprehension skills and may be especially beneficial to low-skilled readers (Elleman, 2017). With adolescents and undergraduates, researchers have found that inference performance exhibits a direct effect on reading comprehension beyond the contributions of decoding, vocabulary, and background knowledge (Ahmed et al., 2016; Cromley & Azevedo, 2007; Cromley et al., 2010). With struggling adult readers, only one investigation has explored the importance of inferences to reading comprehension (Tighe, Johnson, & McNamara, 2017); after controlling for decoding, vocabulary, fluency, and listening comprehension, inference-generation explained unique variance in reading comprehension as indexed by the Gates-MacGinitie Reading Test (MacGinitie, MacGinitie, Maria, & Dreyer, 2000).

**Reading Comprehension Tests**

An important issue to consider in reading research is the measurement of the reading comprehension construct. Reading comprehension tests can differ in terms of the format of items (multiple-choice versus open-ended), the administration method (paper versus computer-based),
and adaptivity to the examinee. Past research suggests that different reading comprehension tests are not equivalent to one another. Tests consisting of multiple-choice items may give examinees an undue advantage (Coleman, Lindstrom, Nelson, Lindstrom, & Gregg, 2010; Katz, Lautenschlager, Blackburn, & Harris, 1990; Keenan & Betjemann, 2006). More pertinently, there are disparities in the influence of component reading skills on test scores: the relative contributions of word reading and oral language skills differed across reading comprehension tests for child samples (Cutting & Scarborough, 2006; Keenan, Betjemann, & Olson, 2008; Nation & Snowling, 1997).

Investigations involving struggling adult readers have also yielded differential findings. Mellard et al. (2015) reported in their regression models that vocabulary made the largest unique contribution to scores on the Reading subtest of the Test of Adult Basic Education (TABE; CTB/McGraw-Hill, 1996), whereas working memory made the largest unique contribution to scores on the Reading subtest of the Comprehensive Adult Student Assessment System (CASAS, 2004). Similarly, Tighe et al. (2017) found that vocabulary was a significant predictor of performance on the Woodcock Reading Mastery Test Passage Comprehension subtest (Woodcock, 2011) but not on the Gates-MacGinitie Reading Test (MacGinitie et al., 2000), whereas the opposite pattern was observed for inferencing. Additionally, in Nanda et al.’s (2010) factor models for native English speakers, performance on the Woodcock-Johnson Passage Comprehension subtest (Woodcock, McGrew, & Mather, 2001) was indicative of word reading skills, but performance on the Comprehension subtest of the Gray Oral Reading Test (Wiederholt & Bryant, 1992) was not. These findings suggest that predictors of reading comprehension should be examined using multiple tests as the outcome measure, so that the differences among
reading comprehension tests can be identified and results can be interpreted in the context of each test’s unique characteristics (Keenan, 2016).

As computerized testing has become more common, it is valuable to explore reading performance across modes of administration. Some researchers have observed with children and proficient adult readers that examinees score similarly on paper-based and computer-based tests of the same domain (Achtyes et al., 2015; Bodmann & Robinson, 2004; Srivastava & Gray, 2012). However, other investigations indicate that adolescents are less likely to identify important information within a passage if it is presented on a screen versus paper (Kobrin & Young, 2003) and adolescents with higher test anxiety generally perform worse on computerized tests (Lu, Hu, Gao, & Kinshuk, 2016). Although such mode comparison studies have not been conducted with struggling adult readers, it has been reported that these adults tend to have deficits in some basic computer skills such as identifying specific keys on the keyboard and right-clicking the mouse (Olney, Bakhtiari, Greenberg, & Graesser, 2017). Therefore, this population may face a greater disadvantage on computerized tests.

**Quantile Regression Models of Reading Comprehension**

Some investigators have used quantile regression to study the effects of component skills across different levels of reading comprehension (e.g., Cho, Capin, Roberts, & Vaughn, 2017; Frijters et al., 2018; Hua & Keenan, 2017; Language and Reading Research Consortium [LARRC] & Logan, 2017; Lonigan, Burgess, & Schatschneider, 2018; Tighe & Schatschneider, 2016). Unlike OLS regression, which estimates the predictor-criterion relation at the average level of the criterion, quantile regression can estimate this relation at different quantiles (or locations) in the criterion distribution (Davino, Furno, & Vistocco, 2014; Koenker & Basset, 1978; Koenker & Hallock, 2001).
With child samples, researchers found that the contributions of predictors such as vocabulary, oral fluency, and motivation to reading comprehension can differ for readers at different proficiency levels (Cho et al., 2017; Frijters et al., 2018; Lonigan et al., 2018; van den Bosch, Segers, & Verhoeven, 2018). Most pertinently, Hua and Keenan’s (2017) quantile regression analyses highlight the influence of reading comprehension measures on predictor-comprehension relationships. For children of ages 8 through 18 years, the authors examined the relations of word recognition and listening comprehension to reading comprehension across five reading comprehension measures. From the .10 quantile to the .90 quantile, the unique effect of listening comprehension increased on two tests, decreased on two other tests, and stayed the same on one test. Similarly mixed trends were observed across tests for the effect of word recognition. Thus, between-quantile comparisons appear to be sensitive to the properties of the reading comprehension measure.

The value of quantile regression to adult literacy research is illustrated by Tighe and Schatschneider (2016), who estimated the effects of morphological awareness and oral vocabulary knowledge on reading comprehension first using ordinary least squares (OLS) regression and then using quantile regression. The OLS regression model indicated that the two predictors accounted for 90% of variance in reading comprehension, with morphological awareness making a larger contribution than oral vocabulary. The quantile regression analyses provided further insight into these relations. First, the total variance explained in reading comprehension fluctuated between 82% and 95% depending on the quantile of reading comprehension. Second, at higher reading comprehension levels, the effect of morphological awareness decreased and the effect of oral vocabulary increased, such that the two predictors appeared to exert similar effects on reading comprehension for readers at the .90 quantile.
The Current Study

Overall, the adult literacy literature on reading comprehension indicates multiple gaps. Very little is known about the contributions of important competencies like background knowledge and inferencing on reading comprehension in the context of more well-established predictors. Moreover, it has not been established whether reading-related competencies change in importance for lower- or higher-skilled comprehenders. Additionally, more research is needed on how these predictors influence struggling adult readers’ performance on different reading comprehension tests.

The main goal of the current study is to understand how decoding, oral vocabulary, reading fluency, listening comprehension, background knowledge, and inference contribute to struggling adult readers’ performance across different reading comprehension measures and across different performance levels within each measure. The results can provide insight into the value of adult literacy programs administering multiple reading comprehension tests to students and can also help researchers contextualize and interpret their performance on different tests.

Two research questions were addressed in this study:

1. For struggling adult readers, what are the joint and unique contributions of decoding, oral vocabulary, fluency, listening comprehension, background knowledge and inference to performance on different reading comprehension tests?

