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A Model-Based Meta-Analytic Examination of Specific Reading Comprehension Deficit: How Prevalent Is It and Does the Simple View of Reading Account for It?

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Abstract

Many individuals with poor reading comprehension have levels of reading comprehension that are consistent with deficits in their ability to decode the words on the page. However, there are individuals who are poor at reading comprehension despite being adequate at decoding. This phenomenon is referred to as specific reading comprehension deficit (SRCD). The two purposes of this study were to use a new approach to estimate the prevalence of SRCD and to examine the extent to which SRCD can be explained by the simple view of reading. We used model-based meta-analysis of correlation matrices from standardized tests to create composite correlation matrices for the constructs of reading comprehension, decoding, and listening comprehension. Using simulated datasets generated from the composite correlation matrices, we used residuals from regressing reading comprehension on decoding to create a continuous index of SRCD. The prevalence of SRCD is best represented not as a single number but as a continuous distribution in which prevalence varies as a function of the magnitude of the severity of the deficit in reading comprehension relative to the level of decoding. Examining the joint distribution of the residuals with reading comprehension makes clear that the phenomenon of reading comprehension that is poor relative to decoding occurs throughout the distribution of reading comprehension skill. Although the simple view of reading predictors of listening comprehension and decoding make significant contributions to predicting reading comprehension, nearly half of the variance is unaccounted for.

Keywords

specific reading comprehension deficit; prevalence; meta-analysis

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Reading comprehension refers to engaging with text for the purpose of extracting and constructing meaning (Snow, 2002). How well one reads for comprehension is predictive of success in school and in future occupations (National Institute of Child Health and Human Development, 2000; Snow, 2002). Unfortunately, problems comprehending what one reads

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are relatively common. In the United States, for example, only about a third of fourth- and eighth-grade students score at or above proficiency in reading comprehension (National Assessment of Educational Progress, 2019).

For many individuals with poor reading comprehension, their levels of reading comprehension are consistent with deficits in their ability to read the words on the page. However, there are individuals who are poor at reading comprehension despite being adequate at decoding (Nation & Snowling, 1997). Because their deficit is specific to comprehension rather than general to both decoding and comprehension, this phenomenon is commonly referred to as specific reading comprehension deficit (SRCD) (Oakhill et al., 1986; Nation & Snowling, 1998). The two purposes of the current study were to use a new approach to estimate the prevalence of SRCD and to determine how well the simple view of reading accounts for it.

Specific Reading Comprehension Deficit

SRCD refers to impaired comprehension despite adequate decoding (Nation & Snowling, 1997; Stothard & Hulme, 1995; Yuill & Oakhill, 1991). In a meta-analysis of the literature (Spencer & Wagner, 2018), four operational definitions of SRCD were identified that have been used in primary studies: (1) discrepancy between reading comprehension and decoding (e.g., Isakson & Miller, 1976; Nation & Snowling, 1998; Oakhill et al., 1986; Pimperton & Nation, 2010); (2) discrepancy between reading comprehension and decoding with the stipulation that decoding skills are within the normal range (e.g., Cain et al., 2001; Cataldo & Oakhill, 2000; Cragg & Nation, 2006; Torppa et al., 2007); (3) discrepancy between reading comprehension and decoding, decoding skills are within the normal range, and reading comprehension is discrepant from chronological age (e.g., Cain, 2003, 2006; Cain et al., 2000, 2003, 2004; Cain & Oakhill, 2006, 2011; Cain & Towse, 2008; Clarke, 2009; Marshall & Nation, 2003; Nation & Snowling, 1997, 2000; Nation et al., 2001; Oakhill et al., 2005; Spooner et al., 2006; Stothard & Hulme, 1995; Yuill, 2009; Yuill & Oakhill, 1991); and (4) discrepancy between reading comprehension and decoding, decoding skills are in the normal range, and reading comprehension scores fall below a given percentile or cut point (e.g., Cain & Towse, 2008; Carretti et al., 2014; Catts et al., 2006; Henderson et al., 2013; Kasperski & Katzir, 2013; Megherbi et al., 2006; Nation et al., 2004, 2007; Nesi et al.,2006; Pelegrina et al., 2014; Pimperton & Nation, 2014; Ricketts et al., 2007; Shankweiler et al., 1999; Tong et al., 2011, 2014). What is common to the four operational definitions and the central feature of SRCD is a discrepancy between reading comprehension and decoding.

Results from a large-scale study support the existence of substantial numbers of students who are poor at reading comprehension yet adequate at decoding (Spencer et al., 2014). Participants consisted of 3 cohorts of first (N = 143,672), second (N = 135,943), and third (N = 144,815) grade students who were attending Reading First schools in a large southeastern state in the US. Reading First was a large, federally funded initiative designed to improve reading performance of students at risk for reading problems in high-poverty schools. A three-step procedure was used. First, students who were poor at reading comprehension were identified using the operational definition of scoring at or below the 5th percentile on a test of reading comprehension. Second, students who were poor at reading comprehension yet adequate at decoding were identified by retaining students who scored at or above the 25th percentile on a measure of decoding. Third, students who were poor at reading comprehension yet adequate at both decoding and vocabulary were identified by retaining students who scored at or above the 25th percentile on a measure of vocabulary.

The results were different for first-grade students compared to second- and third-grade students. Of the 5,286 first-grade students who were poor at reading comprehension, only 548 (10 percent) were adequate at decoding and only 173 (3 percent) were adequate at both decoding and vocabulary. One year later, 2,731 (58 percent) of the 4,716 students who were poor at decoding initially were adequate at decoding by second grade. However, only 235 (5 percent) were adequate at decoding and vocabulary. For third grade, a measure of reading comprehension and a combined measure of decoding and vocabulary were available, which meant that is was possible to determine how many students who were poor at reading comprehension were adequate at both decoding and vocabulary, but not who were adequate in decoding only. Of the 3,830 students who were poor at reading comprehension, 309 (8 percent) were adequate at both decoding and vocabulary. In summary, although most first-grade students who are poor at reading comprehension are also poor at decoding, by second grade over half of the poor comprehenders were adequate at decoding. At all three grade levels, very few students who were poor at reading comprehension were adequate at both decoding and vocabulary. These results are consistent with the simple view of reading if vocabulary serves as a proxy for linguistic comprehension.

There were two limitations of the (Spencer et al., 2014) study, however. First, the sample consisted of students from schools that served primarily at-risk readers from schools with high rates of poverty who are known to have a higher rate of oral language deficits compared to students from typical schools. Consequently, the results might not generalize beyond studies of at-risk readers. Second, they did not examine the magnitudes of deficits that were observed but merely reported frequency counts of whether a deficit existed or not. To address these limitations, two meta-analyses and one large-scale study of SRCD were carried out (Spencer & Wagner, 2017, 2018; Spencer et al., 2019). The results of all three studies challenge the idea, based on the simple view of reading, that poor linguistic comprehension fully explains the reading comprehension problems of individuals who are adequate at decoding. Although deficits in linguistic comprehension were found in each of the three studies, the magnitude of the deficit in reading comprehension was approximately three times greater than the deficit in linguistic comprehension.

