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Oral and Silent Reading Fluency: An Investigation Utilizing Structural Equation Modeling

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ORAL AND SILENT READING FLUENCY:

AN INVESTIGATION UTILIZING STRUCTURAL EQUATION MODELING

by

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Abstract

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Oral and silent reading fluency are often conflated in the literature such that they are treated as a single construct. The current study examined whether oral and silent reading fluency represent distinct constructs in a sample of fourth-grade students. In addition to oral and silent reading fluency, lower-level reading skills (e.g., word reading, nonword reading, rapid automatic naming) and vocabulary were included in structural equation models in order to determine their impact on students' reading fluency and reading comprehension. The results suggest that oral and silent reading fluency represent separate constructs; however, only oral reading fluency was found to contribute to reading comprehension in the current sample. The method used to assess silent reading fluency was found to impact the results. Additionally, vocabulary was found to contribute significantly to comprehension above and beyond the contributions of reading fluency or the subcomponent skills.

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Once thought of as a neglected area within the reading literature, oral reading fluency has recently taken on a privileged status within the school psychology, reading instruction, and special education literatures (Kuhn, Schwanenflugel, & Meisinger, 2010). This shift in emphasis arose partially because of information presented by the National Reading Panel (2000) outlining the importance of fluency instruction and attainment. It is also partially due to increased use of curriculum-based measures of reading (CBM; Deno, 1985) within response-to-intervention (RTI) models for the identification of learning disabilities. In contrast, within the cognitive science literatures, oral reading is almost completely overlooked and silent reading is almost solely used to obtain information about the reading process. Although interest in silent reading fluency has gradually built within the school-based literatures over the past several years, it has not attained near the level of emphasis that oral reading fluency has secured. Oral reading fluency is often used as a proxy for measuring general reading skill in young students (e.g., Fuchs & Fuchs, 1992; Fuchs, Fuchs, Hosp, & Jenkins, 2001), but this practice may become less tenable as children get older and are more often, like adults, expected to read silently as opposed to orally. Few studies have worked to tie these two types of reading together in order to model the similarities and differences between oral and silent reading fluency.

Oral reading contains several benefits for young readers. Children are likely to first be exposed to literacy through adults reading poems and stories aloud to them. Later, as children are cementing their emerging literacy skills, they are likely to practice by reading aloud with the support of a more proficient reader, such as a teacher or parent (Chall, 1996). Oral reading provides benefit to beginning or struggling readers as it allows for self-monitoring of progress (Hiebert, Samuels, & Rasinski, 2012; Kuhn & Schwanenflugel, 2007), reinforcement of letter–sound correspondence, and the use of both reading and listening comprehension skills to facilitate understanding (Hoover & Gough, 1990; Kuhn & Schwanenflugel, 2007). Additionally, oral reading results in longer time on-task, as children generally read more slowly when they read aloud (Rayner & Pollatsek, 1989). However, proficient adult readers rarely read aloud, and as children reach the fourth grade they are expected to effectively transition to silent reading. Students should be increasingly able to read faster and with equivalent comprehension silently, no longer requiring the added support of oral reading (Hiebert et al., 2012). As Share (2008) eloquently states, "silent understanding rather than oral reading is the literacy benchmark in knowledge-based societies" (p. 594).

Although fluent oral reading skills have been shown to emerge between the first and third grade (Chall, 1996; Kuhn & Stahl, 2003), little research has been conducted on silent reading fluency. Although the similarities between oral and silent reading cannot be discounted, some researchers (e.g., Share, 2008) have suggested that overarching dependence on oral reading provides an incomplete picture of both reading and reading development. Methodological problems could include an overestimation of the importance of phonological variables as well as overstated conclusions about the cognitive processes underlying oral and silent reading. Indeed, eye-tracking research demonstrates that, in skilled readers, the eye tends to be ahead of the voice (e.g., Radach, Schmitten, Glover, & Huestegge, 2009; Rayner & Pollatsek, 1989) suggesting a need to pay closer consideration to oral reading's often ignored counterpart, silent reading. Recent advances in the assessment of silent reading fluency provide an opportunity to conduct research on this important, yet overlooked, skill.

The present study seeks to model the relations between both silent and oral reading fluency in relation to comprehension. First, however, a more thorough examination of terminology and the literature is warranted. The construct of reading fluency is discussed first, followed by a discussion of the relation between reading fluency and reading comprehension, an examination of the literature on the difference between oral and silent reading, and finally a presentation of those subcomponents that will be modeled in the present study.

Defining Reading Fluency

The construct of reading fluency is disputed, with camps of researchers proposing differing definitions that prioritize various aspects of the reading process as essential to the development and characterization of reading fluency (for a more detailed discussion of definitions of reading fluency, see Kuhn et al., 2010). Probably the most widely accepted definition of reading fluency is somewhat practitioner-driven through the proliferation of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good & Kaminski, 2002), AIMSweb (Shinn & Shinn, 2002), and other curriculum-based measures (CBM) of oral reading. This definition includes an almost unilateral focus on the rate and accuracy of reading to define fluency through the use of the words read correctly per minute metric. However, other camps in the reading literature have proposed differing definitions of fluency that include other aspects of reading, including those that focus specifically on prosody, or appropriate expression and intonation (e.g., National Assessment of Educational Progress [NAEP]; Daane, Campbell, Grigg, Goodman, & Oranje, 2005), or definitions that incorporate aspects of comprehension processes (e.g., Chard, Pikulski, & McDonagh, 2006).

Arguably, one of the reasons for using a simplified fluency definition that includes predominantly measures of readers' rate and accuracy is ease of assessment. That is, this type of simplified assessment can be done through cheap, readily available, reliable CBM with little equipment and easy back-end analysis (i.e., count the number of words read correctly within one minute). There have been developments, however, in the assessment of prosody as computerized spectrographic assessment has become more accessible. This type of analysis allows researchers to quantify aspects of prosody, including, for example, changes in pitch, intonation, and stress (Schwanenflugel, et al., 2004). However, this type of prosodic analysis requires a great deal of technical expertise, making it largely inaccessible to school personnel. Therefore, the most widely utilized measure of prosody continues to be the use of rating scales (e.g., the NAEP Oral Reading Fluency Scale; Pinnell et al., 1995), which can be somewhat subjective and have limited interrater agreement (e.g., approximately 79%; Kuhn et al., 2010). Conflating aspects of comprehension with reading fluency also results in a problem for studies that attempt to model contributions to reading comprehension. For these reasons, the current study will utilize a definition of reading fluency that is somewhat simplified, incorporating only accuracy and speed of reading.

Implicit in the current literature is the idea that oral reading fluency and silent reading fluency involve essentially the same processes (Share, 2008). For the reasons described above, English-language studies of reading within the school-based literatures, especially those conducted with children, have mostly been conducted using oral reading measures. The results of these studies have been largely assumed to apply to silent reading. Few theoretical definitions of reading fluency make distinctions between the two modalities, and rarely have studies explicitly examined their differences. Although discussions of this issue within the literature are starting to appear (e.g., Hiebert et al., 2012; Share, 2008) and some theoretical definitions of reading fluency specify that oral and silent reading involve separate skills (e.g., Kuhn et al., 2010), there has yet to be an empirical study that thoroughly examines these issues. The present study attempts to address that gap by including measures of both oral and silent reading and comparing how these fluency measures contribute to reading comprehension.

The Link between Reading Fluency and Comprehension

Comprehension of written discourse is a complicated process for which there are many proposed models with varying empirical support (e.g., Kintsch, 1988; Gernsbacher, 1991; Sweet & Snow, 2008; Zwaan & Radvansky, 1998). However, in general, comprehension can be defined as the construction of a mental representation of discourse. Overall, it can be postulated that comprehension represents the sine qua non of the reading process. As children transition from viewing reading as a word decoding exercise to a meaning gathering endeavor (e.g., Baker & Brown, 1984), they are increasingly required to utilize their developing comprehension skills to obtain knowledge both in and out of the classroom. Although mental representation and integration of discourse is an important endpoint of the reading process, as previously noted, reading fluency has been an emergent focus of the reading instruction literature. Fluency has been shown to be essential for effective comprehension, although the directionality of this relationship is somewhat debated (e.g., Klauda & Guthrie, 2008; Kuhn et al., 2010).

Overall, studies examining reading fluency and comprehension have found moderate to strong positive correlations between the two in diverse samples comprised of students from primary to secondary grades (e.g., Daane et al., 2005; Fuchs, Fuchs, & Maxewell, 1988; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Pinnell et al., 1995; Yovanoff, Duesbery, Alonzo, & Tindal, 2005). There are two primary theoretical explanations that have been posited for the link. One builds upon automaticity theory: as cognitive resources are freed by automatic word recognition, more resources are available for higher-order processes, such as comprehension (LaBerge & Samuels, 1974; Perfetti, 1985). Studies that have indicated that reading fluency does not contribute to reading comprehension beyond what is explained by word recognition in early elementary school students (e.g., Schwanenflugel et al., 2004) support this theoretical standpoint. Alternatively, it has also been proposed (e.g., Jenkins et al., 2003; Klauda & Guthrie, 2008) that fluency and comprehension could be linked through their common basis in the syntactic and semantic processes involved in processing language at the phrase and sentence level. However, beyond the sentence and phrase level, fluency may be related to comprehension at the passage level based on what has been termed the macrostructure of the text (Kintsch,1988 ; Klauda & Guthrie, 2008). For example, as previously discussed, emergent readers have limited understanding of story grammar, and their comprehension is enhanced as they become more aware of typical narrative and text structure (e.g., Rayner & Pollatsek, 1989).

