The Contributions of Oral and Silent Reading Fluency to Reading Comprehension

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Abstract

Silent reading fluency has received limited attention in the school-based literatures across the past decade. We fill this gap by examining both oral and silent reading fluency and their relation to overall abilities in reading comprehension in fourth-grade students. Lower-level reading skills (word reading, rapid automatic naming) and vocabulary were included in structural equation models in order to determine their impact on reading fluency and comprehension. Results suggested that oral and silent reading fluency represent separate constructs, but only oral reading fluency contributed to reading comprehension. Vocabulary was found to contribute uniquely to comprehension even after controlling for reading fluency.

*Keywords*: silent reading fluency, oral reading fluency, reading comprehension, vocabulary
The Contribution of Oral and Silent Reading Fluency to Reading Comprehension

Oral reading fluency has recently received increased attention in the school-based literatures, even though it was once thought of as a neglected area in reading research (Kuhn, Schwanenflugel, & Meisinger, 2010). The prominence of research on oral reading fluency may be in part due to the information presented by the National Reading Panel (2000) outlining the importance of fluency instruction and attainment. Although interest in silent reading fluency has gradually increased over the past several years, it has not garnered the level of attention that oral reading fluency has secured with few studies having examined the similarities and differences between oral and silent reading fluency.

Oral reading provides several benefits for young readers. Children are likely to first be exposed to literacy by adults reading 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 (Chall, 1996). Oral reading also provides benefits 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 (Kuhn & Schwanenflugel, 2007), 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, as children reach the fourth grade they are expected to effectively transition to silent reading. Students should increasingly be able to read faster and with equivalent comprehension silently, no longer requiring the added support of oral reading (Hiebert et al.,
Fluent oral reading skills have been shown to emerge between the first and third grade (Chall, 1996; Kuhn & Stahl, 2003). However, far less research has been conducted on silent reading fluency. In fact, some researchers (Share, 2008) have suggested that the overarching dependence on oral reading provides an incomplete picture of both reading fluency and reading development. For instance, the emphasis on oral fluency might have led to an overestimation of the importance of phonological variables as well as overstated conclusions with regards to the cognitive processes underlying oral and silent reading. Further, eye tracking research has demonstrated that, in skilled readers, the eye tends to be ahead of the voice (Radach, Schmitten, Glover, & Huestegge, 2009; Rayner & Pollatsek, 1989). In short, even though oral reading fluency is an important skill in young readers, emphasizing oral reading fluency in research and its conclusions at the expense of silent reading fluency is undesirable.

Implicit in the current literature on reading fluency is the idea that oral reading fluency and silent reading fluency involve essentially the same processes (Share, 2008). English-language studies of reading within the school-based literatures have mostly been conducted using oral reading measures, and their 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 (Hiebert et al., 2012) 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 in late elementary students.
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 the literature is warranted. In the remainder of this section, the relation between reading fluency and reading comprehension will be discussed, the differences between oral and silent reading will be examined, and finally the reading subcomponents modeled in the present study will be presented.

**The Link between Reading Fluency and Reading Comprehension**

Comprehension represents the sine qua non of the reading process. As children transition from viewing reading as a word decoding exercise to a meaning construction endeavor (Sweet & Snow, 2003), they are increasingly required to utilize their developing comprehension skills to obtain knowledge both in and out of the classroom. Oral reading 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 oral 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 (Daane et al., 2005; Fuchs, Fuchs, & Maxwell, 1988; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Pinnell et al., 1995; Yovanoff, Duesbery, Alonzo, & Tindal, 2005).

Although researchers have been interested in the difference between oral and silent reading for decades (Jones, 1932), relatively few studies have examined comprehension differences between the two reading modes. Findings across such studies involving elementary students are somewhat varied, yet several themes have 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 typically have equivalent comprehension after either reading mode (Holmes, 1985; Salasso, 1986). Given the limited existent literature, further examination of oral and silent reading fluency with regard to reading comprehension seems warranted.