A large-scale study by Catts et al. (2006) also challenges the simple view of reading account of SRCD. Because their sample was part of a larger epidemiologic study of language impairments in children (Tomblin et al., 1997), it was possible to determine the percentage of students with poor reading comprehension who met criteria for either developmental language disorder or nonspecific language impairment. The results showed that only a third of the sample of students with poor reading comprehension met criteria for either type of language impairment.

Prevalence of SCRD

How prevalent is SRCD? Answering this question is important for at least two reasons. The first is that knowing the prevalence of any condition or disorder is important for policy and planning purposes. It matters for policy and practice whether a condition is found to a substantial degree in 1 out of 7, 1 out of 20, or 1 out of 1,000 individuals. Second, knowing prevalence can be useful for Bayesian-based identification models. In the absence of completely informative test data, Bayesian-based identification models can be more accurate than models based on frequentist statistics by incorporating prevalence into the model as a base rate that is updated with results from tests and other sources of information (Congdon, 2003; Gelman et al., 1995; Robeva et al., 2004).

Estimates of the prevalence of SCRD vary widely, ranging from 8% to 15% of 7 to 14-year-old children (Keenan et al., 2014; Nation & Snowling, 1997; Stothard & Hulme, 1995; Yuill & Oakhill, 1991). However, these estimates vary as a function of the stringency of the criteria used for identification (Rønberg & Petersen, 2015) and on the specific operational definition used. Prevalence estimates that vary as a function of the stringency of the criteria used for identification have also been found for word-level reading disability (Fletcher et al., 2019). Until recently, different degrees of stringency of the criteria used for identification have served only to explain the variability in prevalence estimates. However, a new approach to modeling the prevalence of word-level reading disability was proposed that incorporates the severity of the problem into the model (Wagner et al., 2019, 2020). Rather than conceptualize prevalence as a single number, prevalence was conceptualized as a distribution of values that vary as a function of severity. How this new conceptualization of prevalence might be applied to SCRD was a motivation for the present study.

How Well Does the Simple View of Reading Account for SRCD?

According to the simple view of reading, reading comprehension is the product of decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). This view provides the basis for a classification of readers (see Figure 1) by whether they are good or poor in decoding and in linguistic comprehension (Catts et al., 2003, 2006; Nation & Norbury, 2005). Individuals with deficits in word recognition but with normal language comprehension are classified as having dyslexia. Individuals who have problems in language comprehension but not in decoding are classified as having specific comprehension deficit. Individuals who are good in both word recognition and language comprehension are classified as having no impairment. Individuals who are poor in both are classified as having a mixed deficit.

Although four discrete categories are depicted in Figure 1, strengths and weaknesses in word recognition and linguistic comprehension are conceptualized by Catts et al. (2006) to be dimensional rather than categorical. For this conceptualization, the horizontal line in Figure 1 represents the dimension of poor to good word recognition and the vertical line represents the dimension of poor to good linguistic comprehension. Members of a category who are prototypical members of the category would be found in the corners of the figure whereas less prototypical members of a category would be found more towards the center of the figure.

How well the simple view of reading explains SRCD remains an open question. On the one hand, if the reading comprehension deficit characteristic of SRCD is caused by a comparable deficit in linguistic comprehension, the simple view of reading is likely to provide an adequate account of SRCD. On the other hand, some accounts of SRCD suggest that the magnitude of the reading comprehension deficit is three times as large as any deficit in linguistic comprehension (Spencer & Wagner, 2017, 2018; Spencer et al., 2019). These results would appear to present a problem for the simple view of reading. However, an interaction between decoding and linguistic comprehension is implied by the simple view of reading. It is possible that minor deficits in decoding and linguistic comprehension interact to produce a more severe deficit in reading comprehension.

The Present Study

The two purposes of the study were to use a new approach to estimate the prevalence of SRCD and to examine the extent to which SRCD can be accounted for by the simple view of reading. For the new approach to estimate the prevalence of SRCD, the main research questions were whether the approach would work, what the parameters of the distribution would be, and what percentages of cases at various levels of poor reading comprehension were adequate at various levels of decoding? For examining the extent to which SRCD is accounted for by the simple view of reading, the main research question was how much of the variance in reading comprehension not attributable to decoding was accounted for by linguistic comprehension and by the interaction of decoding and linguistic comprehension?

To increase the likelihood of generating replicable results, we used model-based meta-analysis (Becker & Aloe, 2019). Unlike traditional meta-analysis that cumulates individual effects, model-based meta-analysis is a multivariate approach that cumulates correlation matrices and results in a composite correlation matrix upon which additional analyses can be performed. Examples of using model-based meta-analysis followed up by structural equation modeling to study component predictors of literacy are provided by Quinn and Wagner (2018) and Ahmed (2014).

To obtain unbiased estimates of the needed correlations, we carried out a meta-analysis of nationally normed standardized tests. We chose nationally normed tests for four main reasons. First, the reported correlations are not likely to be inflated by publication bias. Publication bias refers to the fact that studies with significant results are more likely to be published than studies with non-significant results (Cooper et al., 2019). Publication bias can inflate parameter estimates because large estimates are more likely to be statistically significant. Because tests are not subject to peer-review and the key results are not limited to significance testing, publication bias is minimized. Second, the samples are large and nationally representative. Third, standardized tests represent an independent source of data. Standardized tests do not typically show up in conventional meta-analytic searches. For example, no standardized tests were identified in the searches carried out by Quinn and Wagner's (2018) model-based meta-analysis of relations between language and literacy. If they were included in a typical meta-analysis, their large sample sizes would drown out the contributions of typical correlational studies because composite effect sizes are weighted by sample size. Fourth and finally, reliability data based on substantial sample sizes is available for standardized tests. Reliabilities can be used to disattenuate correlations for unreliability. Because unreliability will produce observed correlations that are underestimates of population correlations when variables are measured without error, it was important to determine whether the pattern of results obtained from the composite correlations based on observed correlations from the studies was comparable to the pattern of results obtained from composite correlations based on correlations corrected for unreliability.