Finally, there remains debate in the literature about the directionality of the relation between the constructs of reading fluency and comprehension. Some researchers have espoused the viewpoint that the development of proficient fluency skills primarily facilitates proficient comprehension of text because of its ties in automaticity theory (LaBerge & Samuels, 1974), or through the reader's use of appropriate prosodic features (Kuhn & Stahl, 2003; Young & Bowers, 1995). Others have noted that proficient comprehension may facilitate proficient reading fluency in children with higher reading skill whereas limited reading skill limits both fluency and comprehension in poor readers (e.g., Jenkins et al., 2003). Finally, other researchers note that the relationship is most likely bi-directional and reciprocal, with fluency as both a contributor to and facilitated by reading comprehension (e.g., Klauda & Guthrie, 2008; Pikulski & Chard, 2005; Stecker, Roser, & Martinez, 1998). Further studies using higher-order statistical procedures that can provide information on directionality are needed to disambiguate these relations. The literature would also benefit from additional examination on the interplay between oral and silent reading and whether these different types of reading modalities are differentially related to comprehension. Although researchers have been interested in the difference between oral and silent reading for decades (e.g., Jones, 1932), results from studies examining comprehension differences between the two reading modes have been inconclusive, perhaps due to variations in the methodology, samples, and dependent measures used across the studies.

Studies Comparing Comprehension following Oral and Silent Reading

Children are first exposed to literacy through oral reading via informal and formal instructional activities and interactions with adults; however, silent reading becomes the primary modality as children transition to late-elementary school (i.e., fourth-grade). Several studies have examined differences in comprehension after oral and silent reading in elementary students. Whereas some have found support for superior comprehension after oral reading, especially in younger elementary students (Elgart, 1978; Fletcher & Pumfrey, 1988), others have reported equivalent comprehension after oral and silent reading (Juel & Holmes, 1981; McCallum, Sharp, Bell, & George, 2004). In adults, studies have been more equivocal (Holmes, 1985; Salasso, 1986).

A handful of studies have examined samples of early-elementary-school students to compare comprehension following oral reading, silent reading, and listening. In 7- and 8-year-olds, both oral reading and listening have been shown to foster comprehension (N = 36; Fletcher & Pumfrey, 1988), but in slightly older students, studies have shown a comprehension advantage following oral reading over both listening and silent reading (N = 45; Elgart, 1978). More recently, Prior and Welling (2001) examined the effect of oral versus silent reading on comprehension in a sample of 73 second- through fourth-grade children. Second graders comprehended equally poorly (approximately 50% of comprehension questions were answered correctly) after both modes; however, third- and fourth-grade students had better comprehension scores after reading orally than they did after reading silently. The study's results are limited by a few methodological problems. First, the authors suggested that the passages used for each grade might have not been equally incremented in difficulty: the passages for the second- and third-grade students were narrative, whereas the fourth grade passage was expository. Further, it was suggested that the results for the silent reading passages could have been colored by the fact that they had no way of ensuring that students actually read the silent reading passages instead of simply bowing their heads and pretending to read.

Other studies have suggested that ability level may moderate the relation between fluency and comprehension. In a study of second- and fifth-grade students, Juel and Holmes (1981) compared comprehension after oral and silent reading. Instead of a grade-level effect, they found that more-skilled readers comprehended well after both oral and silent reading whereas less-skilled readers comprehended poorly in both conditions. The use of sentence-level text and a unique method of comprehension assessment (i.e., matching schematic drawings to sentence content), may limit generalizability of these findings to typical classroom reading situations. These moderation findings were replicated in a sample of students in kindergarten through sixth grade (McCallum et al., 2004), but unfortunately the generalizability of this study was limited by other methodological issues. Specifically, although the sample itself was sizeable (N = 108), students were collapsed across a large age range.

Other studies suggest that text difficulty further complicates the picture. Comprehension was enhanced by oral reading when low-ability fourth-grade students were presented with instructional or grade-level text, but no differences in comprehension were found following oral or silent reading when these students read text at the independent level (Burge, 1983). However, the small sample size (N = 18) within the study limits generalizability of the results. The facilitatory role of oral reading on comprehension in low ability readers was replicated in a sample of learning-disabled students in grades 3 - 8 (N = 44; Fuchs & Maxwell, 1988) and in a normative sample of students in grade 2 - 5 (N = 94; Miller & Smith, 1985). Interestingly, Miller and Smith

(1985) extended the ability level moderator finding slightly: As in the other studies, low-ability readers had higher comprehension scores after reading orally than silently, and medium-ability readers had higher comprehension scores after silent than oral reading. In contrast to their low-ability and medium-ability counterparts, high-ability readers comprehended equally well after both oral and silent reading.

Finally, Swalm (1973) examined how listening and oral and silent reading impacted comprehension in a sample of second-, third-, and fourth-grade students. Results indicated that differences were found in only the second-grade students such that comprehension was higher for the oral reading group than for either the listening or silent reading groups. However, when reading ability was examined, a trend emerged such that the above-average readers at each grade had better comprehension scores after reading (either orally or silently) than after listening. Average readers had approximately equal comprehension after each of the three modes, but for the below-average readers, the trend was reversed: Listening produced the highest comprehension scores, followed by oral reading, then silent reading.

Researchers have also compared oral and silent reading in regards to comprehension in adult readers. Results generally suggested that readers comprehend equally well after oral and silent reading (Salasso, 1986), although the introduction of an audience to oral readers seems to hinder comprehension, perhaps because of added anxiety (Holmes, 1985).

Overall, several themes emerged from the literature. First, oral reading may support comprehension in younger (Elgart, 1978; Fletcher & Pumfrey, 1988) or low-ability readers (Burge, 1983; Fuchs & Maxwell, 1988; Miller & Smith, 1985). Second, at some point, children may become equally proficient at comprehending across reading modes. By adulthood, readers likely have equivalent comprehension after either reading mode (Holmes, 1985; Salasso, 1986), although the introduction of an audience (even a single graduate student) may affect the task demands enough to impact comprehension after oral reading (Homes, 1985). Given the limitations and gaps present in the current literature, further examination of oral and silent reading fluency with regard to reading comprehension seems warranted.

State of the Current Literature on Silent Reading Development

Though there have been a number of studies comparing oral and silent reading with regard to comprehension, a variety of methodological concerns have limited generaliziabilty of results. Many of the studies within the literature had methodological flaws that are detailed in the above discussion. A common methodical issue is an inability to monitor whether participants in silent reading conditions were indeed reading (i.e., Prior & Welling, 2001). That is, researchers struggled with a way to determine that participants were indeed reading passages and not simply bowing their heads and staring blankly at the passage for a fixed amount of time. Although some silent reading methodologies combat this issue (i.e., eye-tracking, moving window, slasher, and underlining techniques), many researchers comparing comprehension after oral and silent reading in children did not employ these methodologies for understandable reasons. First, eyetracking, a technique in which the reader's eye movements are computationally tracked, is expensive and unwieldy, especially in studies employing children as participants. Self-paced reading, a technique in which segments of text are presented sequentially and the reader moves the visible window of text forward through button pushes, may not be as ecologically valid as other methods for gauging subcomponents of silent reading. Slasher techniques, in which interword spaces are deleted from passages and readers are required to insert slashes in between words, could also be argued to have limited ecological validity. Underlining, a method that computationally tracks the reader's behavior through having them underlining "on-line" with their reading on a tablet PC, is a relatively new technique which offers substantial benefit to research desiring an ecologically valid and inexpensive way to ensure that readers are indeed engaged in reading during silent reading assessment (Price, Meisinger, De'Mello, & Louwerse, 2012).

Another common methodological limitation of this literature is related to limited sample sizes. Whereas some of the studies presented did indeed have robust sample sizes (i.e., Swalm, 1972), most had relatively small sample sizes (e.g., Burge, 1983; Fletcher & Pumfrey, 1988; Fuchs & Maxwell, 1988, Juel & Holmes, 1981) and others had relatively small samples sizes over large age ranges (e.g., McCallum et al., 2004; Prior & Welling, 2001). Larger sample sizes allow not only for increased statistical power, but also for the use of more sophisticated statistical techniques (e.g., structural equation modeling).

Modeling Reading Fluency

Several attempts have been made to parse apart literacy development in children in order to determine the importance of various subcomponent skills of reading fluency and their relative importance in regards to reading comprehension (e.g., Berninger et al., 2010; Kendeou, van den Broek, White, & Lynch , 2009; Ouellette & Beers, 2009; Schwanenflugel et al., 2006;Vellutino, Tunmer, Jaccard, & Chen, 2007). With few exceptions, the majority of these studies have examined reading fluency in early elementary school students, and those studies who have looked at older students (e.g., Barth, Catts, & Anthony, 2008) have solely examined oral reading fluency, largely overlooking the importance of silent reading fluency within this age group. Several subcomponents of the reading process have been identified within the literature as important for reading fluency and reading comprehension including: phonological awareness, word reading accuracy, naming speed, language comprehension, vocabulary, and reading comprehension. Each of these subcomponents will now be discussed based on the previous literature. Further, available evidence regarding the subcomponents in relation to oral and silent reading fluency will be provided. It should be noted that relatively little is known about the associations between these reading subcomponents and silent reading fluency, due to the dearth of studies examining silent fluency per sé.

Phonological decoding. Phonological skills, such as phoneme segmentation and phonological (letter-sound) decoding are essential for emergent readers with small sight word vocabularies who rely heavily on decoding during reading (National Reading Panel, 2000). Indeed, phonemic awareness has been said to constitute an integral part of the reading acquisition process for alphabetic languages (Share, 2008). However, it is likely that these skills are less important for more-skilled readers (Vellutino et al., 2007), especially those who are able to utilize other strategies for word reading, such as sight word recognition, analogizing, prediction, and the use of context (Kuhn et al., 2010). Indeed, studies have shown that the largest gains in phonemic awareness occur during the first year of reading instruction, regardless of age of initiation of instruction (Share, 2008).

