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Impact of Text Complexity Effects across Student Reading Skills

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ABSTRACT

IMPACT OF TEXT COMPLEXITY EFFECTS ACROSS STUDENT READING SKILLS

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A reader's ability to go beyond their surface-level understanding of words and to build a deeper representation of the text in their mind (i.e., reading comprehension) is predicated on a range of reader- and text-level variables that indicate how well a certain reader can read a certain text. The following study evaluates the extent to which the interaction between the reader characteristics of 50 first graders (e.g., decoding and oral reading fluency skill and demographic characteristics) and the textual characteristics of commonly administered, first-grade oral reading fluency passages (e.g., text complexity) may impact the participants' reading comprehension of the oral reading fluency passages. It was hypothesized that accounting for superfluous variation in text complexity of oral reading fluency passages (i.e., text complexity effects) would recalibrate participants' oral reading fluency scores, allowing for more valid interpretations of student reading skill. Results were mixed and indicated limitations with the study's comprehension recall measure. Conclusions underlined the importance of including basic reading measures such as decodable and sight word fluency, particularly for students with low oral reading fluency skills.

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IMPACT OF TEXT COMPLEXITY EFFECTS ACROSS STUDENT READING SKILLS

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CHAPTER I

INTRODUCTION

The Simple View of Reading states that the complex processes involved in reading comprehension can be separated into two sets of skills: decoding and linguistic comprehension (Gough & Tunmer, 1986). Specifically, a reader's ability to understand what they have just read is a product of a set of cognitive processes necessary to sound out (i.e., decoding) or otherwise instantly recognize printed words (i.e., word recognition) and a set of cognitive processes necessary to make meaning of oral language (i.e., linguistic comprehension). Consequently, a reader's ability to go beyond their surface-level understanding of the text's words and to integrate the text base with their own knowledge base along with other cognitive processes help build what Kintsch (1998) refers to as a situation model–essentially a deeper and fuller representation of the text in the reader's mind (i.e., reading comprehension). This assumption has been tested and validated by multiple studies that have found that individual differences in reading comprehension can be wholly explained by the word recognition and linguistic comprehension skill sets (Hjetland et al., 2019; Kendeou et al., 2009; Lervåg et al., 2018).

Following this line of reasoning, the Simple View of Reading also presupposes that readers who have deficits in decoding/word recognition skills (hereby referred to as word reading skills) and/or linguistic comprehension skills may have difficulties with reading comprehension (Hoover & Gough, 1990). This assumption has been supported by research that has demonstrated that there is a negative relation between word reading and linguistic comprehension skills in less skilled readers (Catts et al., 2006). It is also widely recognized that the relations between word reading skills, linguistic comprehension skills, and reading comprehension skills change over time (Nation, 2019). Specifically, the relation between word reading skills and reading comprehension skills is strongest in early readers who are learning to access the printed word (Catts et al., 2006; Schatschneider et al., 2004) and weakest among readers who are master decoders (Adlof et al., 2006; Kim, 2015; Kim & Wagner, 2015; LARRC, 2015).

Oral reading fluency of connected text is another reading skill that has received relatively less attention in the Simple View literature but is heavily relied upon in practice to assess reading skill. Oral reading fluency is the ability to read connected texts quickly, accurately, and/or with expression and has been consistently found to be a reliable measure of reading comprehension (Fuchs et al., 2001) and other general outcome measures of reading skills (Christ et al., 2018). Oral reading fluency passages are quick and easy to administer and are increasingly widely used in schools, not only as a measure to screen, monitor progress, and inform interventions for students with reading difficulties but also as a source of data for high-stakes decisions such as determining eligibility for special education services (Ardoin et al., 2013). Strong but distinct connections have been found between word reading and oral reading fluency measures as early readers simultaneously learn to read words accurately and quickly (Schwanenflugel et al., 2006).

CHAPTER II

REVIEW OF THE LITERATURE

Word Reading

Word reading is a set of skills that has been assessed through measures of phonological awareness, letter identification, phonological decoding accuracy/fluency, and/or orthographic word recognition accuracy/fluency (e.g., Kim, 2015; LARRC, 2015). Cummings et al. (2011) specifically studied word reading as a measure of alphabetic principle, or the ability to make connections between individual sounds in spoken words and between individual letters in written words, using a decodable word fluency measure. They found that the decodable word fluency skill of a sample of 3,150 first-grade students at the beginning of the school year predicted their oral reading fluency skill at the end of the school year. Using a small sample of 66 first-grade students from the larger participant group, Cummings et al. (2011) further concluded that being able to accurately recognize words as a whole, rather than using lower level decoding skills like sounding (/t/ /e/ /b/) and blending (/t/ /e/ /b/ /teb/), most closely related to later oral reading fluency outcomes. These findings align with Ehri's (2005) theory of sight word development, whereby readers first learn to decode unfamiliar words using the alphabetic principle while they then begin building a mental bank of words that they can recognize by sight (i.e., sight words). In fact, sight word fluency skill may mediate an early reader's decodable word fluency skill and oral reading fluency skill (Wise et al., 2010).

Oral Reading Fluency

Furthermore, oral reading fluency–the ability to read connected texts accurately, quickly, and/or with expression–has been consistently found to be a reliable measure of reading comprehension (Fuchs et al., 2001). In particular, readers who are able to read connected texts fluently demonstrate better reading comprehension (Pressley et al., 2006). In contrast, those who read slowly, inaccurately, and with less expression spend more time and cognitive effort on decoding individual words and consequently show impaired comprehension (e.g., Logan, 1997; Meisinger et al., 2010; Perfetti, 1985). However, relatively few studies have investigated the role of oral reading fluency within the Simple View model of reading development and the research that does exist has produced mixed results. For example, some studies have found that fluency did not independently predict reading comprehension beyond word reading skill (Adlof et al., 2006; Schwanenflugel et al., 2006), but others reported that fluency did mediate the relation between word reading and reading comprehension (Kim & Wagner, 2015; Silverman et al., 2013). Kim et al. (2011) further noted that word reading fluency as measured as sight word fluency may be a better predictor of oral reading fluency and reading comprehension for readers with lower sight word reading skills, whereas listening comprehension may be a more important predictor for readers with higher sight word reading skills. This makes sense within the developmental trajectory of reading development wherein oral reading fluency first develops from the ability to read individual words fluently and, as this word reading skill improves, is more and more influenced by meaning-related processes necessary to understand words in the context of connected texts (i.e., linguistic comprehension; Kim & Wagner, 2015).