**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 to reading comprehension (Berninger et al., 2010; Kendeou, van den Broek, White, & Lynch, 2009; Ouellette & Beers, 2010; Schwanenflugel et al., 2006; Vellutino, Tunmer, Jaccard, & Chen, 2007). The majority of these studies have examined oral reading fluency in early elementary school students. Kim, Wagner, and Foster (2011) however examined the relations among oral reading fluency, silent reading fluency, and reading comprehension in a sample of first-grade students. Importantly, oral and silent fluency were found to represent distinct constructs, each predicting reading comprehension skill. The studies that have looked at older students (Barth, Catts, & Anthony, 2009) 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 as being important for reading fluency and reading comprehension including phonological awareness, word reading accuracy, naming speed, and vocabulary. Each of these subcomponents will be discussed along with available evidence regarding the relation of each to oral and silent reading fluency. It should be noted that given the limited number of studies on silent reading fluency, relatively little is known about the associations between these reading subcomponents and silent reading fluency.

**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). 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). Nonword decoding is often used as a way to measure student’s facility with letter knowledge, letter string, rime units, and speech sounds (Schwanenflugel et al., 2006) and can be used as an indicator of readers’ phonological processing skill (Siegel, 1993). 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.** 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. For example, automaticity at the word level is thought to facilitate fluent reading by freeing cognitive resources for use in comprehension. Indeed, word reading ability is moderately to strongly related to fluency and comprehension within the literature (Barth et al., 2009, Berninger et al., 2010; Ouellette & Beers, 2010; Vellutino, Fletcher, Snowling, & Scanlon, 2004; Vellutino et al., 2007). Although basic reading competencies such as phonological decoding 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 texts (Floyd, Meisinger, Gregg, & Keith, 2012; Jenkins & Jewell, 1993; Shinn, Good, Knutson, & Collins, 1992; Vellutino et al., 2007).
Naming speed. Students’ rapid automatic naming skill (RAN), or the ability to provide rapid, fluent verbal responses to visual information (e.g., naming letters or numbers), is related to reading development in general, and more specifically to oral reading fluency (Norton & Wolf, 2012; Wolf, Bowers, & Biddle, 2000) and word reading fluency (Schwanenflugel et al., 2006), although its unique contribution is less than that of word reading (Barth et al., 2009). The relation between rapid automatic naming and oral reading fluency is not surprising because children’s’ ability to produce oral language fluently in response to visual stimuli 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. 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 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 (Braze, Tabor, Shankweiler, & Mencl, 2007). The relations between vocabulary and oral and silent reading fluency have yet to be fully examined.

The Present Study

Few studies have carefully examined the relation between these subcomponents in oral and silent reading fluency and comprehension in the late elementary years. Although several studies have modeled oral reading fluency (Berninger et al., 2010; Kendeou et al., 2009;
Ouellette & Beers, 2010; Schwanenflugel et al., 2006; Vellutino et al., 2007), especially in relation to reading comprehension, the role of oral and silent reading fluency in the reading process is unclear. The present study addressed this important gap in the literature by examining both oral and silent reading fluency and their relation to overall abilities in reading comprehension in a normative sample of fourth-grade students. Specifically, the current study utilized structural equation modeling (SEM; Kline, 2010) to test the viability of various theoretical models depicting how oral reading fluency, silent reading fluency, and reading comprehension relate to one another and to various reading subcomponents. Two main research questions were addressed in the present study: (1) Do oral reading fluency and silent reading fluency represent distinct constructs? and (2) What is the relation between the reading subcomponents (i.e., word reading, nonword reading, rapid automatic naming, vocabulary) and oral and silent reading fluency and reading comprehension?

In order to investigate whether or not oral and silent reading fluency represent distinct constructs, two SEM models were compared. Consistent with the broader literature that conflates oral and silent reading fluency into a single construct, the singular model represented oral and silent reading fluency as a single latent variable contributing to reading comprehension (see Figure 1). In contrast, the split model represented both types of reading fluency as separate skills each contributing directly 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 also specified to contribute directly to silent reading fluency.

Next we investigated the relation between the reading subcomponents and oral and silent reading fluency and reading comprehension by adding the reading subcomponent skills (i.e., word reading, nonword reading, rapid automatic naming, vocabulary) to the structural equation
models. 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.

We predicted that (a) those subcomponents 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 public intermediate school located in the mid-south region of the United States. 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 56.2% Caucasian, 40.8% African American, 12.2% Hispanic, 2% multiracial, and 1% Asian or Pacific Islander. Approximately 52% of the school population was eligible for free or reduced lunch.