Nonword decoding is often used as a way to measure student's facility with letter knowledge, letter string, rime units, and speech sounds (e.g., Schwanenflugel et al., 2006). Nonword reading is also highly correlated with readers' isolated word reading skills (Schwanenfluegel et al., 2006; Torgesen, Wagner, & Rashotte, 1999) and can be used as an indicator of readers' phonological processing skill (Siegel, 1993). Previous attempts to model reading in elementary-aged students have suggested that phonological awareness is strongly predictive of students' word reading abilities in early elementary school, but may be somewhat less predictive once students enter the late-elementary and middle school grades (e.g., Vellutino et al., 2007).

It is likely that skill in phonological decoding is more necessary for the oral rendering of text than for silent reading because silent understanding does not necessarily require the ability to fully pronounce words. However, to our knowledge no study to date has examined the association between silent reading fluency and phonological decoding.

Word reading. The ability to accurately identify words is an obvious, yet important, subcomponent of the reading process. Theories specifically relate proficient word reading to general reading fluency development (e.g., La Berge & Samuels, 1974) and provide suggestions for how reading fluency mediates the relation between word reading skill and comprehension. This subcomponent is generally assessed by having the student read aloud from a graded list of words until a ceiling criterion is met.

Facility in word reading is moderately to strongly related to fluency and comprehension within the literature; however, this relation is affected by the participant age and data-analytic technique. Most studies have demonstrated moderate predictive power in early to late elementary grades (e.g., Berninger et al., 2010; Ouellette & Beers, 2010; Vellutino, Fletcher, Snowling, & Scanlon, 2004; Vellutino et al., 2007). Yet, studies are more equivocal with middle school students. Some studies have found moderate predictive power (e.g., Barth et al., 2008), whereas others show very weak relations in these older students (Ouellette & Beers, 2010). That is, although basic reading competencies such as phonological decoding (see above) and word reading are essential to comprehension for emergent readers, their contributions diminish across development and are less predictive of comprehension as children gain in proficiency and begin to encounter more complex text (Floyd, Meisinger, Gregg, & Keith, in press; Jenkins & Jewel, 1994; Shinn, Good, Knutson, & Collins, 1992; Vellutino et al., 2007).

It seems likely that the role proficient word reading in supporting fluency and comprehension could be moderated by reading modality. However, the relation between word reading and silent reading fluency has yet to be examined, leaving many unanswered questions. First, it seems probable that word reading is important to both silent and oral reading fluency. However, we hypothesize that the relation between (oral) word reading and oral reading fluency will be greater than that of word reading and silent reading fluency. Word reading and oral reading fluency both require the production of verbal language, whereas oral pronunciation does not slow reading rate during silent reading. Eye-tracking evidence that suggests that proficient readers' eyes are ahead of their voice during oral reading again supports this supposition (e.g., Radach et al., 2009; Rayner & Pollatsek, 1989).

Naming speed. Students' rapid automatic naming skill (RAN), or the ability to provide rapid, fluent verbal responses, is related to reading development in general, and more specifically to oral reading fluency (e.g., Wolf, Bowers, & Biddle, 2000) and word reading fluency (e.g., Schwanenflugel et al., 2006), though its unique contribution is less than that of word reading (Barth et al., 2009). During the first years of children's reading instruction (e.g., prior to grade 3), slow, algorithmic word decoding makes accuracy more predictive of reading skill than is speed (Share, 2008). However, once children break the spelling–sound code (e.g., after grade 3), rapid automatic naming should become more predictive of both oral reading fluency and overall reading skill. Indeed, although phonological decoding represents a core deficit for disabled readers (Fletcher et al., 1994; Stanovich & Siegel, 1994), other evidence shows that naming speed may explain additional deficits in many struggling readers (e.g., Wolf et al., 2000).

The relation between rapid automatic naming and oral reading fluency is logical in that children's ability to produce oral language fluently probably underlies their ability to read connected text aloud with appropriate fluency. Given that silent reading fluency does not require verbal output, skills in rapid automatic naming may not be as central to its development. However, to our knowledge, this relation has not been empirically examined. Overall, it seems probable that rapid automatic naming is more closely related to oral reading fluency than silent reading fluency.

Vocabulary. Vocabulary has been shown to be a very strong predictor of reading comprehension, even after controlling for word reading, phonemic awareness, and letter knowledge (Muster, Hulme, Snowling, & Stevenson, 2004). Further, it has been shown to contribute unique variance to reading comprehension in studies examining various age groups, including children in the early elementary (Ouellette & Beers, 2010), mid-elementary (Senechal, 2006), and late-elementary grades (Ouellette & Beers, 2010), as well as young adults (e.g., Braze, Tabor, Shankweiler, & Mencl, 2007). More specifically, vocabulary has been shown to contribute to reading ability beyond its role in simple language comprehension or in word recognition (Ouellette & Beers, 2010; Senechal, 2006). The relations between vocabulary and oral and silent reading fluency has yet to be fully examined. It is hypothesized that vocabulary will contribute significantly to both oral and silent reading fluency and also directly to reading comprehension beyond its contribution through fluency.

Implicit in the existing literature is the notion that oral and silent reading are essentially the same process. Few definitions of fluency differentiate between oral and silent reading, yet some researchers caution against generalizing findings generated from oral reading to silent fluency (e.g., Share, 2008). A review of prominent subcomponents of the reading process exposed potential differences between oral and silent reading fluency. Oral and silent reading fluency have not been sufficiently modeled in late-elementary students, and this remains the primary purpose of the current study.

Purpose and Theoretical Models

Few studies have thoroughly examined the relation between oral and silent reading fluency and comprehension in the late elementary years. Although several studies have modeled oral reading fluency (e.g., Berninger et al., 2010; Kendeou et al., 2009; Ouellette & Beers, 2009; Schwanenflugel et al., 2006;Vellutino et al., 2007), especially in relation to reading comprehension, to our knowledge, no studies to date have used structural equation modeling to examine the role of silent reading fluency in the reading process. The present study fills this gap in the literature by examining both oral and silent reading fluency and their relation to overall abilities in reading comprehension in fourth-grade students. Structural equation modeling was utilized to test the viability of various models depicting how oral reading fluency, silent reading fluency, and reading comprehension relate to one another.

Specifically, two models were compared. First, a *singular model* in which oral and silent reading fluency were represented as a single variable that was specified to contribute directly to reading comprehension was examined (see Figure 1). The singular model is consistent with previous literature that conflates oral and silent reading fluency into a single construct.

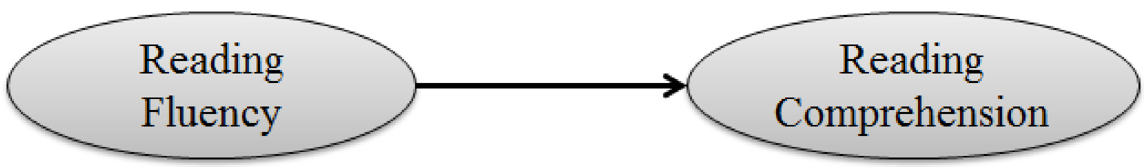


Figure 1. The singular model which represents reading fluency as a single construct.

This singular model was compared to a *split model* in which oral and silent reading fluency were represented as separate constructs and specified to contribute directly and individually to reading comprehension (see Figure 2). As oral reading fluency has been shown to develop prior to improvements in silent reading fluency, in this split model, oral reading fluency was additionally specified to contribute directly to silent reading fluency. Therefore, oral reading fluency also indirectly contributed to comprehension as mediated by silent reading fluency in the split model. This split model is consistent with the major purpose of the current study.

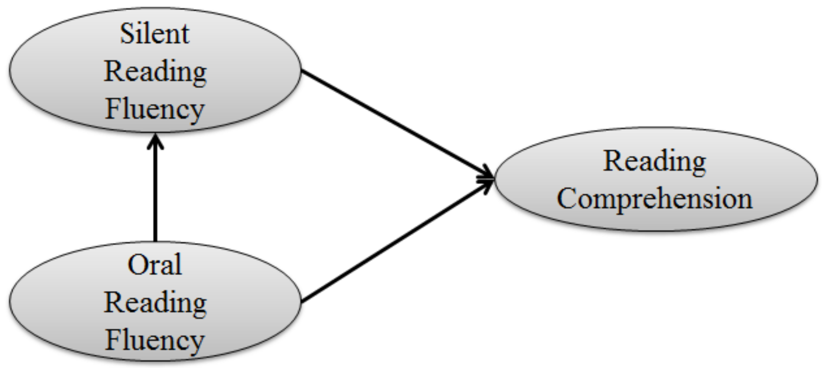


Figure 2. The split model specifies two separate reading fluency constructs: oral reading fluency and silent reading fluency.

Additionally, following a comparison of the singular and split models, the reading subcomponent skills (i.e., word reading, nonword reading, rapid automatic naming, vocabulary) were added in order to examine how these variables impact the larger picture of reading development in late elementary students. Each of the subcomponent skills was specified to contribute directly to the reading fluency factors, and vocabulary was also specified to contribute directly to reading comprehension. Table 1 provides a summary of the characteristics for each of the constructs included in the proposed models.