Method

Model-based meta-analysis was used to produce a composite correlation matrix for the constructs of reading comprehension, listening comprehension, and decoding.[1] An initial search was attempted using the search terms *standardized measure(s)* and *norm referenced* and *reading* and *English* and *intercorrelation*, as well as search combinations with *decoding, listening comprehension, reading comprehension and phono**. The ProQuest, ERIC, Google Scholar and PubMed databases were used. The search was not productive, in that a large number of articles was returned but they did not provide specific assessments meeting the search requirements. We revised our search by carrying out a Google search using the search string *standardized measures of reading*. This search yielded the Southwest Educational Development Laboratory (SEDL) reading assessment database (www.sedl.org/reading/rad/list.html). We then found more assessments from an early reading assessment guiding tool on the Reading Rockets website (www.readingrockets.org) and from the Wrightslaw reading assessment list (www.wrightslaw.com/bks/aat/ch6.reading.pdf).

The search yielded 91 assessments. Six inclusionary criteria were applied to the assessments: (1) norm referenced; (2) nationally representative norming sample; (3) in English; (4) included subtests measuring listening comprehension, reading comprehension, vocabulary, decoding, and phonological awareness; (5) correlation matrix of subtests and subtest reliability available; and (6) included data from multiple ages or grades. Seven assessments met the inclusionary criteria.

Data Analysis Plan

The ‘metaSEM’ package in R (Cheung, 2015) was used for the analyses. This is a two-stage, structural equation modeling approach (TSSEM) in which the first stage involves calculation of a composite correlation matrix and the second stage involves modeling using the composite correlation matrix as data. Next, we created a simulated dataset with 5,000 observations and three variables representing reading comprehension, listening comprehension, and decoding. This was done using a syntax script (available from the first author) in SPSS version 25 software (IBM Corp., 2017). The syntax script matrix includes

[1]This meta-analysis was carried out as part of a larger project. The correlation between reading and listening comprehension from this meta-analysis is the basis of analyses reported by (Wagner et al., 2020) in a study of the prevalence of dyslexia. Phonological awareness and vocabulary were not included in the present study.

data to be read in the composite correlation matrix, a loop to create vectors of random values for as many cases as desired, a factor procedure to generate uncorrelated principal components, and a matrix procedure to transform the uncorrelated variables to a set of correlated values that match the correlations in the composite correlation matrix. As a final test, correlations are run on the simulated dataset to see whether they match the correlations in the composite correlation matrix.

Results

Included Assessments

The following standardized tests were included in the meta-analysis.

The Wechsler Individual Achievement Test – III (WIAT III)—The WIAT III is an individually administered measure for students in pre-Kindergarten through grade 12. The Reading Comprehension, Listening Comprehension, and Pseudoword Decoding subtests were used in the present study. The Reading Comprehension subtest requires examinees to read passages and answer questions. The Listening Comprehension subtest requires examinees to listen to passages read aloud and then answer questions. The Pseudoword Decoding subtest requires examinees to read a list of nonwords and is untimed. Average split-half reliabilities were .87 for Reading Comprehension, .84 for Listening Comprehension, and .96 for Pseudoword Decoding. Extensive validity data are available in the technical manual (Breaux, 2009).

The Woodcock Reading Mastery Tests – Third Edition (WRMT III)—The WRMT III is administered individually for students in pre-Kindergarten to grade 12. The Passage Comprehension, Listening Comprehension and Word Attack subtests were included in current study. Passage Comprehension is a cloze task that requires examinees to read a sentence or short passage and select the correct missing word for that sentence or short passage. Listening Comprehension requires examinees to listen to orally presented passages (read by the administrator or by audio CD depending on age) and answer questions about the passage. Word Attack requires the examinee to read a list of nonsense words and is untimed. Average alternate form and test-retest reliabilities were .87, .83., and .96 for the Passage Comprehension, Listening Comprehension and Word Attack subtests, respectively. Extensive validity data are available in the technical manual (Woodcock, 2011).

Kaufman Test of Educational Achievement – Third Edition (KTEA III)—The KTEA III is an individually administered as battery of tests for individuals ages 4 to 25 years. The subtests we utilized for this analysis were Reading Comprehension, Listening Comprehension, and Nonsense Word Decoding. Depending on age, the Reading Comprehension subtest requires examinees to match a symbol or word with a picture, read sentences and follow directions, or read passages and answer questions. The Listening Comprehension subtest requires examinees to listen to passages and answer questions. The Nonsense Word Decoding subtest requires examinees to read a list of nonsense words in a specified amount of time. Average split-half reliabilities were .88, .94, and .96 for the Reading Comprehension, Listening Comprehension, and Nonsense Word Decoding subtests, respectively. Extensive validity data are available in the technical manual (Kaufman et al, 2014).

The Early Reading Diagnostic Assessment Second Edition (ERDA II)—The ERDA II is an individually administered measure for students in Kindergarten through grade 3. We used the Reading Comprehension, Listening Comprehension and Pseudoword Decoding subtests in the current analysis. The Reading Comprehension subtest requires examinees to match a word to a picture (younger children) or read a passage and answer corresponding questions (older children). The Listening Comprehension subtest requires examinees to answer questions about orally presented passages. The Pseudoword Decoding subtest requires examinees to read lists of nonsense words and is untimed. Developers reported test retest reliabilities by grades. Average reliabilities were .86, .81, and .95 for the Reading Comprehension, Listening Comprehension, and Pseudoword Decoding subtests, respectively. Extensive validity data are available in the technical manual (Pearson, 2003).

The Woodcock Johnson IV (WJIV)—The WJ IV is an individually administered set of measures for individuals ages 2 to 80+ years. We used the Passage Comprehension, Oral Comprehension and Word Attack subtests. The Passage Comprehension subtest is a cloze task that requires examinees to read sentences and passages and supply a missing word. The Oral Comprehension subtest requires examinees to supplying a missing word for orally presented sentences or passages. The Word Attack subtest requires examinees to read a list of nonsense word and is untimed. Average split-half reliabilities were .88, .80, and .94 for the Passage Comprehension, Oral Comprehension, and Word Attack subtests, respectively. Extensive validity data are available in the technical manual (McGrew et al, 2011).

The Iowa Test of Basic Skills (ITBS)—The ITBS is a group administered measure consisting of multiple-choice questions. We used the Reading Comprehension, Listening, and Word Analysis subtests. The Reading Comprehension subtest requires examinees to answer questions about picture stories, sentences, and passages. The Listening subtest requires examinees to answer questions about passages read aloud by the examiner. The Word Analysis subtest requires letter recognition, decoding skills, and sound and word structure. Average reliabilities (test-retest and Kuder-Richardson Formula 20 [KR20]) were .88 for Reading Comprehension, .77 for Listening and .90 for Word Analysis. Extensive validity data are available in the technical manual (Hoover et al, 2003).