Measures

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 six fourth-grade expository passages available. Three passages are biographies of
famous Americans and three passages are descriptive science and social studies materials about various topics. The six selected passages were counterbalanced across the conditions using a Latin square procedure.

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

**Underlining.** In order to monitor online silent reading fluency, we used a measure that has been demonstrated to be a substitute for alternative measures of self-paced reading time (Price, Meisinger, D’Mello, & Louwerse, 2012). The underlining procedure was previously validated for use with late elementary-aged students (Price et al., 2012). As students read the passage, they underlined the text word-by-word in a smooth motion using a stylus while their underlining time (approximating their reading time) was recorded. 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 stylus position on the screen 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.). The software was specifically designed for the underlining task and was programmed in C# to run on the Windows Operating System and is available to researchers upon request. 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).

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. After the student finished reading each passage, eight comprehension questions related to the passage content were orally presented, and the student provided oral responses which were scored by the examiner as correct or incorrect based on provided criteria. These questions were used to gauge reading comprehension, and are described in greater detail in a subsequent section. A single raw score from the underlining measure was the 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 obtain 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 three minutes to draw lines or slashes between as many words as possible. The total score was derived from the number of correctly marked words. Reported 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 three seconds. Although standard administration of R-CBM oral reading fluency probes requires the administration of three passages, for the purpose of this study only two passages were administered in order to mirror the procedure for the underlining measure. The time required for 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, eight 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. These questions were used to gauge reading comprehension, and are described in detail in a subsequent section. A single raw score from the oral reading fluency passages was the mean number of words read correctly per minute across both passages. Reliability estimates for DIBELS Oral Reading Fluency ranged from .92 to .97; correlations with other measures of oral reading and reading comprehension have ranged from .52 to .91 (Shaw & Shaw, 2002).

**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 yielded 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. The split-half reliability coefficient for the Word Reading test was .98 for grade four; 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 (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. The split-half reliability coefficient for the Pseudoword decoding subtest was .97 for grade four; the validity estimate with the WIAT-2 (Wechsler, 2001) Pseudoword Decoding subtest was .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 three-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.**

*Gates–MacGinitie Reading Test, Fourth Edition.* 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 was accompanied by a series of multiple-choice questions. Students were 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).

*Reading Maze.* 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 and then had three minutes to read a grade-level passage and complete the task. No students
finished the passage in less than three minutes. Test–retest reliability estimates of .90 have been reported for maze tasks similar to the ones used in this study, and validity estimates have ranged from .77 to .85 for students in grades 3-5 (Fuchs & Fuchs, 1992).

*Qualitative Reading Inventory, Fourth Edition*. Each of the previously described comprehension measures provides a holistic estimate of students’ ability to comprehend written discourse. Additional comprehension questions corresponding to the QRI-4 passages (Leslie & Caldwell, 2006) were also administered following the silent and oral reading procedures described above in order to quantify students’ comprehension skills. The use of these additional questions allows for a direct measure of students’ comprehension following both oral and silent reading of passages. The QRI-4 provides eight comprehension questions for each passage: four explicit questions and four 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 participants’ 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 in order to address order effects. The TOSCRF, GMRT-4, and maze tasks were group-administered following the completion of the individual measures. Order of the tasks was counterbalanced across classes. 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 on all individually administered measures prior to the 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 gift (i.e., a pencil following the individual assessments and candy following the group-administered assessments) as a token of appreciation for participating in the study. Teachers received a gift card in appreciation of their participation in the study.

Analytic Technique

First, descriptive statistics and correlations were calculated in order to determine the data’s suitability for further analyses. 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 of the reading process. This technique allowed us to build models based on appropriate theory and then assess how the model fits the observed correlations among the variables. Parameters were estimated using maximum likelihood estimation, which is a commonly used and accepted approach. It is also considered to be the most accurate approach 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 fitted model. First, the model $\chi^2$ statistic associated with the $p$ value is reported, 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 $\chi^2$ represents 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 fits; 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 missed group-administered measures due to absence. Little’s Missing Completely at Random test (Little, 1988) was used to determine these data were missing completely at random and these participants were consequently dropped from the dataset. 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 normalcy. No out of range data points were found, but three additional missing data points were missing at random (attributed to examiner error; Tabachnick & Fidell, 2007). These single points were imputed using the multiple imputation technique available in PASW Statistics 18.