2. Do the effects of these predictors vary across levels of performance on each reading comprehension test?
Method

Participants

This study included data collected from 168 individuals who were participants in the research conducted by the Center for the Study of Adult Literacy (CSAL). This sample consists of native English speakers who had completed the pretest in the CSAL intervention on three measures of reading comprehension: the Passage Comprehension subtest of the Woodcock-Johnson III Normative Update (WJ; Woodcock, McGrew, & Mather, 2007), the Reading Comprehension subtest of the Reading Inventory and Scholastic Evaluation (RISE) developed by the Educational Testing Service (ETS; Sabatini, Bruce, Steinberg, & Weeks, 2015), and the Reading Comprehension subtest of the Reading Assessment for Prescriptive Instructional Data (RAPID) developed by Lexia Learning (Foorman, Petscher, & Schachtsneider, 2017). All participants attended adult literacy programs in the United States (57.1%) or Canada (42.9%) and they were recruited from these sites. In terms of gender and race, the major groups in the sample were women (71.4%) and individuals of African descent (76.8%). Participants had a mean age of 42.19 years ($SD = 14.39$). Table 2.1 provides more detailed demographic information.

Procedure

Upon completing informed consent procedures, trained graduate research assistants administered assessments to participants at their adult literacy program sites; this study focuses on a subset of the assessment battery. All tests were individually administered to each participant with the exception of the RISE and the RAPID, which were administered at computers to small groups of participants. Participants received $10 per hour for their time.
Table 2.1

Demographic Information

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>96</td>
<td>57.1</td>
</tr>
<tr>
<td>Canada</td>
<td>72</td>
<td>42.9</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>120</td>
<td>71.4</td>
</tr>
<tr>
<td>Male</td>
<td>48</td>
<td>28.6</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 – 19 years</td>
<td>7</td>
<td>4.2</td>
</tr>
<tr>
<td>20 – 29 years</td>
<td>30</td>
<td>17.9</td>
</tr>
<tr>
<td>30 – 39 years</td>
<td>39</td>
<td>23.2</td>
</tr>
<tr>
<td>40 – 49 years</td>
<td>29</td>
<td>17.3</td>
</tr>
<tr>
<td>50 – 59 years</td>
<td>41</td>
<td>24.4</td>
</tr>
<tr>
<td>60 – 69 years</td>
<td>14</td>
<td>8.3</td>
</tr>
<tr>
<td>70 years or older</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>Not reported</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Race and Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African Descent</td>
<td>129</td>
<td>76.8</td>
</tr>
<tr>
<td>White</td>
<td>6</td>
<td>3.6</td>
</tr>
<tr>
<td>Native/Indigenous</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Asian</td>
<td>29</td>
<td>17.3</td>
</tr>
<tr>
<td>Not reported</td>
<td>1</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Measures

This study included measures that assess reading comprehension, decoding, oral vocabulary, fluency, background knowledge, and inference. There were three measures of reading comprehension and decoding, and only one measure for each of the other constructs. Participants also completed demographic and computer familiarity questionnaires.

Reading Comprehension.

WJ Passage Comprehension. The first measure of reading comprehension was the WJ Passage Comprehension subtest. The items on this measure were connected texts comprised of one or two sentences with missing words indicated by blanks. The participant silently read each item and filled in the blank by speaking the missing word out loud. Easier items involved pictures. Administration started at Item 14. Following the ceiling rule, items were administered by complete pages in the testing booklet until the participant received a score of zero on six consecutive items. This was the only reading comprehension measure in this study that was not administered at a computer. This measure was standardized on individuals 2 years old to over 80 years old and the internal consistency reliability estimates ranged from .73 to .96 (McGrew, Schrank, & Woodcock, 2007).

RISE Reading Comprehension. The second measure of reading comprehension was the Reading Comprehension subtest of the RISE developed by ETS. The RISE is a Web-based test battery completed at a computer and is part of the Study Aid and Reading Assessment (SARA). The RISE was administered with the sound setting turned on; with this setting, instructions are provided via text as well as audio. In the Reading Comprehension subtest, the participant saw a passage and with the passage still in view, answered multiple-choice questions about the
passage. All questions include three answer choices and the participant selected the answer by pressing one of three keys: 1, 2, and 3.

**RAPID Reading Comprehension.** The third measure of reading comprehension was the Reading Comprehension subtest of the RAPID developed by Lexia Learning. The RAPID is also a Web-based test administered at a computer. In the Reading Comprehension subtest, the participant saw a passage and with the passage still in view, answered multiple-choice questions about the passage. All questions include four answer choices and the participant selected the answer using mouse clicks.

Unlike the other two reading comprehension tests, the RAPID is an adaptive assessment, which means that not all participants were administered the same passages in Reading Comprehension subtest. Based on the adaptive algorithm, the starting passage of the Reading Comprehension subtest is determined by the participant’s performance on the other RAPID subtests (Word Recognition, Vocabulary Knowledge, and Syntactic Knowledge) and the participant may complete one or more passages until a reliable estimate of performance is reached.

**Decoding.**

**WJ Word Attack.** In the WJ Word Attack subtest, the participant read nonsense words out loud. Starting with Item 4, the items were administered in sets corresponding to testing booklet pages. As per the ceiling rule, administration was discontinued after the participant received six consecutive scores of zero. The norming sample for this measure including a wide age range, from 4 years to over 80 years. Internal reliability estimates ranged from f .78 to .94 (McGrew et al., 2007).
**WJ Letter-Word Identification.** In the WJ Letter-Word Identification subtest, the participant read real words out loud. Starting with Item 33, the items were administered in sets corresponding to testing booklet pages. As per the ceiling rule, administration was discontinued after the participant received six consecutive scores of zero. The norming sample for this measure included individuals who were 4 years to over 80 years old. Internal reliability estimates ranged from .88 to .99 (McGrew et al., 2007).

**Challenge Word Test.** In the Challenge Word Test (Lovett et al., 1994; Lovett et al., 2000), the participant read aloud real words that contain multiple syllables. Administration started at Item 1. Following the ceiling rule, administration was discontinued after the participant received a score of zero on ten consecutive items. Because this is an experimental measure, no standardization information is available.

**Oral Vocabulary.**

**WJ Picture Vocabulary.** In the WJ Picture Vocabulary subtest, the participant looked at pictures and named the depicted objects or actions. Starting with Item 15, the items were administered in sets corresponding to testing booklet pages. As per the ceiling rule, administration was discontinued after the participant received six consecutive scores of zero. The norming sample for this measure included individuals who were 2 years old to over 80 years old. Internal reliability estimates ranged from .70 to .93 (McGrew et al., 2007).