Stanford Achievement Test Series Tenth Edition (SAT 10)—The SAT 10 is a group administered multiple-choice measure for students in Kindergarten through grade 12. We included the Reading Comprehension, Listening Comprehension, and Word Study Skills subtests. The Reading Comprehension subtest requires examinees to read materials from literary, informational, and functional sources and answer questions about them. The Listening Comprehension subtest requires examinees to answer question about orally presented passages. The Word Study Skills subtest requires examinees to make selections based on the analysis of sounds, letters, and structure of words. Average KR20 reliabilities were .89, .80, and .87 for the Reading Comprehension, Listening Comprehension, and Word

Study Skills subtests, respectively. Extensive validity data are available in the technical manual (Harcourt, 2004).

Composite Correlation Matrices

The correlations obtained between reading comprehension, listening comprehension, and decoding from the primary studies are presented in Table 1. Also included are reliability coefficients and correlations after correction for unreliability. We used the formula for disattenuating correlations for unreliability (i.e., the estimated correlation between true scores equals the observed correlation divided by the square root of the product of the reliabilities of the two variables) to calculate correlation coefficients corrected for unreliability.

A multivariate random effects model yielded the composite correlation matrix below the diagonal in Table 2. The choice of a random effects model was supported by significant tau-squared estimates of heterogeneity of population effect sizes for all but one of the elements in the composite correlation matrix. Whereas a fixed-effects model assumes there is a single population effect size that can be estimated from all studies in the meta-analysis, a random-effects model assumes there is not one, but rather a distribution of effect sizes in the population. The variance of this distribution is what is estimated by tau-squared. The significant Q value of 48356.0 ($df = 120$, $p < .001$) indicates the presence of significantly more variability in effect sizes across studies than would be expected on the basis of sampling error, which also supports the choice of a random-effects model. Finally, the I-squared values, which represent the percentage of variance in estimates across studies that is not due to sampling error ranged from 97% to 99%, which also supports the choice of a random effects model.

We carried out a comparable set of analyses on the correlations that had been disattenuated for unreliability. The resultant composite correlation matrix is presented above the diagonal in Table 2. The choice of a random effects model again was supported by significant tau-squared estimates of heterogeneity of population effect sizes for all but one of the elements in the composite correlation matrix, the significant Q value of 4911.6 ($df = 120$, $p < .001$), and the I-squared values ranging from 97% to 98%. There was little difference between composite correlations derived from observed correlations and those derived from correlations corrected for unreliability, with an average difference in correlations less than .03.

A Two-Dimensional Representation of the Four Kinds of Readers

Recall that word recognition and language comprehension were used to categorize readers into the four categories depicted in Figure 1, but it was assumed that a better representation was as a continuously distributed two-dimensional space (Catts et al., 2006). An analogous two-dimensional space was created in a scatterplot (Figure 2) with listening comprehension representing the language comprehension dimension and decoding representing word-level reading dimension. To visualize the four kinds of readers in the two-dimensional space, the vertical line splits the decoding variable into upper and lower halves. The horizontal line splits the listening comprehension variable into upper and lower halves. The upper left quadrant represents dyslexia with above average listening comprehension and below average decoding. The upper right quadrant represents no impairment with above average listening comprehension and decoding. The lower left quadrant represents mixed deficit with below average listening comprehension and decoding. The lower right quadrant represents specific comprehension deficit with above average decoding and below average listening comprehension. The further away points are from the center of the figure out into one of the quadrants, the more representative they are of the quadrant. Points relatively near the center regardless of which quadrant they are in would not be strongly representative of any of the quadrants but rather cases that are in the average range for both decoding and listening comprehension.

Note the multinormal joint distribution of listening comprehension and decoding and the positive correlation between them. The positive correlation is represented by the positive slope of a line of best fit drawn through the distribution. In general, cases that are high in listening comprehension tend to be high in decoding, and conversely, cases that are low in listening comprehension tend to be low in decoding. An alternative but related conceptualization of the upper right quadrant would be good readers instead of no impairment. An alternative conceptualization of the lower left quadrant would be poor readers instead of mixed deficit.

Prevalence of SRCD

We then cross-tabulated the distributions of decoding and reading comprehension to examine the proportion of cases that met four levels of poor reading comprehension and that also met the three levels of adequate decoding. Analysis of the frequency distribution of the variables enabled us to determine the values of poor reading comprehension that corresponded to the 20th, 15th, 10th, and 5th percentiles levels of performance. Four binary variables were added to the dataset that represented scoring at the four percentiles just mentioned as indicators of poor reading comprehension. The same procedure was used to determine the values of decoding that corresponded to the 50th, 40th, and 30th percentiles. Three binary variables were added to the dataset that represented scoring at or above the three percentiles just mentioned as indicators of adequate decoding.

These results are presented in Table 3. The percentages of cases that met criteria for poor reading comprehension yet adequate decoding varied systematically. The lowest percentage (8 percent) was found for the most extreme deficit in reading comprehension (5th percentile) and the highest level of adequate decoding (at or above the 50th percentile). The highest percentage (36 percent) was found for the least extreme deficit in reading comprehension (20th percentile) and the lowest level of adequate decoding (at or above the 30th percentile). Percentages of poor comprehenders who were adequate decoders went down as the criterion for poor reading comprehension became more severe (i.e., moving down the columns in Table 3). Percentages of poor comprehenders who were adequate decoders went up as the criterion for adequate decoding became less stringent (i.e., moving across rows in Table 3). The pattern of results depicted in Table 3 supports the underlying continuous nature of relations between reading comprehension and decoding.

To better examine this underlying continuous distribution, a hierarchical multiple regression was carried out with decoding, listening comprehension, and their interaction as predictors of reading comprehension. The results relevant here are those of the first step in which reading comprehension was predicted by decoding only. These regression results are presented at the top of Table 4. Standardized estimates (β) are reported. The results on the left side of the Table 4 were based on the composite correlation matrix generated from observed correlations. The results on the right side of the Table 4 were based on the composite correlation matrix generated from the correlations that were disattenuated for unreliability.

For analyses based on the composite correlation matrix generated from observed correlations, decoding accounted for a significant 35 percent of the variance in reading comprehension. The unstandardized residuals were used as an index of SRCD as they represent variance in reading comprehension independent of decoding. Their distribution is presented in Figure 3. The unstandardized residuals had a mean of 0 and a standard deviation of 0.806. Residuals below the mean of zero represented reading comprehension lower than predicted by decoding, with larger negative residuals indicating larger deficits in reading comprehension relative to predicted levels based on decoding.

To relate the joint distributions of the unstandardized residuals and of reading comprehension, a scatterplot of unstandardized residuals with reading comprehension is presented in Figure 4. The scatterplot accurately portrays the relation between residuals and reading comprehension as a two-dimensional space. But to provide points of reference, a vertical line was added that represents the 20th percentile of scores in reading comprehension. Points to the left of the vertical line represent the poor reading comprehension defined by scoring at the 20th percentile. A diagonal line was added that represents the 20th percentile of the residuals. Points below the diagonal line represent reading comprehension worse than predicted by decoding defined by the residuals at the 20th percentile.