Table 1

Summary of Measurement Characteristics for the Reading Constructs

Construct	Oral response	Passage -based	Word-based	Speed-based	Accuracy -based	Comprehension -based
	Measure Characteristics					
Silent Reading Fluency		+		+		
Oral Reading Fluency	+	+		+	+	
Word Reading	+		+		+	
Nonword Reading	+		+		+	
Vocabulary	+		+		+	
Rapid Automatic Naming	+		+	+	+	
Reading Comprehension	+	+			+	+

Based on these characteristics and the review of available literature, several hypotheses were made regarding the relations between the subcomponent skills. Specifically, it was predicted that (a) those that require the oral rendering of text would be more closely related to oral rather than silent reading fluency (i.e., word reading, rapid automatic naming, and nonword reading), (b) that vocabulary would contribute directly to comprehension above and beyond the contributions of the other subcomponent skills and reading fluency, and (c) that the reading subcomponent skills would contribute a smaller proportion of the variance to comprehension than would reading fluency.

Method

Participants

Participants were 106 fourth-grade students attending a local intermediate school in Arkansas. All students attended general education classes; none were excluded on the basis of special education status except for those students in self-contained special education classes. The sample was composed of 52% girls and race/ethnicity was 56.1% Caucasian, 40.8% African American, 2% multiracial, and 1% Asian or Pacific Islander. Approximately 12.2% of the sample was of Hispanic descent. According to demographic information, approximately 52% of the school population was eligible for free or reduced lunch.

Measures

Table 2 provides a summary of the various measures used in the study. Each measure is described in further detail below.

Reading passage selection. Reading passages for the oral and silent reading assessments were drawn from the Qualitative Reading Inventory, Fourth Edition (QRI-4; Leslie & Caldwell, 2006). The QRI-4 is a criterion-referenced, individually administered test of reading ability. There are 6 fourth-grade expository passages available. Three passages are biographies of famous Americans and 3 passages are descriptive science and social studies materials written about various topics. One passage included pictures or diagrams; these visual aids were eliminated for the purposes of this project due to concerns about including them in the computerized task. The six[1] selected passages were counterbalanced across the underlining and oral reading fluency tasks using a Latin square procedure such that each passage was equally likely to be used in each procedure.

[1] The procedures originally included a third, group-administered silent reading fluency measure that utilized the QRI-4 passages. Passages were counterbalanced, taking in account the need to counterbalance including this third measure. Due to time constraints during the group assessment, this third measure was cut from the study, and therefore each student read only 4 of the 6 possible QRI-4 passages. Students were equally likely to read any combination of the 4 passage across the remaining oral reading fluency and underlining tasks.

Table 2
Assessment battery

Construct	Measures
Silent Reading Fluency	• *Underlining procedure using Qualitative Reading Inventory, Fourth Edition (QRI-4) passages* • Test of Contextualized Silent Reading Fluency (TOSCRF)
Oral Reading Fluency	• *Oral reading fluency procedure (utilizing Dynamic Indicators of Basic Early Literacy procedures) using QRI-4 passages*
Word Reading	• *Word Reading subtest from the Wechsler Individual Achievement Test, Third Edition (WIAT-3)*
Nonword Reading	• *Pseudoword Decoding subtest of the WIAT-3*
Vocabulary	• *Picture Vocabulary subtest from the Woodcock Johnson Tests of Achievement, Third Edition (WJ III ACH)*
Rapid Automatic Naming	• *Rapid Picture Naming subtest from the Woodcock Johnson Tests of Cognitive Abilities, Third Edition (WJ III COG)*
Reading Comprehension	• Gates-MacGinitie Reading Test, Fourth Edition (GMRT-4) • AIMSweb Reading Maze • *QRI-4 questions administered after each oral reading fluency passage* • *QRI-4 questions administered after each underlining passage*

Note. Italicized measures were administered individually to students, whereas those measures that are not italicized were group administered.

Silent reading fluency. Children's silent reading fluency was assessed using underlining and slasher techniques.

Underlining. The underlining procedure was administered individually to students. The reading passages for the underlining procedure were presented in size 12 Andale Mono (fixed width) font on a Dell Latitude XT tablet personal computer (PC). Students read one brief practice trial to familiarize themselves with the underlining procedure. After the practice passage, students completed two trials, each with a different QRI-4 passage.

The underlining procedure was previously validated for use with late elementary-aged students (Price et al., 2012). The task required students to read the passage while underlining the text word-by-word in a smooth motion using a stylus. Students were instructed to continue to underline on-line with their reading (e.g., if students regressed, the regression was to be underlined, if they paused during reading, the underlining was to pause). During the underlining of each passage, the location of the mouse was be recorded at the rate of 10 Hz (i.e., 10 times per second) in order to track various characteristics of students' reading (e.g., rate, regressions, pauses, etc.) using software specially designed for the task. Alternate-form reliability estimates of .86 (mean word reading time) were previously obtained for the underlining task (Price et al., 2012). Validity estimates ranged from .56 to .73 with other validated measures of silent reading fluency (Price et al., 2012). After the student finished reading the passage, 8 comprehension questions tied to the passage were orally presented, and the student provided oral responses which were scored by the examiner as correct or incorrect based on provided criteria. A single raw score from the underlining measure was the calculated mean number of words read per minute across both passages.

Test of Silent Contextual Reading Fluency. The Test of Silent Contextual Reading Fluency (TOSCRF; Hammill, Wiederholt, & Allen, 2006) was group-administered to students in order to provide a second, timed measure of students' silent reading fluency. The TOSCRF is a standardized, norm-referenced group administered test that yields standard scores and percentile ranks. It measures how quickly students can determine individual words within a series of passages that increase in difficulty, from the preprimer up through the adult reading level. Within each passage, words are printed in uppercase, but spaces and punctuation are omitted. Students were provided 3 minutes to draw lines between as many words as possible. The total score is derived from the number of correctly marked words. Test–retest reliability ranged from .84 to .92, whereas alternate form-delayed reliability ranged from .81 to .87. Validity estimates ranged from .67 to .85 with other validated measures of reading (Hammill et al., 2006).

Oral reading fluency. Reading passages were individually administered to each student in order to assess proficiency in the oral reading of connected text. Students were provided a passage and asked to read aloud while an administrator recorded any oral reading errors. Modeling a common procedure (DIBELS Oral Reading Fluency subtest; Good, Kaminski, & Dill, 2002), the following were considered word reading errors: mispronunciations or substitutions, omissions, and hesitations of more than 3 seconds. Although standard administration of the DIBELS oral reading fluency subtest requires the administration of 3 passages, for the purpose of this study only 2 passages were administered in order to mirror the procedure for the silent reading measures[2]. Time for

[2] Two passages were administered for each measure in order to allow for the 6 4th-grade QRI-4 passages to be utilized. Additionally, a 3rd passage was not administered due to concerns about the length of individual testing time.

the student to read the passage in its entirety was recorded by the examiner. As in the underlining procedure, after the student finished reading the oral reading passage, 8 comprehension questions tied to the passage were orally presented one at a time, and the student provided oral responses which were scored by the examiner as correct or incorrect based on provided criteria. A single raw score from the oral reading fluency passages was the mean number of words read correctly per minute across both passages.

Word reading. In order to provide a measure of students' ability to recognize individual words in isolation, the Word Reading subtest from the Wechsler Individual Achievement Test, Third Edition (WIAT-3; Psychological Corporation, 2009) was individually administered. The WIAT-3 is a standardized, norm-referenced test of academic achievement that yields standard scores and percentile ranks. Students were asked to read aloud from a provided list of words. The subtest yields two scores: accuracy and speed. Only the accuracy score was included for the purposes of this research. The Word Reading total score reflects the number of words read aloud correctly in untimed conditions. The WIAT-3 provides standard scores, and these were used in subsequent analyses. Split-half reliability coefficients for the Word Reading test were .98 and .97 for grades 4 and 6, respectively; validity estimates with the WIAT-2 (Wechsler, 2001) Word Reading subtest were .85 (Breaux, 2009).

Nonword reading. The Pseudoword Decoding subtest of the WIAT-3 was individually administered as a measure of students' nonword reading. Nonword reading has been used as a gauge of student's phonological awareness in previous studies (e.g., Schwanenflugel et al., 2008; Siegel, 1983). Students were asked to read from a provided list of phonetically regular, pronounceable non-words (e.g., vonk). The Pseudoword

Decoding total score reflects the number of words read aloud correctly in untimed conditions. The WIAT-3 provides standard scores and these were used in subsequent analyses. Split-half reliability coefficients for the Pseudoword decoding subtest were .97 for both grades 4 and 6; validity estimates with the WIAT-2 (Wechsler, 2001) Pseudoword Decoding subtest were .84 (Breaux, 2009).

Vocabulary. In order to assess students' expressive vocabulary, the Picture Vocabulary subtest from the Woodcock Johnson Tests of Achievement, Third Edition (WJ III ACH; Woodcock, McGrew, & Mather, 2001) was individually administered. Students were shown a series of pictures and asked to orally provide a one-word name for the picture. The score from Picture Vocabulary reflects the total number of correct responses provided. The WJ III ACH provides standard scores and these were used in subsequent analyses. Scores were derived using the WJ III ACH 2007 Normative Update (Woodcock, McGrew, Schrank, & Mather, 2007). Test-retest reliability estimates for students aged 9 years to 12 years ranged from .77 to .80.

Rapid automatic naming. The Rapid Picture Naming subtest from the Woodcock Johnson Tests of Cognitive Abilities, Third Edition (WJ III COG) was individually administered in order to gauge rapid automatic naming. Students are asked to name as many pictures as possible within a 3-minute time limit. The WJ III COG provides standard scores and these were used in subsequent analyses. Scores will be derived using the WJ III COG 2007 Normative Update (Woodcock et al., 2007). Standard test-retest reliability estimates for students aged 9 to 12 years ranged from .96 to .97, and analyses of the WJ III speeded tests indicate one-day test-retest reliability of .78 for this age group (McGrew et al., 2007).