**Fluency.**

**WJ Reading Fluency.** In the WJ Reading Fluency subtest, the participant was given a list of statements printed on paper and given 3 minutes to silently read as many statements as possible, decide if each statement is true or false, and circle Y (for “yes”) or “N” (for “No”) next to each statement. The participant was directed to work as quickly and accurately as possible on
this task. Administration started at Item 1. This measure was standardized on individuals 6 years old to over 80 years old and the internal consistency reliability estimates ranged from .72 to .96 (McGrew et al., 2007).

**Listening Comprehension.**

**CELF Understanding Spoken Paragraphs.** In the Understanding Spoken Paragraphs subtest of the Clinical Evaluation of Language Fundamentals IV (CELF; Semel, Wiig, & Secord, 2003a), the participant listened to very short stories and then answered questions about them. This measure is divided into multiple sets and administration started at Item 1 of the first set. As per the test rules, administered was discontinued after the first set if the participant received a score of zero on any item in that set. The norming sample for this measure included ages 5 years to 21 years. Internal reliability estimates ranged from .54 to .81 (Semel, Wiig, & Secord, 2003b).

**Background Knowledge.**

**WJ General Information.** The WJ General Information subtest had two subscales: *Where* and *What*. The examiner asked questions about where one would usually find certain objects and what one would usually do with certain objects, and the participant provides answered verbally. For both subscales, administration started at Item 1 and the ceiling rule of four consecutive zero scores was followed. This measure was standardized on individuals 2 to over 80 years old and the reliability estimates ranged from .82 to .96 (McGrew et al., 2007).

**Inference.**

**CASL Inference.** In the Inference subtest of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999), the examiner read aloud short passages that have missing information and asked a question about the missing information in each item. The participant answered the question using world knowledge or clues in the passage. Administration
started at Item 1. Following the ceiling rule, administration was discontinued after the participant received a score of zero on five consecutive items. This measure was standardized on individuals 7 to 18 years old and the internal consistency reliability estimates ranged from .86 to .90 (Carrow-Woolfolk, 2008).

Questionnaires. As part of a larger demographic survey, participants answered questions about their demographic characteristics, including age, gender, and race (see Table 2.1). In addition, because the RISE and RAPID Reading Comprehension assessments are Web-based and administered at computers, it was important to examine whether participants’ performance on these assessments were related to their computer experience. Therefore, participants’ responses to questions about their use of computers were also included.

Results

Mean scores on all measures are reported in Table 2.2. Correlations across measures are reported in Table 2.3. The correlation coefficients among WJ Letter-Word Identification, WJ Word Attack, and the Challenge Word Test ranged from .79 to .90. Due to these strong relationships, a decoding composite was computed from $z$-scores on these measures for subsequent analyses.

Computer Experience. Participants’ responses to computer experience questions are summarized in Table 2.4. All but two participants indicated that they had used a computer before. Of those who had used a computer, approximately 41% said that they use a computer every day, 31% said that they use a computer a few times a week, 13% said that they use a computer once a week, and 15% said that they use a computer less than once a week. Four groups were created based on these responses. One-way ANOVAs indicated that there was no significant differences among these four groups on RISE Reading Comprehension ($F(3,162) =$
Table 2.2  
*Performance on Measures*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Raw Scores</th>
<th>Mean Grade Equivalent</th>
<th>Age-Based Standard Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
</tr>
<tr>
<td>WJPC</td>
<td>27.60</td>
<td>4.45</td>
<td>18 - 40</td>
</tr>
<tr>
<td>RISERC</td>
<td>9.21</td>
<td>3.53</td>
<td>2 - 20</td>
</tr>
<tr>
<td>RAPIDRC</td>
<td>421.61</td>
<td>100.37</td>
<td>285 - 732</td>
</tr>
<tr>
<td>WJLWI</td>
<td>51.88</td>
<td>9.26</td>
<td>30 - 69</td>
</tr>
<tr>
<td>WJWA</td>
<td>13.48</td>
<td>7.18</td>
<td>1 - 28</td>
</tr>
<tr>
<td>CWT</td>
<td>15.38</td>
<td>7.64</td>
<td>0 - 30</td>
</tr>
<tr>
<td>CINF</td>
<td>22.65</td>
<td>10.15</td>
<td>0 - 40</td>
</tr>
<tr>
<td>CUSP</td>
<td>6.96</td>
<td>3.32</td>
<td>0 - 14</td>
</tr>
<tr>
<td>WJPV</td>
<td>24.64</td>
<td>4.38</td>
<td>13 - 34</td>
</tr>
<tr>
<td>WJRF</td>
<td>38.56</td>
<td>14.38</td>
<td>6 - 98</td>
</tr>
<tr>
<td>WJGI</td>
<td>25.18</td>
<td>5.32</td>
<td>7 - 37</td>
</tr>
</tbody>
</table>

*Note.* Age-based standard scores and grade equivalents were only available for the WJ subtests.  
WJPC = WJ Passage Comprehension; RISERC = RISE Reading Comprehension; RAPIDRC = RAPID Reading Comprehension; WJLWI = WJ Letter-Word Identification; WJWA = WJ Word Attack; CWT = Challenge Word Test; CINF = CASL Inference; CUSP = CELF Understanding Spoken Paragraphs; WJPV = WJPV Picture Vocabulary; WJRF = WJ Reading Fluency; WJGI = WJ General Information.
### Table 2.3
**Correlations Across Measures**

<table>
<thead>
<tr>
<th></th>
<th>WJPC</th>
<th>RISERC</th>
<th>RAPIDRC</th>
<th>WJLWI</th>
<th>WJWA</th>
<th>CWT</th>
<th>CINF</th>
<th>CUSP</th>
<th>WJPV</th>
<th>WJRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>WJPC</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RISERC</td>
<td>.532***</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAPIDRC</td>
<td>.576***</td>
<td>.581***</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJLWI</td>
<td>.577***</td>
<td>.470***</td>
<td>.601***</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJWA</td>
<td>.426***</td>
<td>.367***</td>
<td>.462***</td>
<td>.839***</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWT</td>
<td>.578***</td>
<td>.482***</td>
<td>.592***</td>
<td>.897***</td>
<td>.786***</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CINF</td>
<td>.472***</td>
<td>.145</td>
<td>.222**</td>
<td>.051</td>
<td>.020</td>
<td>.073</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUSP</td>
<td>.464***</td>
<td>.313***</td>
<td>.401***</td>
<td>.176*</td>
<td>.092</td>
<td>.165*</td>
<td>.553***</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WJPV</td>
<td>.614***</td>
<td>.287***</td>
<td>.268***</td>
<td>.272***</td>
<td>.153</td>
<td>.261**</td>
<td>.438***</td>
<td>.498***</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>WJRF</td>
<td>.542***</td>
<td>.393***</td>
<td>.484***</td>
<td>.601***</td>
<td>.497***</td>
<td>.555***</td>
<td>.220**</td>
<td>.350***</td>
<td>.350***</td>
<td>—</td>
</tr>
<tr>
<td>WJGI</td>
<td>.632***</td>
<td>.292***</td>
<td>.261**</td>
<td>.146</td>
<td>.026</td>
<td>.158*</td>
<td>.616***</td>
<td>.586***</td>
<td>.779***</td>
<td>.290***</td>
</tr>
</tbody>
</table>