Using these operationalizations of poor reading comprehension and reading comprehension worse than expected based on decoding, the vertical and diagonal lines divide the scatterplot into four sections. The upper left section represents cases with poor reading comprehension but with reading comprehension that is not worse than expected based on decoding. The lower left section represents cases with poor reading comprehension but with reading comprehension that is worse than expected based on decoding. The upper right section represents cases with adequate reading comprehension that is not worse than expected based on decoding. The lower right section represents cases with adequate reading comprehension that nevertheless is worse than expected based on decoding. Reading comprehension that was poor relative to decoding was not limited to the low end of reading comprehension but occurred throughout the distribution of reading comprehension.

Turning to regression results based on the composite correlation matrix generated from disattenuated correlations (upper right panel in Table 4), the results were highly similar to those based on the composite matrix generated from observed correlations with a standardized regression coefficient for decoding that was only .02 larger and an R^2 that increased by only .02.

How Well Does the Simple View of Reading Account for SRCD?

Adding listening comprehension to decoding as a second predictor in step two of the hierarchical regression model yielded results that addressed the question of how well the simple view of reading accounts for SRCD. As shown in the middle left panel of Table 4, both variables were significant and comparable predictors of reading comprehension. With the addition of listening comprehension as a second predictor of reading comprehension, the R^2 increased from .350 to .471. This means that 12 percent of the variance in reading comprehension not attributable to decoding was attributable to listening comprehension. Jointly, the simple view of reading predictors of decoding and listening comprehension accounted for less than half of the variance in reading comprehension.

We explored two possible reasons why decoding and listening comprehension accounted for just under half of the variance in reading comprehension. The first was measurement error. We replicated the analyses using data derived from the composite correlation matrix generated from disattenuated correlations (middle right panel in Table 4) that were corrected for unreliability. The R^2 increased from .471 to .510, a value just over 50 percent in variance accounted for but not substantially greater than the value based on the observed correlations before correcting for unreliability. The second possible reason is that some specifications of the simple view of reading include a term representing the interaction of decoding and linguistic comprehension. We did that for data both from the observed and disattenuated composite correlation matrices. The results (lower left and right panels in Table 4) were that the interaction terms were non-significant and did not raise the R^2 value for either model.

Discussion

To recap, using model-based meta-analysis of correlation matrices obtained from nationally standardized tests, random effects models were used to create composite correlation matrices for the variables of reading comprehension, listening comprehension, and decoding. One composite correlation matrix was generated from the observed correlations, and the second was generated from correlations after correcting them for unreliability. Simulated datasets were generated from the both sets of composite correlations. To remove variance from the reading comprehension scores that was accounted for by decoding, regressions were run with decoding as the independent variable and reading comprehension as the dependent variable. The distributions of residuals from these regressions represented the distributions of reading comprehension not explained by decoding. The negative half of the distributions represent poor reading comprehension relative to decoding or SRCD.

The composite correlations we obtained from our model-based meta-analysis of standardized tests were comparable to those obtained in two model-based meta-analyses of the research literature that did not include standardized tests (Ahmed, 2014; Quinn & Wagner, 2018), and a traditional meta-analysis of the simple view of reading across cultures (Florit & Cain, 2011). The minimal differences in the present study between composite correlations based on observed correlations versus correlations corrected for unreliability suggests that measurement error does not play a substantial role in restricting correlation coefficients for well-designed standardized tests.

The Prevalence of SRCD

The prevalence of SRCD is best represented not as a single number but as a continuous distribution in which frequency varies as a function of the severity of the difference between reading comprehension and decoding. This distribution was defined by the distribution of residuals obtained from regressing reading comprehension on decoding. By knowing the mean and standard deviation of this distribution, it is possible to determine the percentage of cases of SCRD that meet any target level of severity. This distribution also can be used as prior probabilities for a Bayesian model of identification. These results represent a successful application of an approach recently used to estimate prevalence for word-level reading disability (Wagner et al., 2019, 2020).

Examining the joint distribution of the residuals with reading comprehension (Figure 4) makes clear that cases with relatively poor reading comprehension relative to decoding occur throughout the distribution of reading comprehension as opposed to being limited to the lower tail representing absolutely poor reading comprehension. The distinction between relative and absolute poor reading comprehension has implications for researchers identifying samples to study and practitioners seeking to help individuals with reading comprehension problems. Of the four operational definitions of SRCD commonly used in the literature, three include criteria that will limit samples to individuals who are in the lower tail of the reading comprehension distribution (Spencer & Wagner, 2018). Doing so leaves out individuals whose reading comprehension is relatively poor compared to their decoding but whose absolute level of reading comprehension may not be poor compared to that of their peers.

How Well Does the Simple View of Reading Account for SRCD?

In our analyses, decoding and listening comprehension both made significant and independent contributions to predicting reading comprehension. However, they accounted for just under half of the variance in reading comprehension using data derived from observed correlations, and just over half of the variance when the observed correlations were corrected for unreliability. Including the interaction of decoding by listening comprehension, as is sometimes done in testing the simple view, did not increase the proportion of variance accounted for.

What might account for our finding that only half of the variance in reading comprehension was explained? One possibility is limitations in the extent to which the measures included in the meta-analysis fully captured the simple view of reading constructs of decoding and linguistic comprehension. Decoding measures need to be selected to reflect the properties of the particular orthography being used (Florit & Cain, 2011). The decoding measures included in the present meta-analysis were typically measures that required pronunciation of nonwords. These kinds of measures are more predictive of word-level reading in regular orthographies than in irregular orthographies such as English (Joshi et al., 2012). In addition, listening comprehension reflects an important yet incomplete part of linguistic comprehension more generally.

A second possible explanation for the limited success of the simple view of reading in accounting for SRCD is incompleteness in the simple view itself. Other models have been proposed to account for individual differences in reading comprehension that include more than simple view of reading constructs of word recognition and linguistic comprehension. For one example, the direct and inferential mediation model (DIME) of reading comprehension (Cromley & Azevedo, 2007; Cromley, et al., 2010) includes five components of reading comprehension: Background knowledge, vocabulary, word reading, strategies, and inferencing. In addition to each of the five components having direct effects on reading comprehension, all four of the other components have effects that are mediated by inference, and background knowledge has an additional effect that is mediated by strategies. Ahmed et al. (2016) reported results from a large-sample study of the DIME model for a sample of 7^{th}- through 12^{th}-grade students. The constructs included in the model were background knowledge, reading strategies, vocabulary, work recognition, and inferencing as predictors of reading comprehension. Direct effects as well as indirect effects were found between many of the predictors and reading comprehension.