Wise et al. (2010) studied relations between decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension measures in two sample subsets including 146 second-grade students who exhibited difficulties with both decoding and fluency and 949 second-grade students who demonstrated proficient decoding skills but difficulties with oral reading fluency. Based on prior research, Wise et al. (2010) proposed that decodable word fluency acted as both an antecedent and moderator to comprehension skills and that sight word fluency acted as a mediator between decodable word fluency and oral reading fluency skills. Study results indicated decodable word fluency was strongly related to sight word fluency and reading comprehension, sight word fluency strongly related to oral reading fluency, and oral reading fluency not significantly related to reading comprehension for the study participants who exhibited both decoding and oral reading fluency difficulties. In contrast, decodable word fluency was moderately related to oral reading fluency, decodable fluency strongly related to sight word fluency, and sight word fluency strongly related to oral reading fluency for study participants who showed difficulties with just fluency. For both subsamples, sight word fluency was the strongest predictor of reading comprehension.

Wise et al.'s (2010) findings are especially meaningful in light of the fact that they used measures that are commonly used in schools for benchmarking and monitoring progress as well as for a population of students with whom these measures may be more frequently used. However, interpretations of their findings may also be limited by two important factors. First, because Wise et al. (2010) dichotomized decodable word fluency skill, their results do not tell us at what *level* of decodable word fluency skill the relations between sight word fluency, oral reading fluency, and comprehension skills change. Specifically, it remains unknown how much decodable word fluency proficiency is required in order for sight word fluency to be significantly related to oral reading fluency skills. Second, Wise et al. (2010) did not account for text complexity effects within their oral reading fluency measure, which is a well-known source of error that can artificially inflate/depress oral reading fluency scores (e.g., Albano & Rodriguez, 2012; Poncy et al., 2005).

Textual Considerations

Interactions Between Student and Textual Characteristics

Text complexity effects must be considered when studying oral reading fluency and reading comprehension performance because a student's skill is determined in the context of the complexity of any given passage text they are asked to read aloud (Francis et al., 2018). The complexity of any passage text is based on a myriad of variables at the word, sentence, and passage levels (Mesmer et al., 2012). For example, text complexity at the word level may be operationalized according to a word's length, decodability, frequency, concreteness, and age of acquisition (e.g. Hiebert et al., 2020), whereas text complexity at the sentence or syntax level has been studied according to its length, grammatical indices, degree of repetition, and patterning among letters, words, and phrases or clauses (Barth et al., 2014). Passage-level indicators such as length, genre, and level of cohesion have more recently emerged as important indicators of text complexity. These factors influence overall passage difficulty level, which has ultimately been found to be the most significant predictor of text complexity (Barth et al., 2014).

Because student skill is always interacting with passage complexity, it cannot be said that a student is either fluent or not fluent or a passage is difficult or not difficult (Hudson et al., 2008). In fact, prior research has documented specific significant interactions between student and textual characteristics that are important to consider when examining variance in oral reading fluency and reading comprehension performance. For instance, students with poor word reading skill have been found to perform better on oral reading fluency passages consisting of words that are shorter, more frequent, more decodable, and known by the student for a longer time (Hiebert et al., 2020), in addition to words that are easier to mentally picture (Coltheart et al., 1988; Hiebert et al., 2019). These students are also more likely to read more quickly and accurately in response to specific discourse-level features including narrative as opposed to expository passage texts (Currie et al., 2021) and texts that contain more repeated words and phrases across sentences that help readers make connections when reading the passage texts (Reed & Kershaw-Herrera, 2016; Tortorelli, 2020). Furthermore, these cohesive ties are particularly important for struggling readers who lack the background knowledge necessary to make inferences when explicit cohesive cues are not present in the text to connect ideas and sentences (McNamara & Kintsch, 1996). In contrast, low cohesion is beneficial for readers with high prior knowledge since they are forced to make inferences based on the information in the text, which facilitates reading comprehension.

Text Complexity Effects

Extraneous interactions between textual and student characteristics may be especially apparent in oral reading fluency passages that are commonly used in schools to screen for student reading difficulties and to monitor student reading progress. Oral reading fluency passages are usually created as a standardized set of 20 individually administered passages that are assumed to have the same complexity level–a necessary assumption for screening and progress-monitoring procedures in which student reading progress is measured by how well they are able to fluently read passages from the same grade level set over time. Recent research, however, suggests that passages from the same grade level set do not demonstrate the same complexity of text; resultant oral reading fluency scores may exemplify *text complexity effects* or error variance that is unrelated to a student's reading proficiency due to unwanted differences in text difficulty levels (Albano & Rodriguez, 2012; Cummings et al., 2013; O'Keeffe et al., 2017).

Specifically, 10-11% of the variance in oral reading fluency scores has been estimated to be attributed to variability in passage text complexity (Chaparro et al., 2018; Poncy et al., 2005). Consequently, text complexity effects impact both screening (Francis et al., 2008; Poncy et al., 2005) and progress-monitoring (Ardoin & Christ, 2009; Francis et al., 2008) assessments and can therefore undermine the validity of any educational decisions made based on words read correct (Albano & Rodriguez, 2012). This means that two students with the same latent reading proficiency who are administered oral reading fluency passages with varying passage text complexity may achieve different scores simply because one student was administered a relatively less or more complex passage than the other student. This has been demonstrated to result in scores that can vary by as much as 19 to 36 words read correct across same grade-level passages (Betts et al., 2009; Chaparro et al., 2018; Cummings et al., 2013).

Furthermore, the degree to which text complexity effects can impact reading assessment may be exacerbated by student demographic characteristics. For example, students from certain backgrounds (e.g., Caucasian, high income, English proficient, general education) demonstrate significantly higher oral reading fluency scores as well as significantly greater growth and rates of growth throughout a school year (Logan, 1997; Paleologos & Brabham, 2011; van Dijk, 2018). On the other hand, students with certain ethnic minority, low income, bilingual, and special education backgrounds may show less developed reading skills that are more likely to interact with textual characteristics. One explanation for these differences in reading outcomes may be found in the inequitable access to opportunities in the home environment, including adult speech, book reading, and out-of-school experiences rich in literacy (Phillips, 2011). These opportunities enhance certain children's word reading and oral language skills, which in turn increase their degree of school readiness and academic achievement, whereas the absence of these opportunities disadvantage others who may start and fall further behind in their reading performance (McNamara et al., 2005).