**Note.** ***p < .001; **p < .01; * p < .05. WJPC = WJ Passage Comprehension; RISERC = RISE Reading Comprehension; RAPIDRC = RAPID Reading Comprehension; WJLWI = WJ Letter-Word Identification; WJWA = WJ Word Attack; CWT = Challenge Word Test; CINF = CASL Inference; CUSP = CELF Understanding Spoken Paragraphs; WJPV = WJPV Picture Vocabulary; WJRF = WJ Reading Fluency; WJGI = WJ General Information.
Table 2.4  
*Participants’ Self-Reported Computer Experience*  

<table>
<thead>
<tr>
<th>Question and Responses</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever used a computer? (<em>N</em> = 168)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>166</td>
<td>98.8</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>How often do you use a computer? (<em>N</em> = 166)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every day</td>
<td>68</td>
<td>41.0</td>
</tr>
<tr>
<td>A few times a week</td>
<td>52</td>
<td>31.3</td>
</tr>
<tr>
<td>Once a week</td>
<td>21</td>
<td>12.7</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>25</td>
<td>15.1</td>
</tr>
<tr>
<td>In a typical day, how many hours do you usually use a computer? (<em>N</em> = 166)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 hours</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>0.5 hours</td>
<td>10</td>
<td>6.0</td>
</tr>
<tr>
<td>1 hour</td>
<td>42</td>
<td>25.3</td>
</tr>
<tr>
<td>2 hours</td>
<td>25</td>
<td>15.1</td>
</tr>
<tr>
<td>2.5 hours</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>3 hours</td>
<td>16</td>
<td>9.6</td>
</tr>
<tr>
<td>3.5 hours</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>4 hours</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>5 hours</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>6 hours</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>7 hours</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>8 hours</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>9 or more hours</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>Not reported</td>
<td>24</td>
<td>14.5</td>
</tr>
</tbody>
</table>
2.58, \( p > .05 \) and RAPID Reading Comprehension \( (F(3,162) = 2.01, p > .05) \). Additionally, participants reported the number of hours they usually use a computer per day, which ranged from zero to 18 hours, with a mean of 2.93 hours \( (SD = 3.19) \). Number of hours of computer use was not significantly correlated with scores on either test \( (ps > .05) \). Since computer experience did not appear to be related to performance on RISE Reading Comprehension and RAPID Reading Comprehension, it was not included as a covariate in any subsequent analyses.

**Research Question 1: What are joint and unique contributions of reading-related skills to performance on different reading comprehension tests?**

To answer the first research question, an OLS regression model was estimated separately for each reading comprehension test in the R statistical environment (R Core Team, 2018). The dependent variable in this model was reading comprehension and the independent variables were decoding, oral vocabulary, fluency, listening comprehension, background knowledge and inference. The parameter estimates of the OLS regression model for each reading comprehension test are reported in Table 2.5.

The data were examined to determine whether the assumptions of linear regression were tenable. Each variable appeared to be normally distributed, as indicated by skewness and kurtosis values between \( \pm 2 \). For each reading comprehension test, scatter plots indicated approximately linear relations with all independent variables. Scatter plots of residuals and fitted values did not exhibit a distinct pattern, which supported the assumption of homoscedasticity. Additionally, residuals appeared to be normally distributed as indicated by Q-Q plots and residual means of approximately 0.

**OLS Regression Model for WJ Passage Comprehension.** The model explained a total of 66\% of variance in WJ Passage Comprehension performance \( (F(6,153) = 48.99, p < .001) \).
Table 2.5
*OLS Regression Parameter Estimates for Each Reading Comprehension Measure*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>SE</th>
<th>t</th>
<th>Unique $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WJ Passage Comprehension (Total $R^2 = .658$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>0.017</td>
<td>0.047</td>
<td>0.366</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.415</td>
<td>0.062</td>
<td>6.739***</td>
<td>.096</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>0.176</td>
<td>0.077</td>
<td>2.292*</td>
<td>.012</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.130</td>
<td>0.060</td>
<td>2.148*</td>
<td>.017</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>-0.013</td>
<td>0.061</td>
<td>-0.208</td>
<td>.000</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.294</td>
<td>0.088</td>
<td>3.321**</td>
<td>.012</td>
</tr>
<tr>
<td>Inference</td>
<td>0.181</td>
<td>0.063</td>
<td>2.875**</td>
<td>.017</td>
</tr>
<tr>
<td><strong>RISE Reading Comprehension (Total $R^2 = .289$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.009</td>
<td>0.067</td>
<td>-0.139</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.389</td>
<td>0.089</td>
<td>4.372***</td>
<td>.081</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.036</td>
<td>0.111</td>
<td>-0.327</td>
<td>.000</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.107</td>
<td>0.087</td>
<td>1.224</td>
<td>.008</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.166</td>
<td>0.089</td>
<td>1.866</td>
<td>.016</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.152</td>
<td>0.128</td>
<td>1.190</td>
<td>.007</td>
</tr>
<tr>
<td>Inference</td>
<td>-0.047</td>
<td>0.091</td>
<td>-0.514</td>
<td>.000</td>
</tr>
<tr>
<td><strong>RAPID Reading Comprehension (Total $R^2 = .428$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.004</td>
<td>0.060</td>
<td>-0.060</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.498</td>
<td>0.080</td>
<td>6.236***</td>
<td>.142</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.072</td>
<td>0.100</td>
<td>-0.718</td>
<td>.001</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.119</td>
<td>0.078</td>
<td>1.517</td>
<td>.010</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.266</td>
<td>0.080</td>
<td>3.345**</td>
<td>.042</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.031</td>
<td>0.115</td>
<td>0.272</td>
<td>.000</td>
</tr>
<tr>
<td>Inference</td>
<td>0.050</td>
<td>0.082</td>
<td>0.609</td>
<td>.000</td>
</tr>
</tbody>
</table>

Decoding, oral vocabulary, fluency, background knowledge, and inference had significant unique effects on reading comprehension score (see Table 2.5). Approximately 10% of the reading comprehension variance was uniquely contributed by decoding, 2% by fluency, 2% by inference, 1% by inference, and 1% by oral vocabulary.

**OLS Regression Model for RISE Reading Comprehension.** The same model was estimated for RISE Reading Comprehension and explained a total of 29% of variance in reading comprehension performance \( F(6,153) = 10.35, p < .001 \). Only decoding had a significant unique effect on reading comprehension score and uniquely contributed 8% of the reading comprehension variance (see Table 2.5).