For a second example of a model of reading comprehension that includes more than word recognition and linguistic comprehension, Kim (2017) reported a study of predictors of reading comprehension that included word reading, listening comprehension, working memory, vocabulary, grammar, inference, comprehension monitoring, and theory of mind. Significant bivariate correlations existed for most of these constructs and the two measures of reading comprehension used in the study. Structural equation modeling was used to test alternative models of direct and indirect relations among the predictors and reading comprehension. The results were that only word reading and listening comprehension had direct effects on reading comprehension. The effects of the remaining constructs on reading comprehension were indirect and mediated through either listening comprehension or word reading. Finally, Spencer et al. (2020) reported a study of predictors of reading comprehension that included the simple view of reading predictors of oral language and decoding, but also two components of executive functioning. The first was working memory and the second was cognitive flexibility (i.e., the shifting component of executive functioning). The results were similar to those of Kim (2017) in that the effects of working memory and cognitive flexibility on reading comprehension were mediated by oral language and decoding.

In comparing the studies of Ahmed et al. (2017), Kim (2017), and Spencer et al. (2020), direct effects as well as indirect effects were found between many of the predictors and reading comprehension only in the Ahmed et al. study. One possible explanation of differences in the results is that the construct of listening comprehension was included in the Kim study but not in the Ahmed et al. study. Therefore, the pattern of results noted by Kim and Spencer et al. of the effects of additional predictors being mediated by listening comprehension was not possible in the Ahmed et al. study because listening comprehension was not included.

Two other constructs deserve mention that are not included in the simple view of reading but have been shown to be predictors of reading comprehension. The lexical quality hypothesis proposes that knowledge about words is important to understanding and predicting reading comprehension (Perfetti, 2007). Specifically, the quality of lexical representation of words is determined by the availability of redundant representations of orthography and phonology, and by flexible representations of meaning. The quality of lexical representations determines how rapid and reliable meaning retrieval is. Rapid and reliable word meaning retrieval is paramount for successful comprehension of text. An expansion of the lexical quality hypothesis is the reading systems framework. The framework embeds the lexical quality hypothesis in a system that also includes linguistic and writing system knowledge, general knowledge, and comprehension processes (Perfetti & Stafura, 2014). The second construct that is not included in the simple view of reading but predicts reading comprehension is background knowledge. A review of the literature on predictors of reading comprehension identified four kinds of knowledge and processes that are essential for reading comprehension and responsible for many cases of poor comprehension (Fletcher et al., 2019): (1) Knowledge about words and knowledge about the world (i.e., background knowledge); (2) broader sources of linguistic knowledge such as grammar and story structure; (3) text-level abilities including inferencing and comprehension monitoring; and (4) working memory capacity.

Limitations of the Present Study

Turning to limitations of the present study, an important limitation of our results is that they need to be validated with empirical datasets. Although an approach using model-based meta-analysis is likely to produce more robust results than would be obtained from individual empirical studies, it is important to cross-validate the results using empirical datasets. A second important limitation is that the range of reading comprehension tasks represented on the standardized tests is limited relative to the broader range of reading comprehension tasks that are of interest. A third important limitation is that the study was limited to the constructs of decoding, listening comprehension, and reading comprehension. It would have been desirable to have constructs beyond those from the simple view of reading included in the study. Nonetheless, the current investigation provides important insights regarding associations between reading and listening comprehension and decoding for children who struggle to comprehend text. Finally, our study does not address the many challenges that would need to be addressed if SRCD were to be considered a type of reading disability for purposes of determining eligibility for accommodations and special education services. The phenomenon of deficits in reading comprehension despite adequate decoding is inherently a discrepancy-based phenomenon, yet there are known problems associated with discrepancy-based operational definitions when used for identification (Fletcher et al., 2019).

We view the two main findings from our study—that the prevalence of SRCD is best conceptualized as a continuous, known distribution with prevalence varying as a function of severity, and that the simple view of reading does not provide a complete account of the existence of SRCD—as generative and pointing the way to promising lines of research on this important deficit in reading comprehension.

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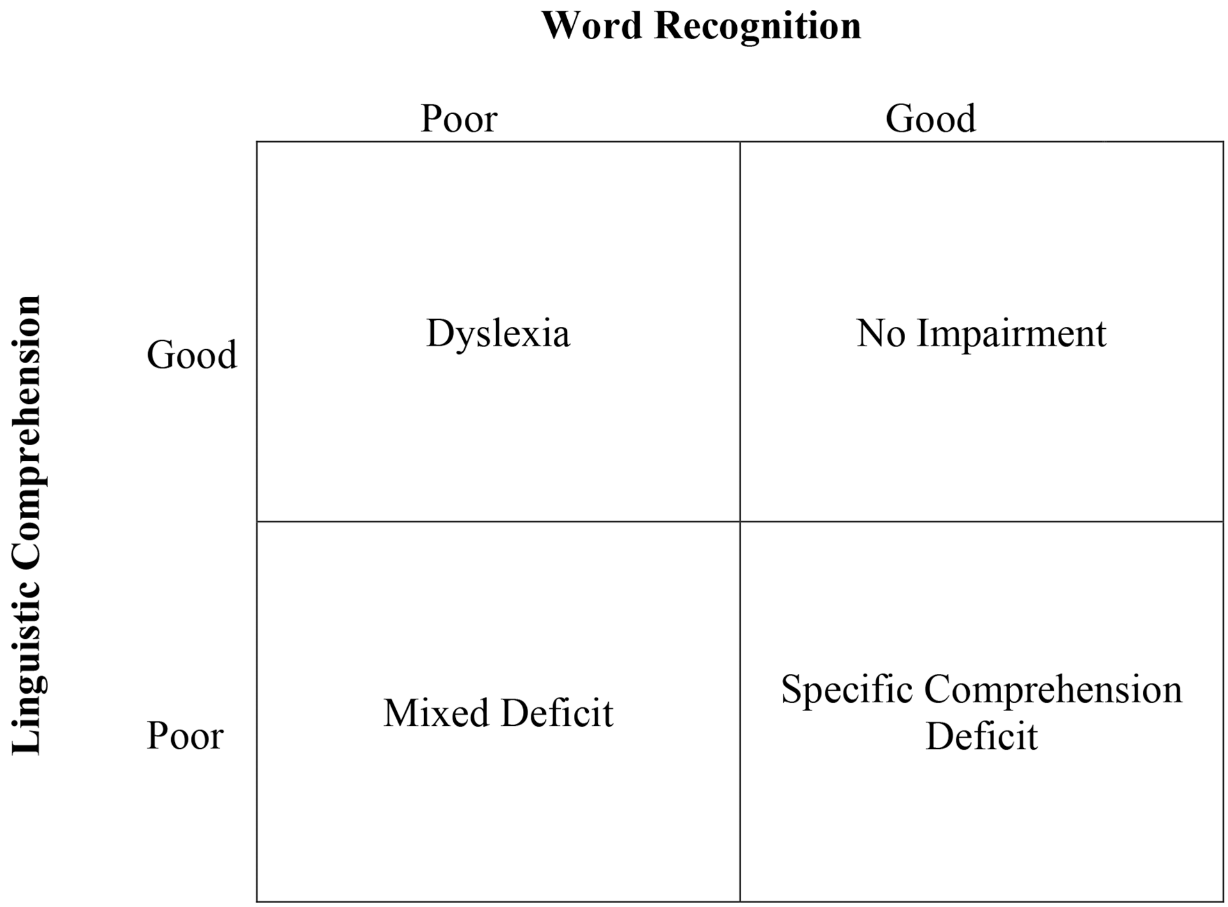