Reading comprehension. Comprehension was assessed using the Gates–MacGinitie Reading Test, Fourth Edition (GMRT-4; MacGinitie, MacGinitie, Maria, & Dreyer, 2007) Comprehension subtest. The GMRT-4 is a standardized, norm-referenced group-administered test that yields normal curve equivalent scores. Students were asked to silently read a sequence of ten passages. Each passage is accompanied by a series of multiple-choice questions. Students are allowed 35 minutes to complete the subtest. Test–retest reliability estimates for the GMRT-4 ranged from .83 to .85, internal consistency coefficients ranged from .96 to .97, and validity estimates with other tests of reading comprehension ranged from .60 to .62 (MacGinitie, MacGinitie, Maria, & Dreyer, 2008).

Comprehension was also assessed by a Reading Maze task from the AIMSweb progress monitoring system (Shinn & Shinn, 2002). The Maze task is a standardized, group-administered, multiple-choice cloze silent reading task. Students read a narrative fiction passage in which the first sentence is left intact, after which every seventh word is replaced by three word choices in parentheses. One of the three word choices is correct, one is a near distracter (same word type, but does not preserve meaning), and one is a far distracter (not the same word type, does not preserve meaning). Each student completed a short practice passage with the group and then had 3 minutes to read a grade-level passage and complete the task. No students finished the passage in less than 3 minutes. Test–retest reliability estimates of .90 were reported for maze tasks similar to the ones used in this study, and validity estimates ranged from .77 to .85 for students in grades 3-5 (Fuchs & Fuchs, 1992).

Each of the previous measures of comprehension provides a holistic estimate of students' ability to comprehend written discourse; however, additional comprehension questions provided with the QRI-4 (Leslie & Caldwell, 2006) passages were also administered following the silent and oral reading measures described above and will be used to quantify students' comprehension skill. The use of these additional questions allows for a direct measure of students' comprehension following both oral and silent reading of connected text. The QRI-4 provides 8 comprehension questions for each passage: 4 explicit questions and 4 implicit questions. Explicit questions could be answered from material stated directly in the text. Implicit questions required information that must be inferred from the text and are based on the interaction between information provided in the text and students' prior knowledge. Correct answers to implicit questions, however, must be tied to the text and cannot be provided simply from prior knowledge. Reliability estimates for the QRI-4 ranged from .80 to .99 and validity estimates with other tests ranged from .44 to .72 (Leslie & Caldwell, 2006). Further, evidence suggests that questions from the QRI-4 are less reliant on participant's decoding skills to comprehend the passage text than other comparable measures of reading comprehension (Keenan, Betjemann, & Olson, 2008).

Procedure

Written parental consent and child assent were required for participation in the study. The underlining, oral reading fluency, vocabulary, rapid automatic naming, word reading, and phonological decoding measures were individually administered in a quiet location in the school. Administration of all individual measures was counterbalanced using a Latin square procedure in order to control for order effects. The TOSCRF, GMRT-4, and maze tasks were group-administered following the completion of the individual measures in a counterbalanced procedure by class. All measures were administered by graduate students in school psychology who were trained by the lead investigator. Administrators were required to reach 95% interrater agreement prior to be beginning of data collection. The first day of data collection for each administrator was then observed by the lead investigator as a secondary fidelity check. Children received a small token gift (i.e., a pencil following the individual assessments and candy following the group-administrated assessments) as thanks for participating in the study. Teachers received a gift card as thanks for participating in the study.

Analytic Technique

First, descriptive statistics and correlations were calculated in order to determine the data's suitability for further analyses. Then, structural equation modeling (SEM) using AMOS 18 was utilized in order to explore the relations between reading comprehension, oral and silent reading fluency, and the various subcomponents to the reading process. This technique allows the researcher to build models based on appropriate theory and then assess how the model fits the relations within the obtained data. Parameters were estimated utilizing maximum likelihood estimation because it is the most commonly used and accepted approach, is assumed to be most accurate when using normally distributed data, and is most appropriate with sample sizes smaller than approximately $N = 250$ (Kline, 2010). Several fit indices were examined for each model that was fitted. First, the model χ^2 statistic associated with the p value is reported for each model, followed by the comparative fit index (CFI), the Tucker Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the standardized root mean square residual (SRMR). A non-significant χ^2represents good model fit, as do CFI and TLI values above .95, RMSEA values that are less than .05, and SRMR values less than

.08 (Kline, 2010). Additionally, the Akaike Information Criterion (AIC) was examined for the structural models in order to compare model fit; the AIC is a comparative fit index that is meaningful only when two models are estimated such that the model with the lowest AIC value provides the best fit to the data.

Results

Data Processing and Screening

Eight participants were missing all group-administered measures due to absences; these values were thought to be missing completely at random, and each of these participants was dropped from the dataset because of the large proportion of the measures that were lacking. These removals resulted in a final sample size of 98[3]. The remaining data were screened in order to examine for missing data points, outliers, and normalacy. No out of range data points were found, but 3 additional data points were missing. These values were thought to be missing at random (attributed to examiner error; Tabachnick & Fidell, 2007), and because they represented a relatively small proportion of the dataset, these single points were imputed using the multiple imputation technique available in PASW Statistics 18.

There were several univariate outliers across measures, and, following the procedures outlined in Tabachnick and Fidell (2007), outlier scores were decreased to the level of the second highest score within that same measure. Subsequent examinations of the recalculated z-scores for each of the measures indicated that there were no longer univariate outliers present ($z \leq 3.3$). Mahalanobis Distance was utilized in order to screen

[3] The final models were run with and without the missing participants and results were comparable, which suggests the removal of these 8 participants did not have a large impact on the final results.

for multivariate outliers (using $p < .001$ as the criterion), and none were found. Skewness and kurtosis were found to be within acceptable limits (value divided by standard error in order to convert to *z* score; all $z < 3.3$; Tabachnick & Fidell, 2007) after correcting for univariate outliers. No problems with curvilinear relationships were found based on visual examination of bivariate scatterplots. There were no problems noted with multicolinearity or singularity ($r < .80$; Kline, 2010).

Descriptive Statistics

Descriptive statistics and intercorrelations between variables are presented in Table 3. Judging by performance for those measures for which the population mean was available (e.g., standard score or normal curve equivalent), the sample had somewhat weak reading comprehension (GMRT-4) and silent reading fluency (TOSCRF) skills. The sample mean scores from the reading subcomponent skills (word reading, nonword reading, rapid naming, vocabulary) were also slightly lower than available population means. Additionally, an examination of the standard deviations for those measures presented in standard scores or normal curve equivalents indicated that there were some issues with score attenuation in the sample. Finally, an examination of student performance on the QRI-4 questions that were administered after the underlining and the oral reading fluency questions indicated that on average students correctly answered about one and a half more questions after oral reading as opposed to the silent reading underlining task.

Some patterns emerged upon examining the correlation matrix. Although the underlining task was strongly correlated with the oral reading fluency measure, its relation with the TOSCRF, the GMRT-4, and the Maze task was weaker. This weak (*r* =

.20) relationship between the two silent reading fluency measures is especially surprising. The GMRT-4 was moderately to strongly related to the other three measures of student's comprehension skills. Additionally, the relations between the subcomponent skills were largely what would be predicted. There was a strong relation between the word reading and nonword reading tasks, and vocabulary related weakly to moderately with all of the other tasks except for the three fluency measures. Finally, although there were weak relations between the rapid naming task and the oral reading fluency and the TOSCRF tasks, the only other measure to which the rapid naming task was significantly related was the vocabulary measure.

In SEM analyses, variances are considered ill-scaled if they differ by greater than a factor of about 10, and ill-scaled covariance matrices can result in problems due to the iterative nature of SEM estimation (Kline, 2010). When using such a criterion, the current data set is considered ill-scaled. Using a method endorsed in the literature (Kline, 2010), raw scores were each multiplied by a constant, which serves to maintain correlations amongst the variables while modifying the variable means and variances, thus resulting in a properly-scaled covariance matrix. Specifically, within each measure, raw scores were multiplied by the same constant. Re-scaling constants for each measure were selected in order to result in an appropriately-scaled matrix (i.e., all covariance values within a factor of 10). Information about the constants used to re-scale the covariance matrix is presented at the bottom of Table 3. The means and standard deviations presented in Table 3 are those of the original, non re-scaled raw scores; however, the re-scaled values were utilized for all further SEM analyses.