The Present Study

The purpose of the present study was to build on prior research that has evidenced decodable word and sight word reading as important measures of word reading skill and predictors of reading comprehension skill alongside oral reading fluency with a sample of first-grade students. First grade is an important period to examine these skills, in particular, as students are mastering their word reading skills and simultaneously developing their ability to accurately and quickly read and understand words in the context of connected text (Schwanenflugel et al., 2006). Reading assessment is also critical during this time as gaps in reading performance between "successful" and "struggling" readers are already evident at the beginning of first grade and have been demonstrated to persist through high school in the absence of effective intervention (Ferrer et al., 2015). The present study intended to replicate Wise et al.'s (2010) conceptual model (Figure 1) to examine the role of decodable word fluency as both an antecedent to reading comprehension skill and a moderator between sight word fluency and oral reading fluency. Additionally, the study addressed the limitations in Wise et al.'s study by examining these reading skills as continuous variables and accounting for text complexity effects that may have impacted oral reading fluency scores. These reading skills were assessed using FastBridge measures of word reading, fluency, and comprehension skills, which are commercially available and commonly used in schools as universal screening and progress-monitoring tools.

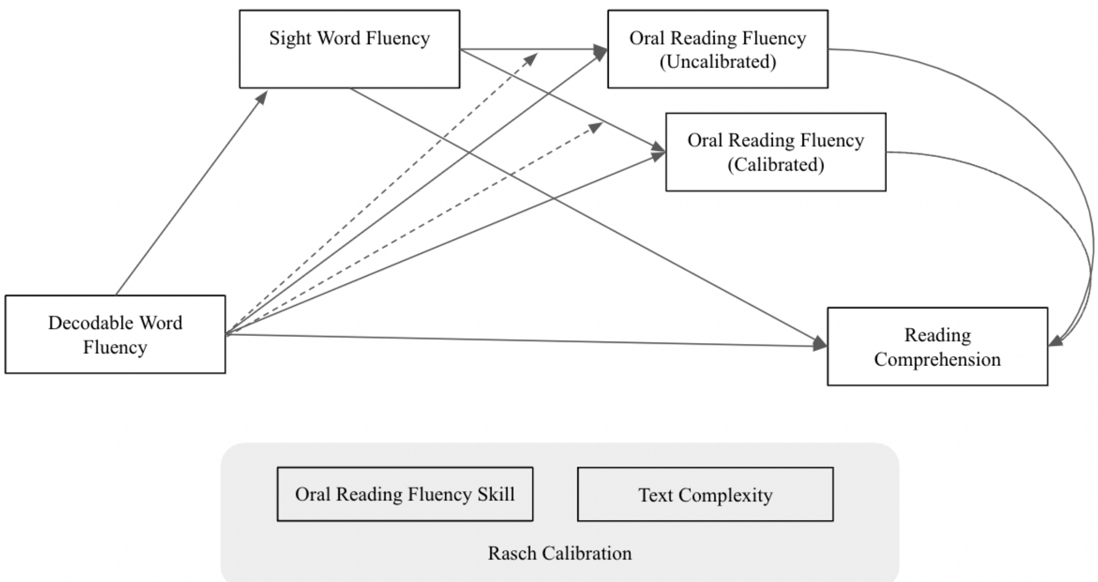

Figure 1: Modified version of Wise et al.'s (2010) theoretical model.

Research Questions

Specifically, the following research questions were addressed: (1) Do sight word fluency and oral reading fluency serially mediate the relation between decodable word fluency and reading comprehension? (2) Does decodable word fluency moderate the relation between sight word fluency and oral reading fluency? (3) Does accounting for text complexity effects in oral reading fluency scores change the strength or direction of the associations between decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension? (4) Does accounting for text complexity effects in oral reading fluency scores reduce differences in oral reading fluency performance across demographic subgroups (i.e., sex, race, free or reduced lunch status, and reading intervention tier)?

Research Predictions

(1) Do sight word fluency and oral reading fluency serially mediate the relation between decodable word fluency and reading comprehension (as depicted in Figure 1)?

Evidence for Ehri's (2005) theory of sight word development suggests that readers first learn to decode unfamiliar words using letter-sound relationships, accurately read words as a whole, accrue a mental bank that they can recognize instantly, and then read and understand these words in context of connected texts (e.g., Cummings et al., 2011). Therefore, the present study expected to find a significant serial mediation effect across decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension.

(2) Does decodable word fluency moderate the relation between sight word fluency and oral reading fluency?

Wise et al. (2010) consistently found that decodable word fluency was most strongly related to sight word fluency and sight word fluency to reading comprehension across two sample subsets of second-grade students who showed both word reading and fluency difficulties and those who showed just fluency difficulties. This finding aligns with prior studies which demonstrated that oral reading fluency may mediate the relation between word reading and reading comprehension skills once students have reached a certain level of word reading skill (Kim & Wagner, 2015; Silverman et al., 2013). Therefore, the present study hypothesized that the relation between sight word fluency and oral reading fluency will be significant at higher levels of decodable word fluency skill and that the relation between sight word fluency and oral reading fluency will be weaker at lower levels of decodable word fluency skill.

(3) Does accounting for text complexity effects in oral reading fluency scores change the strength or direction of the associations between decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension?

Text complexity effects may significantly increase or decrease oral reading fluency scores (e.g., Hiebert et al., 2020). As a result, the present study predicted that using oral reading fluency scores that have been calibrated to account for passage text difficulty level may significantly strengthen the mediation of oral reading fluency between decodable and sight word fluency and reading comprehension.

(4) Does accounting for text complexity effects in oral reading fluency scores reduce differences in oral reading fluency performance across demographic subgroups (i.e., sex, race, free or reduced lunch status, and reading intervention tier)?

Students from certain demographic subgroups (i.e., Caucasian, high income, English proficient, general education) have been demonstrated to have significantly higher oral reading fluency scores as well as significantly greater growth and rates of growth throughout a school year (Logan, 1997; Paleologos & Brabham, 2011; van Dijk, 2018). These differences may reflect differential access to opportunities in the home environment that enhance certain children's reading skills. Calibrating oral reading fluency scores to account for passage text difficulty is expected to reduce these differences by accounting for text complexity effects that have been demonstrated to significantly impact children's reading performance.

CHAPTER III

METHODOLOGY

Participants

Participants included a sample of 50 students (44% male) enrolled in first grade at one of two schools located within a suburban midwestern school district. Participant demographic information was collected from existing school records and indicated that 58% of participating students were White, 20% Black, 10% multiracial, and 12% Hispanic. Approximately 72% of students received free or reduced price lunch and 30% of students were receiving Tier 2 (20%) or Tier 3 (10%) reading intervention support at the time that study data were collected. The study sample included relatively more students identifying as White and less as Hispanic; otherwise, participant demographics closely aligned with the overall demographic makeup of the school district.