Figure 1.
Reader Classification System based on the Simple View of Reading

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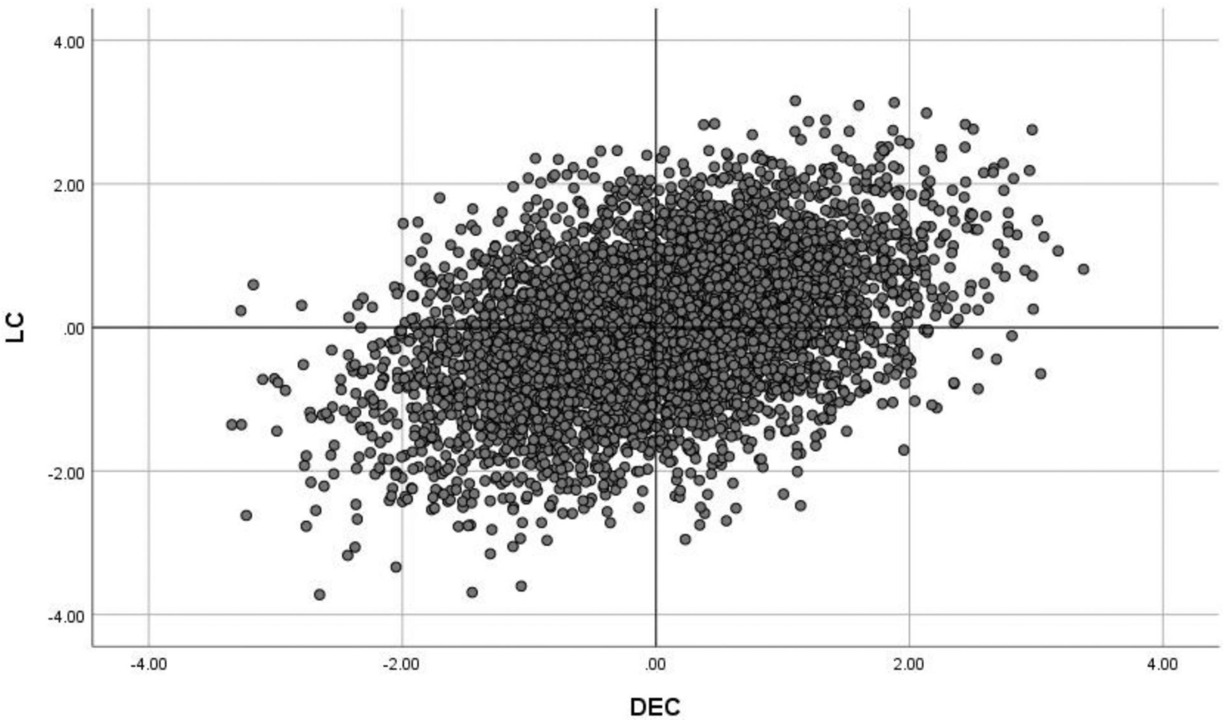

Figure 2.
Scatterplot of Listening Comprehension by Decoding

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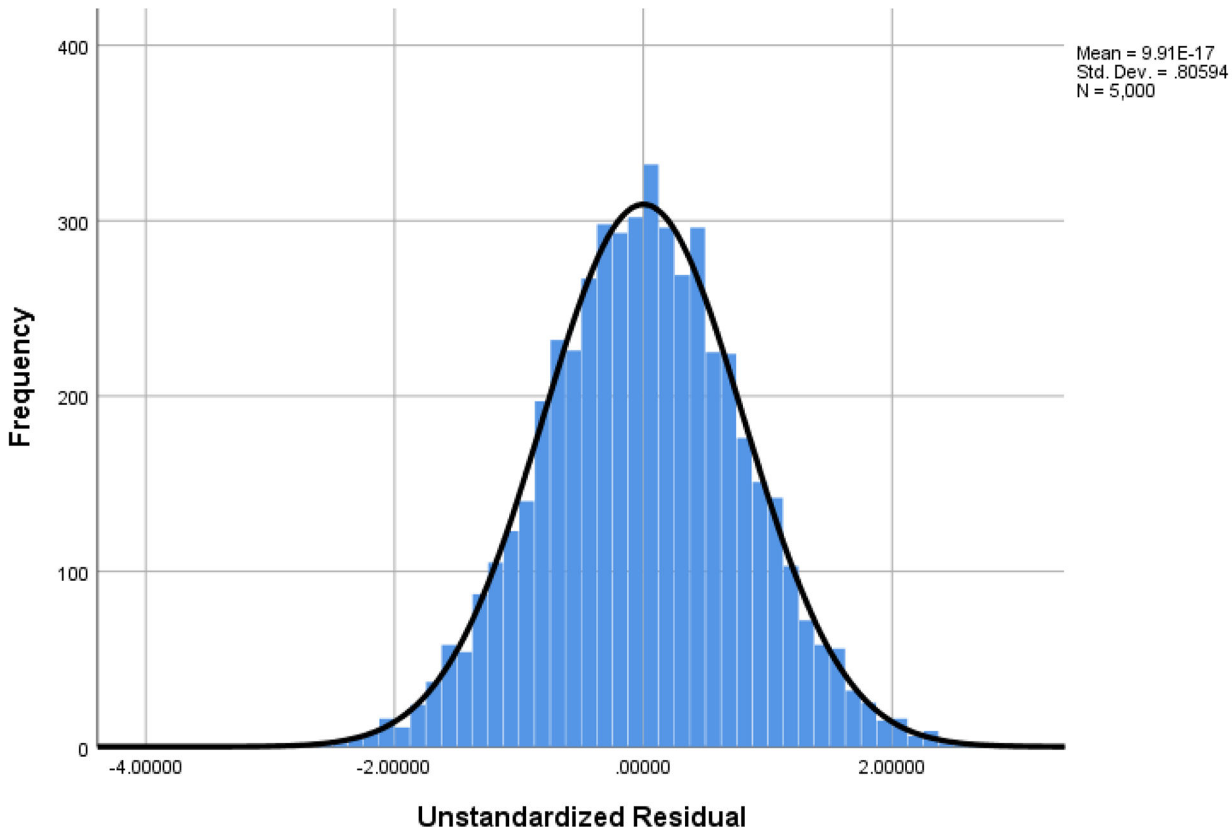