**OLS Regression Model for RAPID Reading Comprehension.** Finally, this OLS regression model was estimated for RAPID Reading Comprehension and explained a total of 43% of variance in reading comprehension performance \( F(6,153) = 19.09, p < .001 \). Decoding and listening comprehension had significant unique effects on reading comprehension score (see Table 2.5). Approximately 14% of the reading comprehension variance was uniquely contributed by decoding and 4% was uniquely contributed by listening comprehension.

**Research Question 2: Do the effects of predictors vary across levels of performance on each reading comprehension tests?**

To answer the second research question, quantile regression models were estimated separately for each reading comprehension test using the quantreg package in R (Koenker, 2018). As in the OLS regression model, the dependent variable was reading comprehension and the independent variables were decoding, oral vocabulary, fluency, listening comprehension, background knowledge and inference. The model parameters were estimated at the .10, .50, and .90 quantiles, which correspond to low, average, and high levels of reading comprehension.
within the sample (Hua & Keenan, 2017). Additionally, between-quantile slope comparisons were conducted across the .10, .50, and .90 quantiles, as reported in Table 2.6.

**Quantile Regression Model for WJ Passage Comprehension.** The quantile regression parameter estimates for WJ Passage Comprehension are reported in Table 2.7. The total variance in reading comprehension explained by the quantile regression model was approximately 47% at the .10 quantile, 46% at the .50 quantile, and 51% at the .90 quantile. At the .10 quantile, decoding and oral vocabulary had significant unique effects on reading comprehension, uniquely contributing 10% and 2% of the reading comprehension variance, respectively. At the .50 quantile, decoding and oral vocabulary had significant unique effects on reading comprehension, uniquely contributing 5% and 2% of the reading comprehension variance, respectively. At the .90 quantile, decoding and background knowledge had significant unique effects on reading comprehension, uniquely contributing 11% and 9% of the reading comprehension variance, respectively.

For WJ Passage Comprehension, between-quantile slope comparisons across the .10, .50, and .90 quantiles revealed significant differences in the unique effects of certain predictors (see Table 2.6 for p-values). The effect of oral vocabulary on reading comprehension was greater at the .50 quantile than at the .90 quantile. Additionally, the effect of background knowledge on reading comprehension was greater at the .90 quantile than at the .10 quantile. Figures 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6 show the unique slope estimates of each independent variable for WJ Passage Comprehension performance at nine equidistant quantiles between .10 and .90.

**Quantile Regression Model for RISE Reading Comprehension.** The quantile regression parameter estimates for RISE Reading Comprehension are reported in Table 2.8. The total variance in reading comprehension explained by the quantile regression model was
Table 2.6
Comparisons of Quantile Regression Coefficients

<table>
<thead>
<tr>
<th>Predictor</th>
<th>WJ Passage Comprehension</th>
<th>RISE Reading Comprehension</th>
<th>RAPID Reading Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.10 vs. .50</td>
<td>.10 vs. .90</td>
<td>.50 vs. .90</td>
</tr>
<tr>
<td>Decoding</td>
<td>.17</td>
<td>.74</td>
<td>.23</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>.56</td>
<td>.16</td>
<td><strong>.02</strong></td>
</tr>
<tr>
<td>Fluency</td>
<td>.81</td>
<td>.53</td>
<td>.65</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>&lt;.01</td>
<td>.02</td>
<td>.21</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>.05</td>
<td>&lt;.01</td>
<td>.08</td>
</tr>
<tr>
<td>Inference</td>
<td>.410</td>
<td>.82</td>
<td>.26</td>
</tr>
</tbody>
</table>

**Note.** For predictors that had a unique effect on reading comprehension, *p*-values significant at the .05 alpha level are in bold. Decoding measured by a composite of WJ Letter-Word Identification, WJ Word Attack, and Challenge Word Test. Oral vocabulary measured by WJ Picture Vocabulary. Fluency measured by WJ Reading Fluency. Listening comprehension measured by CELF Understanding Spoken Paragraphs. Background knowledge measured by WJ General Information. Inference measured by CASL Inference.
Table 2.7
Quantile Regression Parameter Estimates for WJ Passage Comprehension

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>SE</th>
<th>t</th>
<th>Unique Pseudo R²</th>
<th>Total Pseudo R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>.10 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.797</td>
<td>0.066</td>
<td>-11.295</td>
<td>***</td>
<td>.665</td>
</tr>
<tr>
<td>Decoding</td>
<td>0.462</td>
<td>0.092</td>
<td>4.821</td>
<td>***</td>
<td>.100</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>0.254</td>
<td>0.105</td>
<td>2.192</td>
<td>*</td>
<td>.022</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.152</td>
<td>0.078</td>
<td>1.983</td>
<td></td>
<td>.030</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.217</td>
<td>0.113</td>
<td>1.871</td>
<td></td>
<td>.014</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.054</td>
<td>0.105</td>
<td>0.536</td>
<td></td>
<td>.010</td>
</tr>
<tr>
<td>Inference</td>
<td>0.098</td>
<td>0.148</td>
<td>0.638</td>
<td></td>
<td>.032</td>
</tr>
<tr>
<td><strong>.50 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>0.104</td>
<td>0.068</td>
<td>1.600</td>
<td></td>
<td>.462</td>
</tr>
<tr>
<td>Decoding</td>
<td>0.339</td>
<td>0.090</td>
<td>3.914</td>
<td>***</td>
<td>.051</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>0.314</td>
<td>0.112</td>
<td>2.728</td>
<td>**</td>
<td>.015</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.129</td>
<td>0.097</td>
<td>1.298</td>
<td></td>
<td>.015</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>-0.120</td>
<td>0.071</td>
<td>-1.728</td>
<td></td>
<td>.008</td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.288</td>
<td>0.156</td>
<td>1.879</td>
<td></td>
<td>.026</td>
</tr>
<tr>
<td>Inference</td>
<td>0.180</td>
<td>0.086</td>
<td>1.949</td>
<td></td>
<td>.026</td>
</tr>
<tr>
<td><strong>.90 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>0.680</td>
<td>0.066</td>
<td>10.548</td>
<td>***</td>
<td>.507</td>
</tr>
<tr>
<td>Decoding</td>
<td>0.437</td>
<td>0.076</td>
<td>5.482</td>
<td>***</td>
<td>.106</td>
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<tr>
<td>Oral Vocabulary</td>
<td>0.095</td>
<td>0.103</td>
<td>0.936</td>
<td></td>
<td>.003</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.092</td>
<td>0.087</td>
<td>0.956</td>
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<td>.012</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>-0.004</td>
<td>0.089</td>
<td>-0.046</td>
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<td>.000</td>
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<tr>
<td>Background Knowledge</td>
<td>0.491</td>
<td>0.106</td>
<td>5.287</td>
<td>***</td>
<td>.085</td>
</tr>
<tr>
<td>Inference</td>
<td>0.075</td>
<td>0.084</td>
<td>0.979</td>
<td></td>
<td>.013</td>
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</tbody>
</table>

**Figure 2.1.** Quantile regression plot for the relation between decoding and WJ Passage Comprehension after controlling for oral vocabulary, fluency, listening comprehension, background knowledge, and inference. Error bars indicate 95% confidence intervals.