Procedures

Data on study participants' decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension skills were collected from three elementary classrooms in a school district in the midwestern region of the U.S. following university Institutional Review Board approval. Data collection occurred in the spring of 2022 when schools in the district were scheduled to collect spring benchmarking data. Data on decodable word fluency and sight word fluency were collected from existing school records via standard benchmarking procedures; oral reading fluency and reading comprehension measures were administered by research personnel. In accordance with current applied practices, three oral reading fluency passages were administered to each student consisting of: a) two passages from a set of 20 that were identified as the most and least complex based on the Coh-Metrix measure of text complexity (Graesser et al., 2014) and b) a randomly selected third passage out of the “middle” eight passages in the text complexity distribution (Figure 2). Administration order was randomized to address potential order effects (Cummings et al., 2013; Francis et al., 2008).

	Most Complex	Least Complex	Random Middle	Random Middle	Random Middle	Random Middle	Random Middle	Random Middle	Random Middle	Random Middle
1	X	X	X							
2	X	X		X						
3	X	X			X					
4	X	X				X				
5	X	X					X			
…										
100	X	X								X

Figure 2: Proposed study data collection design.

All measures were administered to participants in one sitting by trained administrators. Administrators consisted of graduate students in psychology and school personnel at the study site. University student administrators were trained within one week of data collection through a process of instruction, modeling, role play, and feedback on standardized administration and scoring procedures. In addition, university student administrators completed mock administrations until they achieved 100% procedural fidelity. School personnel were trained according to district-wide procedures. Once collected, data were entered into a computer database for later analyses.

Measures

Antecedent Variables

Decodable Word Fluency

Study participants were administered the FAST Decodable Words subtest as part of existing school benchmarking procedures. The FAST Decodable Words subtest was designed to assess how many phonetically regular, real words students could decode in one minute (Christ & Colleagues, 2018). The subtest is aligned with the 2010 Common Core State Standards for Reading RF.2.3 and RF.3.3 within the Alphabetic Principle (Phonic) area of reading. Additionally, criterion-related validity of Decodable Words and other FAST earlyReading subtests was examined using the Group Reading Assessment Classification Evaluation (GRADE). Resultant concurrent and predictive validity coefficients for Decodable Words ranged from .22 to .78. Evidence was also reported for internal consistency reliability (.76-.98), short-term stability across a two- to three-week interval (.97), inter-rater reliability (.99), and alternate form reliability (.97-.98). No significant results were found as a result of ANOVA tests with five randomly selected alternate forms of the subtest.

Sight Word Fluency

Student participants were also administered the FAST Sight Words-150 subtest as part of existing school benchmarking procedures. The FAST Sight Words-150 subtest was designed to assess how many real words from a list of the 150 most high-frequency English words students could instantly recognize in one minute (Christ & Colleagues, 2018). It was distinguishable from the previous subtest in that students were expected to recognize the high-frequency words with automaticity rather than decoding strategies. The subtest is aligned with the 2010 Common Core State Standards for Reading RF.K.3.c, RF.1.3.g, R.2.3.f, and RF.3.3.d within the Fluency area of reading. Concurrent and predictive validity with the GRADE ranged from .43 to .80. Evidence was also reported for internal consistency reliability (.90-.99), short-term stability across a two- to three-week interval (.94), inter-rater reliability (.97), and alternate form reliability (.91-.96). ANOVA tests with five randomly selected alternate forms of the Sight Words-150 subtest were not significant.

Oral Reading Fluency

The word reading measures were then followed by oral reading fluency passages from the FAST CBMreading measure designed to assess fluency of connected texts (Christ & Colleagues, 2018). FAST CBMreading passages were developed based on a narrative text type; parallel text structure; the exclusion of biased language, technical words, and dialogue; and varied levels of cohesive cues across passages. Passages were also written according to three form levels with Level A indicating Grade 1 passages, Level B indicating Grades 2-3 passages, and Level C indicating Grades 4-6 passages. They were further organized into sets of either three screening forms and a set of 20 progress-monitoring forms for each grade. Resultant scores consisted of words read correctly, errors, and total words read. The number of words read correctly per minute (WRCPM) could be used to compare with FAST CBMreading benchmark and normative scores.

All CBMreading passage sets were aligned with the 2010 Common Core Standards within the subcategories of Print Concepts, Phonological Awareness, Phonics and Word Recognition, and Fluency, providing evidence of content-related validity. Concurrent and predictive correlations between the FAST CBMreading and the Test of Silent Reading Efficiency and Comprehension (TOSREC), Measures of Academic Progress (MAP), AIMSweb, and DIBELS Next range from .66 to .97 and from .47 to .94, respectively. Furthermore, internal consistency across passages ranged from .90 to .92 and inter-rater reliability from .97 to .98. Alternate-form reliability ranged from .62 to .88, with the widest range found for Level A (i.e., Grade 1) passages.

Additional information was provided for the use of CBMreading passages as both a screening and a progress-monitoring tool. Specifically, first-grade screening CBMreading passages demonstrated classification accuracy using the TOSREC (.71 in relation to the 20th and 30th percentiles) and the MAP (.74 to .76 in relation to the 20th benchmark percentile and .71 to .76 in relation to the 30th benchmark percentile). Furthermore, first-grade progress-monitoring CBMreading passages in Level A demonstrated slope reliability when measured across 27 to 30 weeks (.95) and across 7 to 10 weeks (.78). Reliability of the slope based on Spearman-Brown split half correlation for Level A passages was also investigated across 10 weeks (.71) and across 14 to 30 weeks (.95). Finally, validity of slopes for Level A CBMreading passages was examined using AIMSweb (ranging from .96 to .98), DIBELS Next (ranging from .76 to .89), MAP (ranging from .03 to .21), and TOSREC (ranging from .43 to .58) measures.

Two types of oral reading fluency scores were computed: raw and Rasch-adjusted scores. Raw scores were the average raw score of all three oral reading fluency passages administered to each participant. Rasch-adjusted scores were statistically derived using a two-facet Rasch model that calibrates raw scores to account for passage text difficulty level using the Winsteps computer program (Linacre, 2020). The Rasch model is unique from other traditional methods of score calibration in that it simultaneously measures multiple facets (e.g., student oral reading fluency proficiency, passage text difficulty). As a result, it provides facet scores that are on the same scale (i.e., logits) and can be directly compared with each other.

Outcome Variable

Comprehension Recall

Prior studies have documented concerns regarding the content validity of commonly used standardized measures of reading comprehension (Keenan & Meenan, 2014). Less research was available on the psychometric properties of passage-specific comprehension measures, particularly for commercially available measures like the FAST. Accordingly, reading comprehension specific to the FAST CBMreading passages was collected using the CBMreading Comprehension Recall measure following each oral reading fluency passage. Based on this timed-recall task, participants were scored on how many details they could recall and synthesize in one minute immediately after reading an oral reading fluency passage. Specific instructions directed students to recall the "important parts" of the passage. Depending on their decoding and linguistic comprehension skills, this required each participant to create a situation model that they then used to verbally produce details that they had deemed important after reading the passage (Kintsch, 1998). A total of three oral reading fluency passages and three comprehension recall measures were administered to each participant. Psychometric information for the FAST CBMreading passage subtest was not available from the publisher.