Several univariate outliers across measures were identified and were decreased to the level of the second highest score within that same measure following the procedures outlined in Tabachnick and Fidell (2007). Subsequent examinations of the recalculated z-scores for each of the measures indicated that there were no longer univariate outliers present ($z \leq 3.29$). Mahalanobis Distance was utilized in order to screen 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 \( z < 3.29 \); 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 multicollinearity or singularity (\( r < .80 \); Kline, 2010).

**Descriptive Statistics**

Descriptive statistics and intercorrelations between variables are presented in Table 1. Based on the 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. Overall, the patterns among the reading variables were largely what would be predicted with the exception of the underlining task. 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. In particular, the statistically significant but weak (\( r = .20 \)) relationship between the two silent reading fluency measures was surprising.

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). The current data set was considered ill-scaled according to this criterion. 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.
Rescaling 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 1. The means and standard deviations presented in Table 1 are those of the original, non-re-scaled raw scores; however, the re-scaled values were utilized for all further SEM analyses.

**Structural Equation Modeling**

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

**Evaluation of the measurement model.** Table 2 presents the fit indices for the singular fluency measurement model with two latent variables—(a) Reading Comprehension with four indicators (GMRT-4, Maze, oral QRI-4 questions, underlining QRI-4 questions) and (b) Reading Fluency with three indicators (ORF, underlining, TOSCRF). The singular measurement model demonstrated adequate fit, suggesting that it included viable latent factors to which structural components could be added. A second measurement model was tested that examined a latent Silent Reading Fluency factor with two indicators, the TOSCRF and the underlining measure scores. Although model fit was adequate, high standard errors for regression weights indicated disturbance that can probably be attributed to the significant but weak correlation between the TOSCRF and the underlining measure (see Table 1). 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 SEM 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 model in order to address the initial research question regarding whether oral reading fluency and silent reading fluency represent distinct constructs. Fit indices (see Table 2) for both models indicated 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, depicting oral and silent reading fluency as separate constructs, demonstrated a stronger – albeit slightly stronger -- fit to the data.

**Evaluation of the structural models with subcomponents skills.** Next, we turned our attention to addressing the second research question regarding the relations between the reading subcomponents (i.e., word reading, nonword reading, rapid automatic naming, vocabulary) and oral and silent reading fluency. Because the fit indices were rather similar and both the singular and split structural models indicated adequate fit, subcomponent skills were added to both structural models. This ensured 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 the singular and split structural models with subcomponent skills was deemed adequate (see Table 2). However, a comparison of the fit indices for both structural models indicated that in every case the split model represented stronger fit to the data. Notably, a comparison of the AIC values 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 singular model (113.4). Together these findings suggest that the split model, in which oral and silent reading fluency were represented as separate constructs, provided the best fit for our data and was therefore accepted as the most viable model.

Standardized direct, indirect, and total effects from the split model with subcomponents skills are presented in Table 3. 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, effect sizes above .15 are considered moderate, and effect sizes above .25 are considered large (Kline, 2010). In addition to Table 2, the split model is presented in Figure 3, and significant and nonsignificant paths are demarcated.

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 directly contributed significantly 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 \((all \leq |.11|)\). The fact 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. Also, the indirect effects for the subcomponent skills to reading comprehension (mediated by the reading fluency variables) were \textit{not} found to be statistically significant (see Table 3).

\textbf{Evaluation of alternative models.} Due to some surprising relations between the model variables (i.e., the weak relation between underlining and the TOSCRF) 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 are presented in Table 4, 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. Underlining was retained because of the significant contribution of oral reading fluency to this variable. In general, although the values for the fit indices indicated excellent fit to the data, in each case the fit indices were strongest for the original split model with the TOSCRF and the subcomponent skills. Because the AIC value is partially tied to the number of manifest variables present in the sample, the removal of the TOSCRF as a manifest variable reduces its appropriateness as a method of comparing models. Therefore, the AIC was not presented for that model in Table 4.
Second, a model was tested in which the TOSCRF was conceptualized as subcomponent skill contributing directly to the underlining and the oral reading fluency measure. This is in contrast to previous models where the TOSCRF served as a mediator between the subcomponent skills and reading comprehension. This model tested the hypothesis that the TOSCRF is more akin to a silent word reading fluency measure as opposed to a silent text reading measure. Again, although the fit indices indicated adequate fit to the data (see Table 4) across all indices the values for the original split model with subcomponent skills were stronger. In this comparison, the split model and the model with the TOSCRF as a subcomponent had the same number of manifest variables and therefore the AIC was used an appropriate comparative index. Notably, the AIC scores indicated that the split model (AIC = 105.5) had stronger fit to the data than did the TOSCRF subcomponent model (106.5). Across all SEM models tested, consistently stronger fit indices suggested that the split model provided a more viable explanation for the data than did the singular or alternative models.