Table 3

Correlations, Covariances, and Descriptive Statistics

	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*
1 UL	--	371.2	54.7	115.3	52.5	-8.2	18.8	50.0	58.9	3.5	37.2	140.5	32.8
2 ORF	.53**	--	52.1	155.2	54.8	.46	18.5	104.1	138.3	32.2	64.2	105.4	21.5
3 TOSCRF	.20*	.30**	--	36.7	16.0	1.2	3.3	37.9	29.2	13.6	22.3	94.2	8.2
4 GMRT	.24*	.49**	.31**	--	47.4	14.0	24.4	51.4	65.1	48.8	42.5	45.2	14.7
5 Maze	.25*	.39**	.30**	.50**	--	1.7	5.8	15.4	24.4	15.6	12.7	19.2	6.5
6 UL Q	-.08	.01	.05	.29**	.08	--	3.5	.36	-0.8	8.6	3.9	6.3	3.2
7 ORF Q	.11	.25*	.11	.47**	.26*	.31**	--	3.4	8.8	9.8	2.5	7.8	3.5
8 WR	.13	.50**	.48**	.36**	.24*	.01	.10	--	95.1	27.1	19..9	97.6	9.7
9 PWD	.01	.48**	.27**	.33**	.28**	-.02	.19	.73**	--	30.7	17.0	96.0	13.4
10 Vocab	.01	.17	.19	.37**	.27**	.30**	.31**	.31**	.26*	--	29.4	94.1	9.0
11 RPN	.10	.27**	.25*	.26**	.18	.11	.07	.19	.12	.30**	--	97.9	11.1
Original S^2	1075.8	462.3	67.2	216.1	42.3	10.2	12.3	94.1	179.6	81.0	123.2		
Constant	1	2	4	2	5	10	10	4	3	4	3		
Rescaled s^2	1075.8	1849.2	1075.2	864.4	1057.5	1020.0	1230.0	1505.6	1616.4	1296.0	1108.8		
Rescaled *SD*	32.8	43.0	32.8	29.4	32.5	31.9	35.1	38.8	40.2	36.0	33.3		

Note. *N* = 98. 1. UL = underlining; 2. ORF = oral reading fluency; 3. TOSCRF = Test of Silent Contextualized Reading Fluency; 4. GMRT = Gates-MacGinitie Reading Test, Fourth Edition Comprehension; 5. Maze = AIMSweb Maze; 6. UL Q = QRI-4

Table 3 Note continued. comprehension questions for underlining; 7. ORF Q = QRI-4 comprehension questions for oral reading; 8. WR = WIAT-3 Word Reading; 9. PWD = WIAT-3 Pseudoword Decoding; 10. Vocab. = WJ III ACH Picture Vocabulary; 11. RPN = WJ III COG Rapid Picture Naming. Correlations are presented below the diagonal, and covariances are presented above the diagonal.
** $p < .01$, *$p < .05$.

Structural Equation Modeling

The results were analyzed in three phases. First, measurement models were analyzed to determine the feasibility of the various latent variables. Second, structural components for the reading fluency factor(s) were added in order to determine the fit of the singular and split models. Finally, subcomponent skills (i.e., word reading, nonword reading, rapid automatic naming, and vocabulary) were added to the strongest a priori structural model. Following this third phase, two alternative models were tested in order to provide further evidence of the superiority of the proposed models.

Evaluation of the measurement model. Table 4 presents the fit indices for the singular fluency measurement model with two latent variables (a) Reading Comprehension with 4 indicators (GMRT-4, Maze, ORF QRI-4 questions, underlining QRI-4 questions) and (b) Reading Fluency with 3 indicators (ORF, underlining, TOSCRF).

The singular measurement model (see Figure 3) demonstrated adequate fit, suggesting that it included viable latent factors to which structural components could be added. In particular, the X^2 was nonsignificant, the CFI value surpassed .95, the SRMR was below .08, and the TLI and RMSEA values both approached the criterion for excellent fit for both indices.

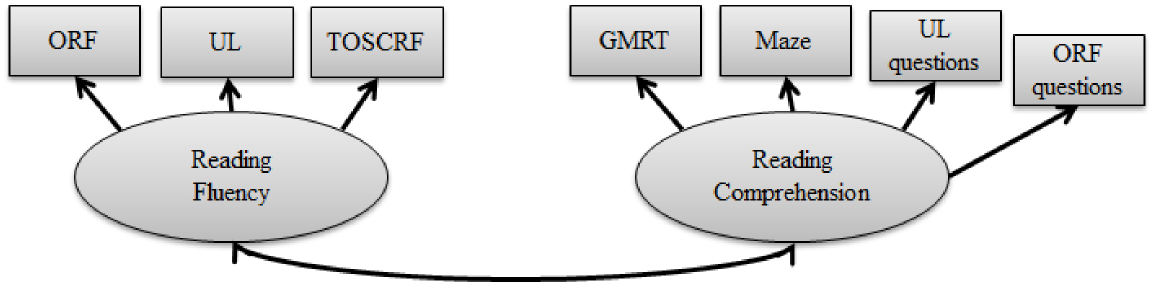
Table 4

Fit Indices for Each of the Fitted Models

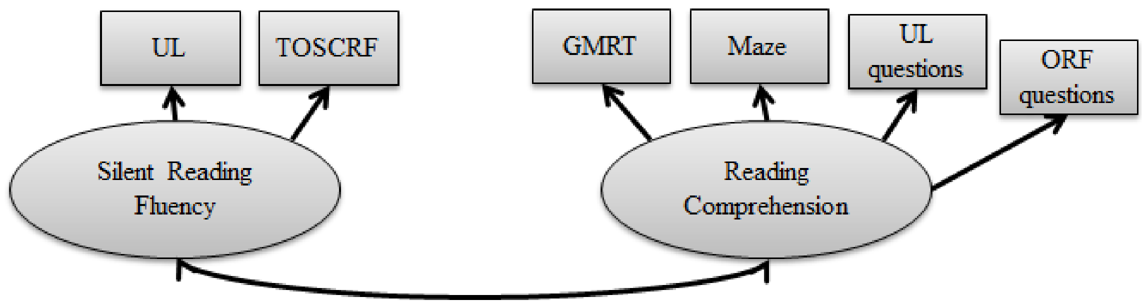
	X^2	*df*	$p_{X}2$	CFI	TLI	RMSEA (90% CI)	SRMR	AIC
Singular Measurement Model	.18	13	.18	.97	.94	.06 (.00-.12)	.07	--
Singular Structural Model	17.4	12	.18	.97	.94	.06 (.00-.12)	.07	47.4
Split Structural Model	14.1	12	.29	.98	.97	.04 (.00-.12)	.07	46.1
Singular Model with Subcomponents	53.4	36	.03	.94	.90	.07 (.02-.11)	.08	113.4
Split Model with Subcomponents	25.7	27	.44	1.00	1.00	.01 (.00-.08)	.06	105.5

Note. CI = confidence interval

Another measurement model was tested that examined a latent Silent Reading Fluency factor with two indicators, the TOSCRF and the underlining measure scores (see Figure 3b). Although model fit was adequate, high standard errors for regression weights indicated disturbance that can probably be attributed to the significant but weak



(a)



(b)

Figure 3 continued. Depiction of the (a) singular measurement model and (b) split measurement model.

correlation between the TOSCRF and the underlining measure (see Table 3). In other words, the two silent reading measures seemed to represent somewhat different aspects of silent reading. Because of this issue, it was determined that it would be more statistically sound to specify each silent reading fluency measure as a manifest variable within subsequent models as opposed to indicators of a single latent silent reading fluency factor.

Evaluation of the structural equation models. With data to indicate that the reading comprehension latent factor and the singular reading fluency factor provide ample fit to the data, structural components were added to both the simple singular model and the split models in order to address the research questions. Fit indices (see Table 4) for both models indicated adequate fit.

In particular, for the singular structural model, the χ^2 was nonsignificant, the CFI and SRMR values met criteria for adequate fit and the TLI was .94 and the RMSEA value was .06, both near the cutoff for adequate fit. However, a comparison of the fit indices for both structural models indicated that in almost every instance, the fit indices for the split model represented stronger fit to the data: for the split model, the χ^2 value was nonsignificant, the CFI and TLI values were .98 and .97, respectively,, the RMSEA value was .04, and the SRMR value was .07. Additionally, a comparison of the AIC values for the two structural models provided further evidence for the assertion that the split model provided better fit to the data; the AIC value for the split model (46.1) was lower than the AIC value for the singular model (47.4). This finding suggests that the split model more adequately models the reading processes of the children within the sample. Therefore, the split model, in which oral and silent reading fluency were represented as separate constructs, was accepted as the most viable model given the current sample.

Evaluation of the structural models with subcomponents skills. Because the fit indices were so similar and both structural models indicated adequate fit, subcomponent skills were added to both structural models in order to determine how these skills impacted the picture of students' overall reading competency. This was done in order to ensure that over reliance on a specific model based on previous decisions did not obfuscate stronger, more complex structural models in the third phase of the analyses. Fit for both structural models with subcomponent skills was deemed adequate (see Table 4).

In particular, for the singular structural model, although the χ^2 was significant, the CFI, TLI, and SRMR values were approaching criteria for adequate fit and the RMSEA value was .07, below the cutoff for adequate fit. However, a comparison of the fit indices for both structural models indicated that in every case, the fit indices for the split model represented stronger fit to the data: for the split model, the χ^2 value was nonsignificant, the CFI and TLI values were 1.00, the RMSEA value was .01, and the SRMR value was .06. Additionally, a comparison of the AIC values for the two structural models provided further evidence for the assertion that the split model provided better fit to the data; the AIC value for the split model (105.5) was lower than the AIC value for the simple model (113.4). This finding further supports the previous supposition that the split model more adequately models the reading processes of the children within the current sample. Therefore, the split model, in which oral and silent reading fluency were represented as separate constructs, was accepted as the most viable model given the current sample.

Standardized direct, indirect, and total effects from the split model with subcomponents skills are presented in Table 5. These coefficients, similar to beta weights from regression analyses, indicate the proportion of standard deviation units that the endogenous factor changes as a function of a one standard deviation change in the exogenous factor. Standardized coefficient effect sizes above .05 are considered *small*, whereas effect sizes above .15 are considered *moderate*, and effect sizes above .25 are considered *large* (Kline, 2010). In addition to Table 4, the split model is presented in Figure 4, and significant and nonsignificant paths are demarcated.