Analyses

The direct and indirect effects of decodable word fluency on comprehension recall were estimated using a conditional process model with both serial and parallel mediation components in order to answer the first research question. Within this model, decodable word fluency affected comprehension recall through three simple indirect effects (i.e., mediated by Sight Words-150, CBMreading raw, and CBMreading Rasch-adjusted), two parallel serial indirect effects (i.e., mediated by Sight Words-150 and CBMreading raw in serial and mediated through Sight Words-150 and CBMreading Rasch-adjusted in serial), and one direct pathway (see Figure 1). In addition, the relation between sight word fluency and oral reading fluency was modeled to be conditioned on decodable word fluency as has been previously demonstrated by Wise et al. (2010).

Next, the second research question regarding the degree to which decodable word fluency moderated the relation between sight word fluency and oral reading fluency was evaluated via the significance of the interaction term (i.e., Decodable Words × Sight Word-150). If decodable word fluency was identified as a significant moderator, the moderation would be probed using the Johnson-Neyman technique (Spiller et al., 2013). In addition, a chi-square difference test was used to evaluate the degree to which passage text complexity moderates this hypothesized moderation effect.

The significance of all indirect effects of the conditional process model was determined using bootstrapped confidence intervals estimated from the percentile method (R = 10,000) and the significance of the direct effect determined using the Sobel test (Hayes, 2018). A direct comparison between the magnitude of the two parallel serial indirect effects representing the relation between decoding skills and comprehension recall through sight word fluency and oral reading fluency with and without contamination from text complexity effects (i.e., serial pathway through Sight Words-150 and CBMreading raw vs. serial pathway through Sight Words-150 and CBMreading Rasch-adjusted) was conducted with a bootstrapped chi-square difference test to address the third research question.

Finally, a series of MANOVA tests was completed to examine differences in raw and Rasch-adjusted oral reading fluency scores across demographic subgroups to answer the fourth research question. Benjamini and Hochberg's (1995) method was used to control the false discovery rate for multiple comparisons.

CHAPTER IV

RESULTS

Missing Data

Data were missing on one or more study variables in 14% of cases (n = 7) due to study discontinue rules (i.e., do not administer Comprehension Recall if the participant reads fewer than 10 words correct on any one Oral Reading Fluency passage) and/or procedural errors. Procedural errors occurred on three cases and were primarily the result of misapplication of discontinue rules (e.g., administrator discontinued administration after one Oral Reading Fluency passage instead of administering all three). However, results of Little's (1988) missing completely at random test indicated that these data were likely missing completely at random, $\chi^2(46) = 61.5$, $p = .062$, unrelated to other study variables. Casewise deletion was used to address missingness in the conditional process analysis due to the small amount of missingness resulting from administrator error (6%) and the use of the PROCESS macro, which requires complete data (Hayes, 2018).

(1) Do sight word fluency and oral reading fluency serially mediate the relation between decodable word fluency and reading comprehension?

Serial mediation analyses were conducted to determine the extent to which sight word fluency and oral reading fluency serially mediated the relation between decodable word fluency and comprehension recall. In addition, a parallel component was included in the model to evaluate whether or not text complexity effects affected these associations. Specifically, the extent to which there was evidence of serial mediation was investigated when both mean oral reading fluency scores and mean Rasch-adjusted oral reading fluency scores were inspected (see Figure 1). Results indicated that there was no significant indirect effect of decodable word fluency on comprehension recall through sight word fluency and oral reading fluency, using either raw oral reading fluency scores, $a_1d_{21}b_2 = -.04$ (95% CI: -.09, .39), or mean Rasch-adjusted oral reading fluency scores, $a_1d_{31}b_3 = .04$ (95% CI: .12, -.37). Likewise, further analyses indicated no significant indirect effect of decodable word fluency on comprehension recall through sight word fluency alone, $a_1b_1 = .03$ (95% CI: -.03, .08); oral reading fluency alone, $a_2b_2 = -.05$ (95% CI: -.09, .46); or oral reading fluency alone after accounting for text complexity effects, $a_3b_3 = .05$ (95% CI: -.46, .10). Moreover, decodable word fluency did not exert a significant direct effect on comprehension recall, $c' = -.00$ (95% CI: -.07, .06). Similar results were found when these serial mediation analyses were conducted using median oral reading fluency scores.

(2) Does decodable word fluency moderate the relation between sight word fluency and oral reading fluency?

Simple moderation analyses were also conducted to determine the degree to which the association between sight word fluency and oral reading fluency (mean raw oral reading fluency scores and mean Rasch-adjusted oral reading fluency scores) was moderated by decodable word fluency. Results indicated that decodable word fluency did not significantly moderate the sight word fluency oral reading fluency association for raw oral reading fluency scores, $F(1, 42) = 2.29$, $p = .14$. However, decodable word fluency did significantly moderate the relation between sight word fluency and oral reading fluency for mean Rasch-adjusted oral reading fluency scores, $F(1, 42) = 4.21$, $p = .05$. Moreover, this effect was positive ($b_5 = .01$), indicating that the association between sight word fluency and mean Rasch-adjusted oral fluency scores was stronger at higher levels of decodable word fluency. Conversely, the association between students' sight word lexicon and oral reading fluency, adjusted for text complexity effects, was weaker when students had lower levels of decodable word fluency skill. Further analyses using the Johnson-Neyman technique revealed that this conditional effect was significant at all levels of decodable word fluency skill except the lowest extreme score (i.e., decodable word fluency score of 1). A follow-up sensitivity analysis using median oral reading fluency scores yielded insignificant results, $F(1, 42) = 1.43$, $p = .24$.

(3) Does accounting for text complexity effects in oral reading fluency scores change the strength or direction of the associations between decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension?

Although the serial indirect effect of decodable word fluency on comprehension recall through sight word fluency and oral reading fluency was not significant, regardless of whether or not text complexity effects were accounted for in oral reading fluency scores, the degree to which these two null serial indirect effects were significantly different from one another was evaluated to determine whether text complexity effects impacted the strength or direction of these associations. Results indicated that the two serial indirect effects were not significantly different from each other, $a_1d_{21}b_2$ - $a_1d_{31}b_3$ = -.08 (95% CI: -.16, .76).

(4) Does accounting for text complexity effects in oral reading fluency scores reduce differences in oral reading fluency performance across demographic subgroups (i.e., sex, race, free and/or reduced lunch status, and reading intervention tier)?