**Figure 2.2.** Quantile regression plot for the relation between oral vocabulary and WJ Passage Comprehension after controlling for decoding, fluency, listening comprehension, background knowledge, and inference. Errors bar indicate 95% confidence intervals.
Figure 2.3. Quantile regression plot for the relation between fluency and WJ Passage Comprehension after controlling for decoding, oral vocabulary, listening comprehension, background knowledge, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.4. Quantile regression plot for the relation between listening comprehension and WJ Passage Comprehension after controlling for decoding, oral vocabulary, fluency, background knowledge, and inference. Errors bar indicate 95% confidence intervals.
Figure 2.5. Quantile regression plot for the relation between background knowledge and WJ Passage Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.6. Quantile regression plot for the relation between inference and WJ Passage Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and background knowledge. Errors bar indicate 95% confidence intervals.
Table 2.8
Quantile Regression Parameter Estimates for RISE Reading Comprehension

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>SE</th>
<th>t</th>
<th>Unique Pseudo $R^2$</th>
<th>Total Pseudo $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>.10 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-1.087</td>
<td>0.099</td>
<td>-10.133***</td>
<td></td>
<td>.216</td>
</tr>
<tr>
<td>Decoding</td>
<td>0.297</td>
<td>0.114</td>
<td>2.824**</td>
<td>.056</td>
<td></td>
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<tr>
<td>Oral Vocabulary</td>
<td>0.326</td>
<td>0.184</td>
<td>1.554</td>
<td>.034</td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>-0.033</td>
<td>0.132</td>
<td>-0.241</td>
<td>.006</td>
<td></td>
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<tr>
<td>Listening Comprehension</td>
<td>0.227</td>
<td>0.128</td>
<td>1.805</td>
<td>.019</td>
<td></td>
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<tr>
<td>Background Knowledge</td>
<td>-0.207</td>
<td>0.219</td>
<td>-0.818</td>
<td>.031</td>
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</tr>
<tr>
<td>Inference</td>
<td>0.010</td>
<td>0.110</td>
<td>0.090</td>
<td>.011</td>
<td></td>
</tr>
<tr>
<td><strong>.50 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.088</td>
<td>0.117</td>
<td>-0.865</td>
<td>.195</td>
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</tr>
<tr>
<td>Decoding</td>
<td>0.385</td>
<td>0.125</td>
<td>2.803**</td>
<td>.039</td>
<td></td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.068</td>
<td>0.169</td>
<td>-0.371</td>
<td>.011</td>
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</tr>
<tr>
<td>Fluency</td>
<td>0.074</td>
<td>0.143</td>
<td>0.458</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.120</td>
<td>0.175</td>
<td>0.751</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>Background Knowledge</td>
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<td>0.230</td>
<td>0.957</td>
<td>.024</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>-0.013</td>
<td>0.162</td>
<td>-0.086</td>
<td>.013</td>
<td></td>
</tr>
<tr>
<td><strong>.90 Quantile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>1.170</td>
<td>0.113</td>
<td>10.710***</td>
<td></td>
<td>.289</td>
</tr>
<tr>
<td>Decoding</td>
<td>0.490</td>
<td>0.183</td>
<td>3.254**</td>
<td>.069</td>
<td></td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.127</td>
<td>0.136</td>
<td>-0.930</td>
<td>.014</td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>0.245</td>
<td>0.195</td>
<td>1.279</td>
<td>.023</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.136</td>
<td>0.170</td>
<td>0.875</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.242</td>
<td>0.169</td>
<td>1.307</td>
<td>.032</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>-0.199</td>
<td>0.144</td>
<td>-1.254</td>
<td>.022</td>
<td></td>
</tr>
</tbody>
</table>

approximately 22% at the .10 quantile, 20% at the .50 quantile, and 29% at the .90 quantile. At all three quantiles, decoding emerged as the only significant predictor of reading comprehension. The unique contribution of decoding to the variance in reading comprehension was 6% at the .10 quantile, 4% at the .50 quantile, and 7% at the .90 quantile. This effect appeared to be stable regardless of proficiency level, as between-quantile slope comparisons did not reveal any significant differences in the magnitude of this effect across the .10, .50, and .90 quantiles (see Table 2.6 for p-values). Figures 2.7, 2.8, 2.9, 2.10, 2.11, and 2.12 show the unique slope estimates of each independent variable for RISE Reading Comprehension performance at nine equidistant quantiles between .10 and .90.

**Quantile Regression Model for RAPID Reading Comprehension.** The quantile regression parameter estimates for RAPID Reading Comprehension are reported in Table 2.9. The total variance in reading comprehension explained by the quantile regression model was approximately 18% at the .10 quantile, 32% at the .50 quantile, and 38% at the .90 quantile. At the .10 and .50 quantiles, decoding was the only significant predictor of reading comprehension, uniquely contributing 6% of the reading comprehension variance at the .10 quantile and 7% at the .50 quantile. At the .90 quantile, decoding and listening comprehension emerged as significant predictors, uniquely contributing 15% and 3% of the reading comprehension variance, respectively.

For RAPID Reading Comprehension, between-quantile slope comparisons across the .10, .50, and .90 quantiles revealed significant differences in the unique effects of both decoding and listening comprehension (see Table 2.6 for p-values). The effect of decoding on reading comprehension was greatest at the .90 quantile and greater at the .50 quantile than at the .10 quantile. The effect of listening comprehension was greater at the .90 quantile than at the .10 quantile.
Figure 2.7. Quantile regression plot for the relation between decoding and RISE Reading Comprehension after controlling for oral vocabulary, fluency, listening comprehension, background knowledge, and inference. Error bars indicate 95% confidence intervals.