Discussion

Although oral reading fluency has received considerable attention in the school-based literatures across the past decade, silent reading fluency has remained largely overlooked. The present study contributed to our understanding of reading processes by utilizing structural equation modeling to examine both types of 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 models in order to determine how these additional skill sets support fluency and comprehension.

Do Oral and Silent Reading Fluency Represent Separate Constructs?
The initial research question addressed whether oral and silent reading represent distinct constructs in a normative sample of fourth-grade students. It is largely assumed that oral and silent reading involve essentially the same processes, but recently researchers have advocated for the need to understand the unique role of silent reading fluency (Hiebert et al., 2012; Share, 2008). Consistent across analyses, models that split oral and silent reading into separate constructs provided a better fit to our data. These fluency-specific results are consistent with the limited extent literature on silent reading fluency and support the depiction of oral and silent reading as separate constructs (Kim et al., 2011).

Our results also indicated that oral reading fluency contributed significantly to comprehension, which is consistent with findings across a variety of diverse samples from students ranging from the primary to the secondary grades (Daane et al., 2005; Fuchs et al., 1988; Jenkins et al., 2003; Pinnell et al., 1995; Yavanoff et al., 2005). This finding was supported at the holistic level, as oral reading was more predictive of students’ reading comprehension within the structural equation models. Further, students participating in this study 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 1).

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). An important caveat should be noted, however. Interestingly, the two silent reading fluency measures used in this study 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 was a more ecologically valid passage reading task whereas the TOSCRF was less similar to everyday silent reading tasks as it required students to identify and demarcate individual words within text.

**The Relation of Subcomponent Skills to Reading Fluency and Reading Comprehension**

The second aim of this study was to examine the contributions of various subcomponent skills to oral and silent reading fluency and reading comprehension in late elementary readers. The inclusion of these variables provided a more comprehensive model of the reading process. Although several previous studies have examined these subcomponent skills and how they contribute to oral reading fluency, reading comprehension, or both, few studies have incorporated silent reading fluency in such investigations. Specifically, we predicted that (a) those subcomponents 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. An examination of the model parameters suggested that rapid automatic naming, nonword reading, and word reading (measures that required oral production of text) each contributed significantly to the oral reading fluency measure. Also consistent with our hypotheses, different patterns were observed with regard to silent reading fluency. None of the subcomponent skills contributed significantly to the underlining measure, and only the word reading task contributed significantly to the TOSCRF. However, oral reading fluency did
contribute significantly to the underlying 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.

Importantly, 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 the examination of reading development (Berninger et al., 2010; Ouellette & Beers, 2010).

With the exception of vocabulary, the impact of the subcomponent skills on comprehension was lower than their effect on reading fluency. Indeed, after taking into account oral and silent reading fluency, the rapid automatic naming, nonword reading, and word reading variables did not contribute significantly to reading comprehension. 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 texts (Floyd et al., 2012; Jenkins & Jewell, 1993; 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).
Limitations and Future Directions

The current study contributes to the literature regarding students’ reading fluency, vocabulary, and comprehension development in late elementary school. There are however limitations that are worth pointing out. 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 longitudinal sample of older readers (e.g., fifth and sixth grade) would provide important information about developmental changes in this age group. Our results provide additional evidence to support the conceptualization of oral and silent reading fluency as separate constructs, but the data further indicate that students in the current sample had not yet fully transitioned to silent reading for comprehension.