Table 5

Standardized Direct, Indirect, and Total Effects on Reading Comprehension for the Split Structural Model with Subcomponent Skills

Exogenous Variables		Endogenous Variables within the Model			
		To ORF	To TOSCRF	To Underlining	To Comprehension
From Word Reading	direct	.29*	.55**	-.05	--
	indirect	--	.02	.18	.22
	total	.29	.57	.13	.22
From Nonword Reading	direct	.26*	-.19	-.11	--
	indirect	--	.02	.16	.09
	total	.26	-.17	.05	.09
From Rapid Automatic Naming	direct	.20*	.14	-.03	--
	indirect	--	.01	.12	.11
	total	.20	.16	.09	.11
From Picture Vocabulary	direct	-.05	.01	-.04	.36*
	indirect	--	.00	-.03	-.02
	total	-.05	.01	-.07	.34
From Underlining	direct	--	--	--	.02
	indirect	--	--	--	--
	total	--	--	--	.02
From TOSCRF	direct	--	--	--	.15
	indirect	--	--	--	--
	Total	--	--	--	.15
From Oral Reading Fluency	direct	--	.07	.62**	.44**
	indirect	--	--	--	.02
	total	--	.07	.62	.46

Note. ORF = Oral reading fluency; TOSCRF = Test of Contextualized Silent Reading Fluency; Statistical significance is notated on direct effects only.

** p <.01, *p < .05.

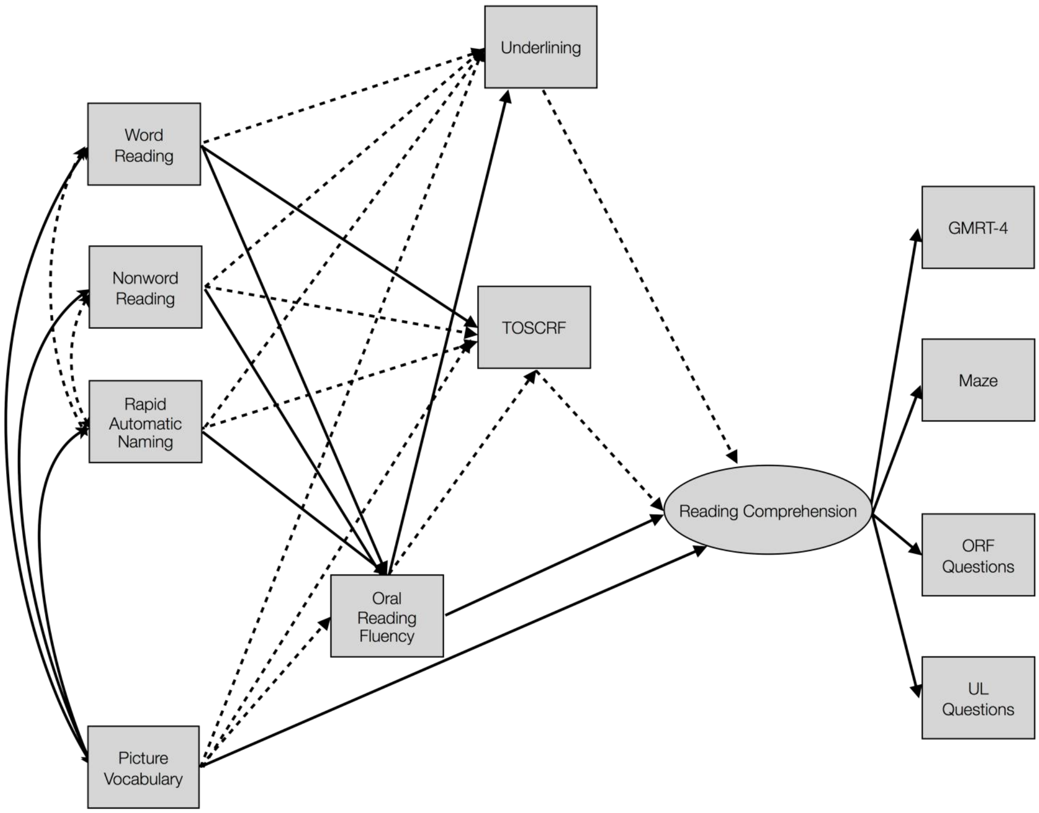


Figure 4. Split structural model with subcomponent relations. Statistically significant path (p < .05) coefficients are indicated by solid lines whereas nonsignificant path coefficients are indicated by dotted lines.

The amount of variance (i.e., squared multiple correlation) explained for comprehension within the split structural model was R^2 = .47. Examining the standardized parameter estimates in the split structural model indicates that oral reading fluency (.44) and vocabulary (.46) both contributed significantly directly to reading comprehension; indeed, both parameters fell within the large range. In contrast, neither silent reading fluency variable (underlining .02; TOSCRF .15) contributed significantly to reading comprehension after controlling for the other factors. Additionally, the oral reading fluency measure contributed significantly to the underlining measure (.62) to a large degree, but it did not contribute significantly to the TOSCRF (.07).

An examination of the remaining subcomponent skills suggested that, although word reading (.29), nonword reading (.26), and rapid automatic naming (.20) each contributed significantly to the oral reading fluency measure, only word reading contributed significantly to the TOSCRF (.55), and none of the subcomponent skills contributed significantly to the underlining measure (all $\leq |.11|$) . That word reading significantly contributed to the TOSCRF measure can perhaps be accounted for by the task demands of the TOSCRF. That is, although the passages in the TOSCRF represented connected text, students were required to identify and demarcate words within the passage, which is perhaps more similar to a word reading measure than the passage reading required in the underlining task.

Evaluation of alternative models. Due to some surprising relations between the model variables as well as the closeness of the fit of the singular and split models, two alternative models were tested based on results from the previously-run models. The fit indices for each of these alternative models is presented below in Table 6, and the fit indices for the original split model with subcomponent skills are included as a baseline for comparison.

First, the TOSCRF was removed from the model and the underlining measure was utilized as the only silent reading fluency variable. This model was tested in order to determine whether a model with only a single silent text reading fluency measure would better fit the current data set. In general, although the values for the fit indices indicated excellent fit to the data (nonsignificant X^2, CFI and TLI values at .98 and .99, respectively, RMSEA values below .05, and SRMR values below .08), in each case the fit indices were stronger for the original split model with the TOSCRF and the subcomponent skills. It is notable that the AIC value is partially tied to the number of manifest variables present in the sample, and therefore the removal of the TOSCRF as a manifest variable reduces in appropriateness as a method of comparing models. Therefore, the AIC was not presented for that model within Table 6.

Table 6

Fit Indices for Each of the Fitted Alternative Models

	X^2	*df*	p_X2	CFI	TLI	RMSEA (90% CI)	SRMR	AIC
Split Model with Subcomponents	25.7	27	.44	1.00	1.00	.01 (.00-.08)	.06	105.5
Split Model without TOSCRF	23.8	23	.42	.98	.99	.02 (.00-.09)	.06	--
TOSCRF as a Subcomponent	28.5	27	.38	.99	.99	.02 (.00-.08)	.06	106.5

Note. CI = confidence interval

Second, a model was tested in which the TOSCRF was demoted to the level of the subcomponent skills and was specified to contribute directly to the underlining and the oral reading fluency measure but not to reading comprehension. This model was specified in order to further test the hypothesis that the TOSCRF is more akin to a silent word reading fluency measure as opposed to a silent text reading measure, and therefore should be at the same level as the other subcomponent skills, as opposed to the level of a mediating variable, such as oral reading fluency and silent reading fluency (here measured by the underlining variable). Again, although the fit indices indicated adequate fit to the data data (nonsignificant X^2, CFI and TLI values at .99, RMSEA value below .05, and SRMR values below .08), again in each case the same values for the original split model with subcomponent skills were stronger. Additionally, in this case both the split model and the model with the TOSCRF as a subcomponent had the same number of manifest variables and therefore the AIC is an appropriate comparative index. A comparison of the AIC scores for each model indicated that the split model (AIC = 105.5) had stronger fit to the data than did the alternative model (106.5), as indicated by a smaller value. In conclusion, an examination of these two alternative models provided further support for the fit and adequacy of the originally selected split model with subcomponent skills as the strongest model for the current dataset.

Discussion

Although oral reading fluency has received increased attention in the reading education, special education, and school psychology literatures across the past decade, silent reading fluency has remained largely overlooked, resulting in some authors suggesting that oral and silent reading fluency are often inappropriately conflated (e.g., Hiebert et al., 2012; Share, 2008). Indeed, although several studies have modeled oral reading fluency (e.g., Berninger et al., 2010; Kendeou et al., 2009; Ouellette & Beers, 2009; Schwanenflugel et al., 2006;Vellutino et al., 2007), especially in relation to reading comprehension, fewer studies within the school-based literatures have examined the role of silent reading fluency in the reading process, especially within late elementary readers.

The present study attempted to fill this gap in the literature by utilizing structural equation modeling to examine both oral and silent reading fluency and their relation to overall reading comprehension abilities in fourth-grade students. Further, several subcomponents of the reading process were included in the examined model in order to determine how these additional skill sets support fluency and comprehension.

Findings Regarding Oral and Silent Reading Fluency

Results from the split structural model indicated that oral and silent reading fluency represent separate constructs and should not be conflated in the literature, as has been suggested by Share (2008) amongst others (e.g., Hiebert et al., 2012). Interestingly, the two silent reading fluency measures did not result in a stable, latent silent reading fluency factor. This result, although somewhat surprising, perhaps stemmed from the statistically significant but weak correlation between the two silent reading fluency measures. Although both measures have been validated against other measures of silent reading, it is notable that the two measures assess silent reading fluency using very different methods—the underlining task required a more ecologically valid passage reading task whereas the TOSCRF required students to identify and demarcate individual words within text. Perhaps the strong correlation between the word reading measure and the TOSCRF indicate that the TOSCRF was actually measuring a different aspect of silent reading fluency than was the underlining measure—perhaps something more akin to silent word reading fluency, rather than the silent text reading fluency assessed by the underlining measure. This conclusion is supported by the fact that the oral reading fluency measure, a passage reading task, contributed significantly to the underlining measure but not to the TOSCRF. Nonetheless, these fluency-specific results are consistent with other studies in the literature that have suggested that oral and silent reading are separate constructs (e.g., Kim et al., 2011).