Lastly, MANOVA analyses were conducted to investigate the degree to which differences between mean unadjusted and mean Rasch-adjusted oral reading fluency performance across demographic subgroups changed as a result of accounting for text complexity effects. It was predicted that accounting for text complexity effects would reduce the differences observed in raw mean oral reading fluency scores within each subgroup. Surprisingly, study results indicated the opposite effect. Students receiving Tier 1, 2, or 3 reading interventions, in particular, showed a significant difference in their mean oral reading fluency and Rasch-adjusted mean oral reading fluency scores, $F(2, 86) = 3.80$, $p = .007$. Based on follow-up *t* test results, these differences were most pronounced between students receiving Tier 1 and those receiving Tier 2 reading interventions. Specifically, differences between students receiving Tier 1 and 2 supports increased by five words on average, whereas differences between students receiving Tier 1 and 3 supports increased on average by four words and between students receiving Tier 2 and 3 supports increased/decreased on average by one word (Figure 3).

On the contrary, differences in unadjusted and mean Rasch-adjusted oral reading fluency scores across student sex, $F(1, 43) = .97$, $p = .39$; race, $F(3, 84) = .30$, $p = .94$; and free and/or reduced lunch status subgroups, $F(1, 43) = .20$, $p = .82$, were not significantly different from one another. However, a visual inspection of the data revealed a similar pattern in that accounting for text complexity effects *increased* differences in unadjusted and mean Rasch-adjusted oral reading fluency scores across subgroups for each demographic variable. For example, an average difference of nine words between male and female students decreased to an average difference of three words (see Figure 3), while the average difference of one word between students who did and did not receive free and/or reduced lunch increased to an average difference of two words (see Figure 3). Based on mean oral reading fluency scores, students who were identified as Hispanic performed four words on average below students who were identified as Black. After accounting for text complexity effects, however, the former were estimated to have performed ten words on average higher than the latter (see Figure 3).

These results suggest that student-level factors (e.g., background knowledge and passage interest or motivation to read) may be masked by text complexity effects. To investigate the association between Coh-Metrix and Rasch difficulty estimates, a post hoc Spearman's rank correlation analysis for the 10 oral reading fluency passages rank ordered by text complexity by Coh-Metrix and Rasch analyses was conducted. Results demonstrated that there was a nonsignificant, negative association between Coh-Metrix estimates of text complexity and Rasch estimates of passage difficulty, $\rho = -.38$, $p = .28$. Additional Spearman's rank correlation analyses were completed between Coh-Metrix component indices of text complexity (Table 1) and Rasch estimates of passage difficulty. The correlation between Coh-metrix narrativity and Rasch difficulty estimates was nonsignificant and negative, $\rho = -.22$, $p = .48$;

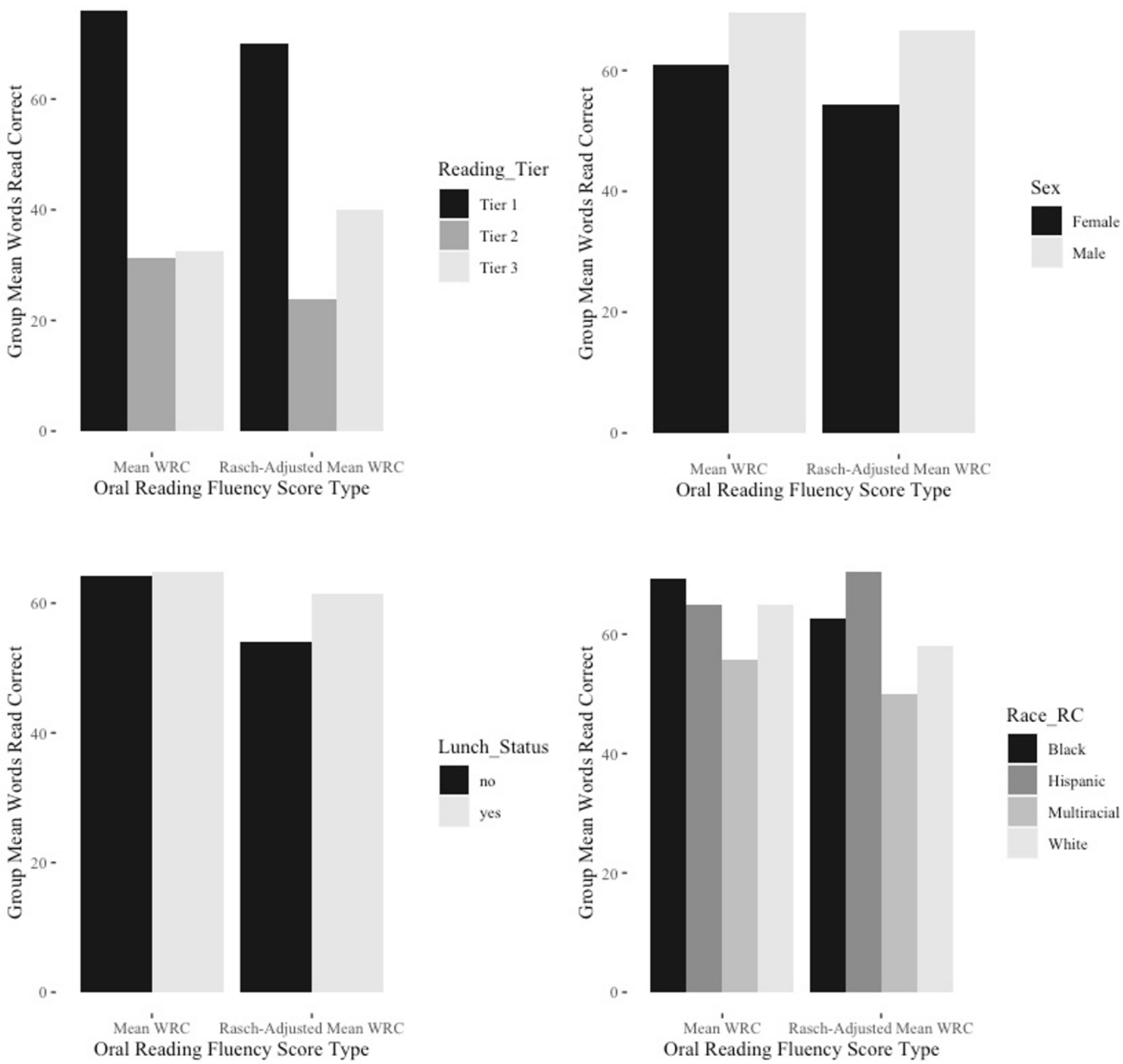

Figure 3: Oral reading fluency performance across demographic subgroups.

syntactic simplicity and Rasch difficulty nonsignificant and positive, $\rho = .25$, $p = .49$; word concreteness and Rasch difficulty nonsignificant and negative, $\rho = -.55$, $p = .10$; referential cohesion and Rasch difficulty nonsignificant and negative, $\rho = -.38$, $p = .28$; deep cohesion and Rasch difficulty nonsignificant and negative, $\rho = -.16$, $p = .65$; verb cohesion and Rasch difficulty nonsignificant and negative, $\rho = -.20$, $p = .58$; connectivity and Rasch difficulty nonsignificant and positive, $\rho = .27$, $p = .45$; and temporality and Rasch difficulty nonsignificant and positive, $\rho = .20$, $p = .58$.