Figure 2.8. Quantile regression plot for the relation between oral vocabulary and RISE Reading Comprehension after controlling for decoding, fluency, listening comprehension, background knowledge, and inference. Errors bar indicate 95% confidence intervals.
Figure 2.9. Quantile regression plot for the relation between fluency and RISE Reading Comprehension after controlling for decoding, oral vocabulary, listening comprehension, background knowledge, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.10. Quantile regression plot for the relation between listening comprehension and RISE Reading Comprehension after controlling for decoding, oral vocabulary, fluency, background knowledge, and inference. Errors bar indicate 95% confidence intervals.
Figure 2.11. Quantile regression plot for the relation between background knowledge and RISE Reading Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.12. Quantile regression plot for the relation between inference and RISE Reading Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and background knowledge. Errors bar indicate 95% confidence intervals.
Table 2.9
Quantile Regression Parameter Estimates for RAPID Reading Comprehension

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>SE</th>
<th>t</th>
<th>Unique Pseudo $R^2$</th>
<th>Total Pseudo $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>.10 Quantile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.907</td>
<td>0.075</td>
<td>-12.869***</td>
<td>.183</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.204</td>
<td>0.085</td>
<td>2.506*</td>
<td>.058</td>
<td></td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.067</td>
<td>0.085</td>
<td>-0.820</td>
<td>.006</td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>0.040</td>
<td>0.097</td>
<td>0.440</td>
<td>.011</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.060</td>
<td>0.101</td>
<td>0.585</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Background Knowledge</td>
<td>0.017</td>
<td>0.122</td>
<td>0.161</td>
<td>.027</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>0.057</td>
<td>0.088</td>
<td>0.659</td>
<td>.018</td>
<td></td>
</tr>
<tr>
<td>.50 Quantile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.122</td>
<td>0.077</td>
<td>-1.505</td>
<td>.324</td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.422</td>
<td>0.119</td>
<td>3.868***</td>
<td>.067</td>
<td></td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>-0.026</td>
<td>0.109</td>
<td>-0.219</td>
<td>.002</td>
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</tr>
<tr>
<td>Fluency</td>
<td>0.183</td>
<td>0.122</td>
<td>1.397</td>
<td>.017</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
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<td>1.739</td>
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<tr>
<td>Background Knowledge</td>
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<td>0.097</td>
<td>-0.133</td>
<td>.019</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>0.139</td>
<td>0.093</td>
<td>1.382</td>
<td>.019</td>
<td></td>
</tr>
<tr>
<td>.90 Quantile</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>1.062</td>
<td>0.110</td>
<td>8.233***</td>
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<tr>
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<td>0.157</td>
<td>-1.406</td>
<td>.014</td>
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</tr>
<tr>
<td>Fluency</td>
<td>0.235</td>
<td>0.175</td>
<td>1.233</td>
<td>.010</td>
<td></td>
</tr>
<tr>
<td>Listening Comprehension</td>
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<td>0.153</td>
<td>2.226*</td>
<td>.024</td>
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<tr>
<td>Background Knowledge</td>
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<td>0.161</td>
<td>1.557</td>
<td>.021</td>
<td></td>
</tr>
<tr>
<td>Inference</td>
<td>-0.018</td>
<td>0.170</td>
<td>-0.103</td>
<td>.005</td>
<td></td>
</tr>
</tbody>
</table>

quantile. Figures 2.13, 2.14, 2.15, 2.16, 2.17, and 2.18 show the unique slope estimates of each independent variable for RAPID Reading Comprehension performance at nine equidistant quantiles between .10 and .90.

**Discussion**

The aim of this study was to examine the explanatory effects of reading-related competencies on reading comprehension performance across different tests and proficiency levels for a sample of adults who struggle with reading. The effects of certain component skills on reading comprehension appeared to be influenced by how comprehension was assessed. Furthermore, the magnitude of some effects changed across levels of performance. The only common finding across tests was that decoding made the largest unique contribution to reading comprehension performance.

**Differential Effects across Tests**

Similar to research with children (Cutting & Scarborough, 2006; Keenan et al., 2008), the current study found differences in predictor-comprehension relations across reading comprehension tests. With the exception of listening comprehension, all the other predictors made significant unique contributions to WJ Passage Comprehension performance. This contrasts with the results for the computerized tests. Significant contributors to reading comprehension performance were limited to decoding and listening comprehension on RAPID-RC and only decoding on RISE-RC.

One explanation for these findings may lie in the format of the questions. On WJ-PC, the examinee must provide the word(s) to fill in the blank in each item; no options are given. In contrast, RISE-RC and RAPID-RC are multiple choice tests. Past research on comprehension tests, including the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993) and the Gray
Figure 2.13. Quantile regression plot for the relation between decoding and RAPID Reading Comprehension after controlling for oral vocabulary, fluency, listening comprehension, background knowledge, and inference. Error bars indicate 95% confidence intervals.

Figure 2.14. Quantile regression plot for the relation between oral vocabulary and RAPID Reading Comprehension after controlling for decoding, fluency, listening comprehension, background knowledge, and inference. Error bars indicate 95% confidence intervals.
Figure 2.15. Quantile regression plot for the relation between fluency and RAPID Reading Comprehension after controlling for decoding, oral vocabulary, listening comprehension, background knowledge, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.16. Quantile regression plot for the relation between listening comprehension and RAPID Reading Comprehension after controlling for decoding, oral vocabulary, fluency, background knowledge, and inference. Errors bar indicate 95% confidence intervals.
Figure 2.17. Quantile regression plot for the relation between background knowledge and RAPID Reading Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and inference. Errors bar indicate 95% confidence intervals.

Figure 2.18. Quantile regression plot for the relation between inference and RAPID Reading Comprehension after controlling for decoding, oral vocabulary, fluency, listening comprehension, and background knowledge. Errors bar indicate 95% confidence intervals.
Oral Reading Test (Wiederholt & Bryant, 1992), suggests that examinees who are administered the multiple-choice questions without reading the corresponding passages have a success rate that is well above chance (Coleman et al., 2010; Katz et al., 1990; Keenan & Betjemann, 2006). It is conceivable that at least some of the correct answers on RISE-RC and RAPID-RC can be attributed to informed guesses, and that decoding skills may be sufficient to select the best answer choice using the process of elimination.

Despite these differential findings, the models for all three reading comprehension tests emphasize the importance of decoding to struggling adult readers. Decoding was the strongest predictor of success across tests regardless of administration mode and question format, which emphasizes the similarities between the adults in this study and children at the same reading levels. The mean decoding performance was between the second and fifth grade levels (see Table 2.2), and decoding influenced comprehension performance more than higher-level competencies, similar to trends observed in elementary school (Hoover & Gough, 1990; Lonigan et al., 2018). Oral language and reasoning skills increase in importance only for more proficient readers (Cain, 2016).

**Differential Effects across Proficiency Levels**

A novel feature of the study design was the evaluation of predictors at low, average, and high levels of the reading comprehension performance of struggling adult readers. It should be noted that these proficiency labels are relative to this particular sample; overall, all of these adults would be classified as having reading difficulties. Although quantile regression has been utilized in service of this broad question in a handful of prior studies with children (e.g., Cho et al., 2017; Hua & Keenan, 2017; LARRC & Logan, 2017), most researchers have not applied this
approach to the adult literacy context, with the notable exception of Tighe and colleagues (Tighe & Schatschneider, 2016; Tighe & Fernandes, 2019).