Additionally, the current model indicated that oral reading fluency contributed significantly to comprehension, which is consistent with findings across a range of diverse samples from students ranging from the primary to the secondary grades (e.g., Daane et al., 2005; Fuchs et al., 1988; Jenkins et al., 2003; Pinnell et al., 1995; Yavanoff et al., 2005). Importantly, the silent reading fluency measures did not contribute significantly to reading comprehension. This finding is consistent with some previous literature which suggests that prior to fifth grade, students comprehend better after oral reading than after silent reading (Elgart, 1978; Fletcher & Pomfrey, 1988; Prior & Welling, 2001). Future studies utilizing older, more proficient readers (e.g., fifth grade and older) may shed light on the developmental shift from oral to silent reading.

It is notable that in the current sample, students performed slightly below average in regards to each of the normative reading measures (see Table 3). Previous studies (Juel & Holmes, 1981; McCallum et al., 2004, Miller & Smith, 1985; Swalm, 1973) have shown an ability level effect when they examined comprehension after oral and silent reading such that high-ability readers had equivalent comprehension after both modalities and low-ability readers comprehended poorly after both modalities. Although the current sample was not substantially below the national average on any single measure, it is possible that their slightly-below-average reading abilities impacted the relations between oral reading fluency, silent reading fluency, and comprehension. Unfortunately, the current sample size was not substantial enough to allow for an ability level analysis.

That oral reading fluency was more predictive of students' overall reading comprehension than was their silent reading fluency is consistent with available information regarding the mental processes underlining reading comprehension. This finding was supported at the holistic level, as oral reading was more predictive of students' reading comprehension within the structural equation models. Furthermore this finding was also supported more specifically as students answered on average 1.5 more comprehension questions correctly following oral as opposed to silent reading, even as the passages were held constant (see Table 3). As introduced earlier, oral reading provides several benefits for younger or lower-ability readers. Oral reading provides the opportunity for multiple representations of the text: students are able to utilize not only their reading comprehension skills but also their listening comprehension skills as they hear the text rendered aloud. Students can self-monitor their reading progress within the passage and can use their listening comprehension to more readily identify their own reading errors, and this dual-processing could lead to gains in overall comprehension. Further, as indicated in Table 3, students' silent reading was approximately one-third again as fast as their oral reading, and they therefore spent substantially more time on task during the oral reading task than during the silent reading task. This greater time on task also provides opportunity for more practice which could partially explain the greater link between oral reading and comprehension as compared to silent reading.

However, as discussed previously, oral reading fluency provides diminishing returns as readers become more proficient. Eventually, as reading rate increases and the reader's eyes advance beyond the point at which they are reading, the dual processing benefits of oral reading should diminish. At this point, the increased speed allowed by silent reading should provide greater benefit to the reader, and students should be able to more effectively comprehend information silently than orally.

Findings Regarding Subcomponents of the Reading Process

Beyond the relations between oral reading fluency, silent reading fluency, and comprehension, the present study included several reading subcomponent skills. As expected, an examination of the model parameters suggested that rapid automatic naming, nonword reading, and word reading each contributed significantly to the oral reading fluency measure. Interestingly, the picture for silent reading fluency was different than that of oral reading fluency. None of the subcomponent skills contributed significantly to the underlining measure. As described above, of the subcomponent skills, only the word reading task contributed significantly to the TOSCRF; none of the other subcomponent skills provided significant effects.

With a notable exception, the impact of the subcomponent skills on comprehension was less than their effect on reading fluency. The total effect on comprehension from both rapid automatic naming and nonword reading was in the small range, although the total effect from word reading was higher, falling in the moderate range. These findings are consistent with previous studies which have suggested that, although basic reading competencies are essential to comprehension for emergent readers, their contributions diminish across development and are less predictive of comprehension as children gain in proficiency and begin to encounter more complex text (Floyd et al., in press; Jenkins & Jewel, 1994; Shinn et al., 1992; Vellutino et al., 2007). The particularly small total effect from nonword reading is consistent with the literature suggesting that the largest gains in phonemic and phonological awareness occur in the first year of reading instruction, and that by late elementary school, non-word reading skills should be less predictive of students overall reading abilities (Share, 2008; Vellutino et al., 2007).

However, vocabulary stood out among the subcomponents as an important contributor to reading comprehension. Although the vocabulary factor did not contribute in any meaningful way to the oral or silent reading fluency measures, it is notable that it contributed strongly to the comprehension measure, even when controlling for the fluency factors. These findings are consistent with an emerging literature that suggests that vocabulary is an important component of the reading process and should not be overlooked in examination of reading development (Berninger et al., 2010; Ouellette & Beers, 2010).

Limitations and Future Directions

Although the current study provides an important contribution to the literature regarding students' reading fluency, vocabulary, and comprehension development in late elementary school, there are some limitations that should be noted and areas which future research should address. First, although the present sample was adequate and the use of complex statistical analyses provided the opportunity to examine relationships between the examined factors, studies utilizing a larger sample size with older readers (e.g., fifth and sixth grade) would provide a more complete picture of the phenomena examined in the present study and would provide important information about developmental changes in this age group. Although the current research provides additional evidence to support the conceptualization of oral and silent reading fluency as separate constructs, the data indicate that students in the current sample had not yet fully transitioned to silent reading for comprehension. Although samples of older, more proficient readers would help to shed light on developmental trends in silent and oral reading fluency and reading comprehension, even more useful, perhaps, would be longitudinal data comparing the development of students across this age range.

Additionally, although several measures were utilized to examine students' fluency, comprehension, and a handful of subcomponent processes, the current study did not examine some factors which may provide additional information about reading development. Although two measures of students' silent reading fluency were included in the present study, the measures did not provide a stable factor, perhaps, as discussed previously, because they were measuring different aspects of silent reading fluency (i.e., word vs. text fluency). Future studies should examine whether a more traditional paper-and-pencil measure (see Price et al., 2012) would provide important additional information about silent reading fluency and perhaps allow for a stable silent reading fluency factor within the model. The inclusion of such a measure would also provide additional evidence to support our conclusion that the TOSCRF may be more akin to a silent word reading measure than a silent text reading measure. Additionally, the inclusion of a measure of non-verbal processing speed would provide interesting information about how this subcomponent is differentially related to oral and silent reading fluency in late elementary readers. Such information would be especially interesting given the findings in the present study that indicated that rapid automatic naming contributes significantly to oral reading, but not to either silent reading measure. It may be that non-verbal processing speed shows the opposite pattern of relations. Finally, some studies in the literature have suggested that the relationship between comprehension and fluency is bidirectional (e.g., Klauda & Guthrie, 2008). Future studies should determine how the inclusion of such a parameter would impact the present findings.

Theoretical and Practical Implications

Silent reading fluency and vocabulary are often overlooked in studies modeling reading processes in elementary students, yet our results suggest they are important variables to include. As suggested by Share (2008), the split structural model provides evidence that oral and silent reading fluency are distinct constructs and should not be assumed to be equivalent in studies purporting to examine reading comprehension and reading development. These findings suggest the importance of differentiating between oral and silent reading fluency in assessment, especially as students reach the late elementary grades and the curriculum shifts from a focus on oral reading fluency and learning to read *to* silent reading fluency and reading to learn.

It is notable that, with the exception of word reading's contribution to the TOSCRF, none of the other subcomponent skills contributed significantly to the silent reading fluency measures. However, oral reading fluency did contribute significantly to the underlining measure. This may suggest that oral reading fluency, rather than the other early emerging reading subcomponent skills, is supporting the development of silent reading fluency. Future studies should further examine this finding.

Additionally, these results indicate that whereas students' skill in vocabulary may not be directly related to their facility with fluent reading of text, vocabulary does explain a sizeable portion of the variance in comprehension, even when controlling for fluency and other subcomponent skills. Vocabulary provides important information about the overall picture of reading development and should be considered when modeling the reading process. Additionally, as discussed earlier, this finding is consistent with previous works suggesting that children's comprehension is negatively impacted when texts contain hard or unfamiliar words (Rayner & Pollatsek, 1989), and that effective vocabulary instruction focused on target words increases children's comprehension of text (e.g., Pullen, Tuckwiller, Konold, Maynard, & Coyne, 2010). In sum, these results suggest that vocabulary should remain an important component of reading curricula, and that students' vocabulary should be assessed when deficits in reading, especially in reading comprehension, are noted.

Conclusion

The current study provides strong evidence that oral and silent reading fluency represent different constructs in late-elementary readers, and that each type of fluency is differentially related to comprehension. Specifically only oral reading fluency significantly contributes to comprehension in this sample of fourth-grade readers. Further, these findings suggest that the method of assessing silent reading fluency impacts the pattern of relationships amongst subcomponents of the reading process. However, further research is needed regarding this finding, perhaps including a third, paper-and-pencil measure of silent reading fluency to allow for the opportunity for a latent silent reading fluency factor. Finally, the current study provides additional evidence for the diminished contributions of lower-level reading skills (word reading, non-word reading, rapid automatic naming) towards comprehension in late elementary school students and for the importance of vocabulary above and beyond its relation to word reading and reading fluency.

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