Table 1.

Spearman's Rank Correlation Results Across Coh-Metrix and Rasch Difficulty Estimates

Coh-Metrix Index	Passage 6	Passage 8	Passage 13	Passage 3	Passage 5	Passage 11	Passage 4	Passage 14	Passage 2	Passage 16
Narrativity	1.476	2.598	1.834	1.389	1.368	2.593	1.647	.202	.386	1.884
Syntactic Simplicity	2.858	3.043	3.001	2.493	3.299	2.676	3.212	2.277	2.431	2.297
Word Concreteness	-.395	-1.28	-1.265	-.76	-1.407	-1.601	-.862	-.691	.298	.046
Referential Cohesion	.156	1.711	.639	.245	.653	.963	-.46	-.315	.815	1.153
Deep Cohesion	-1.49	.781	-.003	-1.07	-.503	.638	-.542	-0.5	.729	.167
Verb Cohesion	.705	1.769	1.222	2.209	.403	.766	.652	4.177	2.553	1.447
Connectivity	-.573	-1.468	1.305	-1.627	-1.648	1.233	-1.599	-.215	-.273	-.586
Temporality	-.245	-1.029	1.441	.003	.935	.785	-1.339	-.463	.402	.693
Readability (i.e., Text Complexity)	32.569	53.969	41.067	42.539	42.774	42.784	43.366	43.879	44.315	44.576
Rasch Difficulty	.12	.11	.42	-.18	.58	.19	-.08	.75	-.34	-1.56

CHAPTER V

DISCUSSION

The purpose of the present study was to examine the role of decodable word fluency as a focal antecedent and moderator of the association between sight word fluency and oral reading fluency in the prediction of reading comprehension (as measured by comprehension recall), a more advanced reading skill, in a sample of first-grade students. The study replicated Wise et al.'s (2010) conceptual model (see Figure 1) and extended it in a number of ways. First, decodable word fluency was treated as a continuous variable so that moderation (if detected) could be appropriately probed to discover at what level of decodable word fluency there was a significant association between sight word fluency and oral reading fluency. Second, the impact of text complexity effects on oral reading fluency scores was investigated by comparing the associations between decodable word fluency, sight word fluency, oral reading fluency, and comprehension recall skills with and without adjusting oral reading fluency scores to account for form difficulty. Present study results are discussed in response to the research questions below.

(1) Do sight word fluency and oral reading fluency serially mediate the relation between decodable word fluency and reading comprehension?

Based on Ehri's (2005) theory of sight word development, it was hypothesized that there would be a significant serial mediation effect across decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension. Study results did not support this hypothesis and instead suggested that there was no significant direct nor indirect effect of decodable word fluency on comprehension recall through sight word fluency and oral reading fluency regardless of whether or not oral reading fluency scores were adjusted to account for text complexity effects. In addition to mean oral reading fluency scores, median scores were also analyzed because they are commonly used in practice in oral reading fluency assessment (Barth et al., 2012). Reanalyzing the data using median scores yielded similar results.

Null results may be attributed to how comprehension was measured in the study. In order to extend Wise et al.'s (2010) study that used a general comprehension measure, the present study predicted that the relation between a student's oral reading fluency and comprehension skill may be more accurately assessed by using a comprehension measure linked to the oral reading fluency passage (i.e., FAST Comprehension Recall). Study results suggest that this may not be the case. Comprehension recall scores ranged from 0 to 7 with a mean of two words across participants with no indication of a significant direct effect of oral reading fluency on comprehension recall nor any apparent patterns in performance between students with stronger and weaker oral reading fluency skill. Additionally, qualitative observations on students' reading skills across the measures administered included variability in student attention (i.e., distractibility), motivation, and attitudes towards reading (e.g., one student noted, "I'm bad at reading") – factors which may have impacted the assessment of students' comprehension recall in the current study.

(2) Does decodable word fluency moderate the relation between sight word fluency and oral reading fluency?

The study also predicted that decodable word fluency would moderate the relation between sight word fluency and oral reading fluency skills, based on literature that has consistently demonstrated that oral reading fluency mediates the relation between word reading and reading comprehension once readers reach a certain level of word reading skill (Kim & Wagner, 2015; Silverman et al., 2013; Wise et al., 2010). Specifically, it was expected that the relation between sight word reading and oral reading fluency would be significant at higher levels of decodable word fluency skill and weaker at lower levels of decodable word fluency skill. Study results supported this hypothesis *only* when text complexity effects were taken into account. In other words, students with a larger word bank (higher sight word fluency scores) read more words correctly per minute (higher mean Rasch-adjusted oral reading fluency scores) if they had good decoding skill (higher decodable word fluency scores). In fact, this moderating effect was evident for all but the lowest level of decodable word fluency, suggesting that the skill of decoding unfamiliar words using letter-sound relationships is essential to being able to accurately read words as a whole and necessary to be able to eventually read entire texts automatically, even and especially when first developing decodable word fluency.

On the contrary, decodable word fluency was not found to moderate the relation between sight word fluency and oral reading fluency when using raw mean or median oral reading fluency scores. This suggests that not accounting for text complexity effects may mask an otherwise significant association, which may make it difficult to accurately interpret students' reading skills. This concern aligns with prior research that suggests that the interaction between textual and student characteristics is particularly pronounced for students with low reading skill. Extraneous textual (e.g., passage with particularly low complexity) and student (e.g., background knowledge) variables may act as compensatory strategies and play a bigger role in oral reading fluency performance when actual reading skill is low. In worst cases, students with weak reading skills may present as fluent readers on certain passages (e.g., passages that are less complex or passages with familiar and/or interesting content to the student) and may not receive the additional reading interventions they need to become proficient readers.

(3) Does accounting for text complexity effects in oral reading fluency scores change the strength or direction of the associations between decodable word fluency, sight word fluency, oral reading fluency, and reading comprehension?

Third, it was predicted that using oral reading fluency scores that have been calibrated to account for passage text difficulty level may significantly strengthen the serial mediation of decodable word fluency on comprehension recall through sight word fluency and oral reading fluency. However, study results found no significant difference in the associations between these reading skills when text complexity effects were accounted for compared to when they were not. These null results may be attributed to the way in which reading comprehension was measured in this study as previously discussed.