As indicated in Tables 2.7, 2.8, and 2.9, variance in reading comprehension was best explained at high levels of performance across tests. Such a trend has not been reported in child research and may be a characteristic of the adult sample in the current study. The weakest among these struggling readers would be expected to have deficits in basic literacy skills and knowledge domains (Greenberg, Ehri, & Perin, 1997; Strucker & Davidson, 2003; Thompkins & Binder, 2003), which would diminish the contributions of these abilities to comprehension performance. Conversely, the relatively stronger readers would be expected to have advanced text and language skills that are highly integrated and can work in concert to construct a cohesive mental representation (Scarborough, 2001).

The quantile regression models in the current study show that the significant unique effects of four predictors were not stable across different levels of reading comprehension proficiency (see Table 2.6). First, the effect of oral vocabulary decreased between average and high levels of WJ-PC performance (see Figure 2.2). This declining importance of oral vocabulary echoes a trend observed by Ahmed et al. (2016) in their investigation of the DIME model with adolescent readers in seventh through twelfth grades: as grade level increased in their sample, oral vocabulary exhibited a gradually smaller effect on reading comprehension. This is not surprising, because proficient readers are adept at activating and integrating word meanings in text processing (Perfetti & Stafura, 2014), which would be expected to reduce the influence of word-level semantic representations on comprehension.

Second, the effect of background knowledge increased between low and high levels of WJ-PC performance (see Figure 2.5). In fact, background knowledge was a significant predictor
only at the .90 quantile of reading comprehension. This adds valuable nuance to past work with struggling adult readers reporting that background knowledge makes a unique contribution to WJ-PC scores (Talwar et al., 2018); this effect appears to exist only for relatively stronger comprehenders. As described by the CI framework, the textbase activates relevant knowledge stored in the reader’s long-term memory, which deepens the understanding of the text content (Kintsch, 1998). Poor readers tend to have gaps in the knowledge domains that are generally covered in formal education (Strucker, 2013) and may be less likely to connect their prior knowledge to what they are reading.

Third, the effect of decoding consistently increased across low, average, and high levels of RAPID-RC performance (see Figure 2.13). This trend was not observed for WJ-PC and RISE-RC, on which decoding emerged as a stable predictor of reading comprehension across proficiency levels. It can be argued that the adaptive algorithm of the RAPID amplifies the influence of decoding skills on comprehension performance, since the starting passage administered to each examinee on this assessment is determined by the examinee’s performance on the other subtests of the RAPID, one of which measures word recognition.

Finally, the effect of listening comprehension increased between low and high levels of RAPID-RC performance (see Figure 2.16). This finding reflects a trend uncovered in cross-sectional research with children and adolescents. As readers’ proficiency level increases, their oral language competence makes larger contributions to reading comprehension variance (Lonigan et al., 2018; Tilstra, McMaster, Van den Broek, Kendeou, & Rapp, 2009; Vellutino, Tunmer, Jaccard, & Chen, 2007). Since listening comprehension was a significant predictor of reading comprehension only at the .90 quantile, it can be concluded that the adaptive algorithm did not unduly inflate this relationship.
Implications for Adult Literacy Assessment and Instruction

Findings from the current study indicate that different reading comprehension assessments do not appear to target the same underlying construct for struggling adult readers. This pattern has also been observed with other tests, including those that are commonly administered in Adult Basic Education programs (Mellard et al., 2015; Tighe et al., 2017). Although such work is recent in the adult literacy context, these findings have been reported with child samples for at least two decades (Cutting & Scarborough, 2006; Keenan et al., 2008; Nation & Snowling, 1997). The biases of reading comprehension tests should be considered when evaluating adults for educational progress or research purposes. Additionally, it may be prudent to practice caution when interpreting reading performance on computerized tests until more is known about how such tests function for this population.

The findings also provide preliminary evidence for delivering more targeted instruction in adult literacy programs. Instruction in both vocabulary and background knowledge has yielded gains in reading skills for children and adolescents (e.g., Dole et al., 1991; Scammacca, Roberts, Vaughn, & Stuebing, 2015), yet the quantile regression results suggest that focusing on both areas may not be appropriate for all adult learners. Vocabulary instruction may be most beneficial for lower-level readers and can be interwoven with lessons on parsing new words and using contextual clues to guess word meanings (Bromley, 2007). Higher-skilled readers may find it more useful to receive instruction in general and academic knowledge, which can improve their comprehension of academic texts (Ozuru et al., 2009) and better equip them for high school equivalency tests (Strucker, 2013).
Limitations and Future Research

A caveat commonly noted in research with struggling adult readers is the heterogeneity of this population. It is very likely that the results reported in the current study are only applicable to adults who are native speakers of English and read between the third and eighth grade levels. Future research should explore the predictors of reading comprehension across different assessments and proficiency levels with adults who are more skilled and who do not speak English as a native language. Some limited evidence suggests that the explanatory effects of certain competencies will be different for such samples (Herman et al., 2013; To et al., 2016).

In addition to this general limitation, it should be noted that the design of the current study was shaped by the data available from the larger CSAL project. The data analyzed here were collected a single time point and only one measure was available for most constructs. Thus, any inferences about important predictors of reading comprehension are based on correlations among observed variables. These measures were largely from the WJ III Normative Update battery of subtests, which may have inflated their associations with WJ-PC scores. Another concern is that some of the measures were not normed on adults over the age of 21 years, which can be problematic because child-normed tests do not function appropriately for adult samples (Greenberg et al., 2009; Nanda, Greenberg, & Morris, 2014; Pae, Greenberg, & Williams, 2012). It would be valuable to see the current study’s models replicated with measures that are psychometrically appropriate for adults or with constructs that are modeled as latent factors, which would address measurement error to a great degree.

An important future direction that arises from the current findings is about computerized testing of reading comprehension with struggling adult readers. Although the results showed that responses to questions about computer experience were not related to performance on RAPID-
RC and RISE-RC, it is possible that participants’ self-reports of computer experience were not accurate. This potential relationship between computer familiarity and test performance should be probed in the future with behavioral measures of computer skills, such as the Northstar Digital Literacy Assessments (Minnesota Literacy Council, 2018). Additionally, it would be valuable to investigate whether adaptive tests like the RAPID function appropriately for this population in terms of item difficulty and progression rules. Greenberg and colleagues found that when struggling adult readers were administered comprehension passages that were arranged from low to high difficulty level based on child norms, about half of the sample performed worse on a lower-difficulty passage than a higher-difficulty passage (Greenberg, Pae, Morris, Calhoon, & Nanda, 2009). Finally, eye-movement tracking technology can be used to obtain a moment-to-moment record of struggling adult readers’ behavior during a computerized administration of a text passage (Barnes et al., 2017). Perhaps when faced with a passage on a screen, some low-skilled adults engage in mindless reading, similar to children with reading difficulties (Nguyen, Binder, Nemier, & Ardoin, 2014).
References


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