A rather extensive battery of reading assessments was employed in this study, but some factors which may provide additional information about reading development were not examined. For example, inclusion of a non-verbal processing speed measure 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. Two measures of students’ silent reading fluency were included in the present study, but these measures did not provide a stable factor. As discussed previously, they might have been measuring different aspects of silent reading fluency (i.e., word vs. text fluency). Future studies should examine whether another text silent reading fluency assessment such as a traditional paper-and-pencil measure (see Price et al., 2012) would shed light on this issue. Finally, some studies in the literature have suggested that
the relationship between comprehension and fluency is bidirectional (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. Furthermore, our findings suggest the importance of differentiating between oral and silent reading fluency interventions, 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. Although our data suggest that proficient oral reading may support the development of proficient silent reading, oral reading should not be allowed to subsume its silent counterpart. Additionally, it may be necessary to provide additional support or interventions specific to silent reading (Scaffolded Silent Reading; Hiebert et al., 2012) to fourth-grade students if they are expected to independently read “in their head” and gain content area knowledge from texts.

Our results also suggest that vocabulary provides important information about the overall picture of reading development and should be considered when modeling the reading process. 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 (Pullen, Tuckwiller, Konold, Maynard, & Coyne, 2010). In sum, these results suggest that vocabulary should remain an important component of reading curricula, and models overlooking vocabulary may provide an incomplete picture of the reading process.
Conclusion

The emphasis on oral reading fluency in the school-based literatures could have been explained by the fact that both types of reading fluency should be considered as a single construct. However, the current study provides 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. Interestingly, for the fourth-grade students who participated in this study, oral rather than silent reading fluency was supporting effective comprehension. Additional research is needed to elucidate the developmental relation between silent reading fluency and reading comprehension to ensure curricular goals are consistent with students’ reading development.
References


Footnotes

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 dropped from the study, and therefore each student read only four of the six possible QRI-4 passages. Students were equally likely to read any combination of the four passages across the remaining oral reading fluency and underlining tasks. Permission was obtained from the test publisher to present the QRI-4 passages on a Tablet PC during the underlining task.

2 Two passages were administered for each measure in order for the six fourth-grade QRI-4 passages to be utilized. Additionally, a third passage was not administered due to concerns about the length of testing time.

3 The final models were run with and without the missing participants and results were comparable, which suggests the removal of these eight participants did not have a large impact on the final results.
Figure 1. The singular model which represents reading fluency as a single construct.

Figure 2. The split model specifies two separate reading fluency constructs: oral reading fluency and silent reading fluency.
Figure 3. 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.
Table 1

Correlations, Covariances, and Descriptive Statistics

<table>
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<td>.30**</td>
<td>.50**</td>
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<td>.48**</td>
<td>.36**</td>
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<td>.17</td>
<td>.19</td>
<td>.37**</td>
<td>.27**</td>
<td>.30**</td>
<td>.31**</td>
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<td>.12</td>
<td>.30**</td>
<td>--</td>
<td>97.9</td>
<td>11.1</td>
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Original S² | 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 S² | 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 comprehension questions for underlining; 7. ORF Q = QRI-4 comprehension questions for oral reading; 8. WR = WIAT-3 Word Reading;
Table 1 Note continued. 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.

** $p < .01$, * $p < .05$. 
Table 2

*Fit Indices for Each of the Fitted Models*

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<tr>
<th>Model</th>
<th>$X^2$</th>
<th>df</th>
<th>$p_{X^2}$</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA (90% CI)</th>
<th>SRMR</th>
<th>AIC</th>
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<td>.97</td>
<td>.94</td>
<td>.06 (.00-.12)</td>
<td>.07</td>
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<td>12</td>
<td>.18</td>
<td>.97</td>
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<td>.06 (.00-.12)</td>
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<td>.03</td>
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<td>.07 (.02-.11)</td>
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<td>.44</td>
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<td>1.00</td>
<td>.01 (.00-.08)</td>
<td>.06</td>
<td>105.5</td>
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*Note.* CI = confidence interval
Table 3
*Standardized Direct, Indirect, and Total Effects on Reading Comprehension for the Split Structural Model with Subcomponent Skills*

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<th>Exogenous Variables</th>
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<th>To TOSCRF</th>
<th>To Underlining</th>
<th>To Comprehension</th>
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<td>.13</td>
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<td></td>
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<td>.07</td>
<td>.62</td>
<td>.46</td>
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</table>

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

**p < .01, *p < .05.
Table 4

Fit Indices for Each of the Fitted Alternative Models

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<th>$p^2$</th>
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<td>1.00</td>
<td>.01 (.00-.08)</td>
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<td></td>
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</tbody>
</table>

*Note. CI = confidence interval*