(4) Does accounting for text complexity effects in oral reading fluency scores reduce differences in oral reading fluency performance across demographic subgroups (i.e., sex, race, free and/or reduced lunch status, and reading intervention tier)?

Finally, the study predicted that accounting for text complexity effects would reduce differences in oral reading fluency performance across subgroups within key demographic variables. There were no statistically significant differences between raw mean oral reading fluency scores and Rasch-adjusted mean oral reading fluency scores for any subgroup except reading intervention tier. However, a visual inspection of the data indicated that there may have been more meaningful differences detected had the present study recruited a larger sample. Specifically, all subgroups demonstrated the opposite effect of what was hypothesized. Accounting for text complexity effects essentially removed textual variability and by doing so *accentuated* student variability. This suggests that differences in students' background experiences and contextual knowledge as a function of group membership may interact with textual characteristics to make reading easier or more difficult for certain participant subgroups. This is especially interesting when considering the Spearman's rank correlation results, which indicated that Coh-Metrix and Rasch difficulty estimates of the student's 10 oral reading fluency passages were not significantly related. Passages that were selected a priori as the least and most complex according to Coh-Metrix, in contrast, fell within the middle of the difficulty range of Rasch estimates. This implies that Coh-Metrix, which estimates passage text complexity according to a myriad of strictly textual characteristics, albeit comprehensive, may not capture the full picture of what makes a text easier or more difficult to read for a particular reader.

Implications

Study results suggest that decodable word fluency, or the ability to decode unfamiliar words using letter-sound relationships, is an essential building block to learning to read individual words and words in text automatically (i.e., oral reading fluency). This is especially critical to consider when interpreting reading scores for students with low reading skill for whom interactions between extraneous text (e.g., a passage that is less complex) and student variables (e.g., interest or motivation and/or background knowledge about the passage content) are more likely to result in increased variability in oral reading fluency scores. As an extension, scores on passage texts that may be more or less difficult for certain student subgroups should be interpreted with due caution. In light of this interaction, specific recommendations for screening assessment include administering not only the same passage to all students but also administering an additional measure of a more basic reading skill such as decodable word fluency and/or sight word fluency. Likewise, in addition to starting with the least complex passage text, administering an additional measure of more basic reading skill such as decodable word fluency and/or sight word fluency is also recommended for monitoring progress assessment, particularly for students with oral reading fluency scores that may fall around score cutoffs.

Limitations and Future Directions

One of the purposes of the study was to determine the extent to which reading comprehension is related to different levels of decodable word fluency, sight word fluency, and oral reading fluency skills. To do this, the present study used a comprehension recall measure that required participating students to recall as many details as possible from the oral reading fluency passages they were administered. In doing so, the reading comprehension measure was directly linked to the passage that each student read to measure their oral reading fluency. Based on this timed-recall task, participants were scored on how many details from a specific passage they could recall and synthesize in one minute. However, there was no available information about the precision or validity of these comprehension recall scores from the test developers or independent empirical research. Instructions at the beginning of the oral reading fluency task (e.g., "Be sure to do your best reading") also did not include specific directions to read for *comprehension*; rather, students may have read the oral reading fluency passages with the intent to simply read accurately and quickly as they have been instructed to do in prior administrations of oral reading fluency passages throughout the school year. Pearson product-moment correlation results between raw oral reading fluency scores and comprehension recall scores ranged between -.69 (Form 4) and .91 (Form 16) with a median correlation of .004, suggesting that there was no linear relation between students' oral reading fluency skills and the number of details they could recall from most passages.

Furthermore, no significant relation was found between decoding skill and comprehension recall; again, specific procedures involved in reading comprehension assessment (e.g., read out loud versus silently) may have posed a significant moderating effect on this correlation, particularly accounting for the young age of the study participants (García & Cain, 2014). Other studies similarly reported that decoding skill was not a significant predictor of reading comprehension for first graders with deficits in both decoding and listening comprehension skills, suggesting that the oral language skills of the study participants that we did not measure (i.e., listening comprehension) may have further impacted the interaction between their comprehension recall and its component skills (Solari et al., 2018). Future research should replicate this study with other measures of "local" comprehension (e.g., comprehension questions) and/or measures of general comprehension skills as well as linguistic comprehension skills.

An additional limitation of the study includes use of the Rasch-Poisson counts model to adjust oral reading fluency scores to account for text complexity effects. This method of adjusting oral reading fluency scores to account for text complexity effects is currently novel and exploratory. Although the Rasch-Poisson counts model is not new, it has never been used to adjust oral reading fluency scores in published research to date and additional research is needed to validate this procedure. Relatedly, the MANOVAs, ANOVAs, and *t* tests that were conducted to evaluate the subgroup differences across demographic variables between raw and Rasch-adjusted oral reading fluency scores were underpowered due to the small number of participants in each demographic subgroup (e.g., there were only five students receiving Tier 3 interventions). Future research should investigate the interactions between student and textual characteristics on oral reading fluency measures using oversampling techniques to recruit sufficient sample sizes of students from different demographic groups, especially students who are members of typically marginalized groups (e.g., racial/ethnic minorities, students who speak English as a second language, and students with disabilities), to further validate the impact of using mean Rasch-adjusted oral reading fluency scores to account for text complexity effects on oral reading fluency measures.

Lastly, access to socioeconomic resources includes access to social, cultural, and economic capital (Phillips, 2011). The use of free and/or reduced lunch status as a proxy for SES may not adequately capture how SES impacts students' performance on oral reading fluency measures (Harwell & LeBeau, 2010).

Conclusion

The purpose of this study was to examine the extent to which decodable word fluency acted as both an antecedent to reading comprehension and a moderator between sight word reading fluency and oral reading fluency for a sample of first-grade students who were developing their word reading and text reading skills. This was investigated by analyzing these reading skills as continuous variables, accounting for text complexity effects that may impact oral reading fluency scores, and using commercially available and commonly used reading measures. Contrary to previous research, study results indicated that comprehension was not significantly related to its component skills. Nevertheless, these results may have been due to limitations inherent to the study's comprehension measure (i.e., comprehension recall). Otherwise, study results underlined the importance of decodable word fluency as a critical word reading skill that may be a significant predictor of subsequent sight word fluency and oral reading fluency skills. In particular, this importance may be overlooked when interpreting scores of students or student subgroups with low reading skills for whom interactions between extraneous textual (i.e., text complexity effects) and student variables may lead to increased variability in oral reading fluency scores. In conclusion, additional consideration for scores derived on basic reading measures such as decodable and sight word fluency is recommended, particularly for students with low oral reading fluency skills.

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