Figure 3.
The Continuous Distribution of Prevalence of SCRD as a Function of Severity

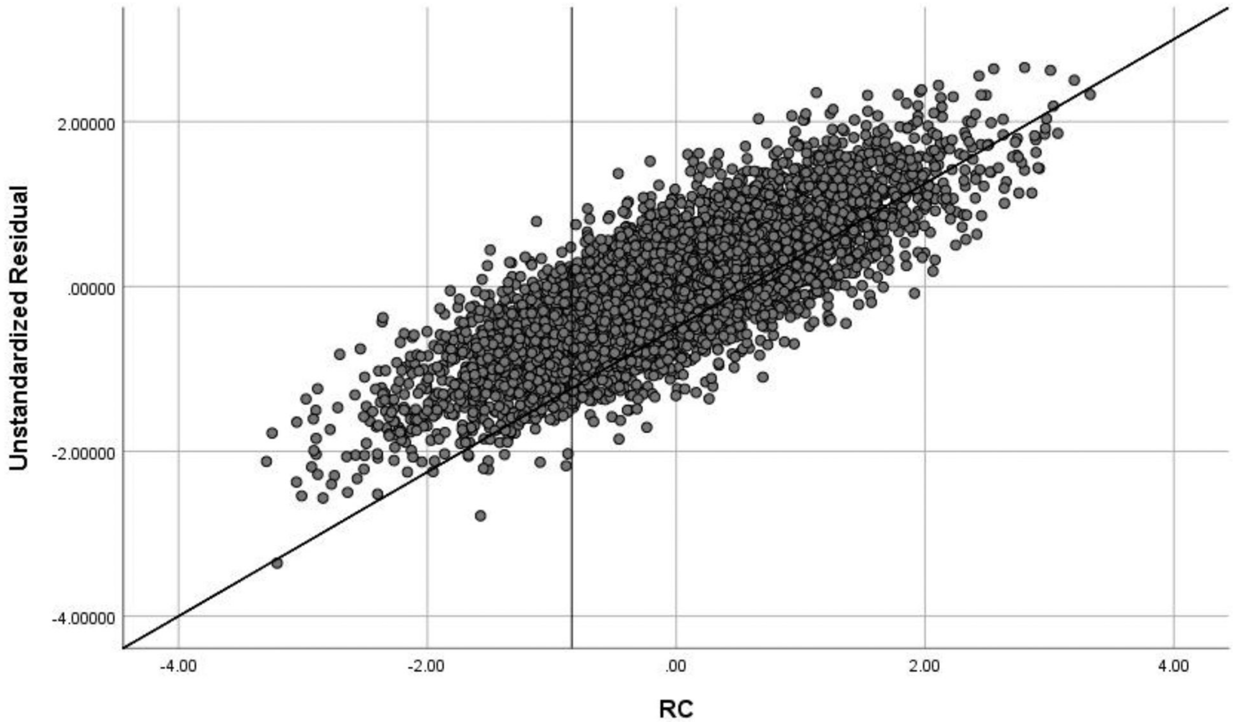

Figure 4. Scatterplot of Reading Comprehension by Residuals from Regressing Reading Comprehension on Decoding (N = 5,000)

Note. Points to the left of the vertical line represent the poor reading comprehension defined by scoring at or below the 20th percentile. Points below the diagonal line represent reading comprehension worse than predicted by decoding defined by the residuals at or below the 20th percentile.

Table 1

Measures, Sample Sizes, Reliabilities, Observed Correlations, and Reliability-Corrected Correlations between Reading Comprehension, Listening Comprehension, and Decoding

Measure	N	Reliabilities			Observed Correlations			Corrected Correlations		
		RC	LC	DC	RCLC	RCDC	LCDC	RCLC	RCDC	LCDC
WIAT III Grade 1	100	0.96	0.84	0.97	0.42	0.72	0.39	0.47	0.75	0.43
WIAT III Grade 2	100	0.91	0.83	0.97	0.63	0.59	0.42	0.72	0.63	0.47
WIAT III Grade 3	100	0.90	0.86	0.96	0.65	0.54	0.38	0.74	0.58	0.42
WIAT III Grade 4	100	0.85	0.84	0.97	0.62	0.47	0.44	0.73	0.52	0.49
WIAT III Grade 5	100	0.91	0.83	0.96	0.58	0.53	0.45	0.67	0.57	0.50
WIAT III Grade 6	100	0.89	0.89	0.97	0.62	0.50	0.40	0.70	0.54	0.43
WIAT III Grade 7	100	0.89	0.84	0.97	0.57	0.40	0.51	0.66	0.43	0.56
WIAT III Grade 8	100	0.81	0.85	0.97	0.52	0.51	0.42	0.63	0.58	0.46
WIAT III Grade 9	100	0.89	0.79	0.95	0.53	0.50	0.33	0.63	0.54	0.38
WIAT III Grade 10	100	0.83	0.86	0.96	0.66	0.40	0.38	0.78	0.45	0.42
WIAT III Grade 11	100	0.81	0.81	0.97	0.58	0.42	0.41	0.72	0.47	0.46
WIAT III Grade 12	100	0.81	0.81	0.95	0.60	0.44	0.39	0.74	0.50	0.44
WRMT III K-2	600	0.93	0.76	0.96	0.43	0.68	0.28	0.51	0.72	0.33
WRMT III 3–8	1200	0.85	0.86	0.94	0.61	0.43	0.30	0.71	0.48	0.33
WRMT III 9–12	800	0.85	0.86	0.93	0.61	0.43	0.37	0.70	0.52	0.44
KTEA III Grade 1	200	0.91	0.83	0.97	0.48	0.79	0.36	0.55	0.84	0.40
KTEA III Grade 2	200	0.89	0.84	0.97	0.54	0.74	0.35	0.62	0.80	0.39
KTEA III Grade 3	200	0.88	0.77	0.97	0.58	0.66	0.37	0.70	0.71	0.43
KTEA III Grade 4	200	0.91	0.89	0.97	0.66	0.49	0.37	0.73	0.52	0.40
KTEA III Grade 5	200	0.82	0.84	0.95	0.61	0.49	0.30	0.73	0.56	0.34
KTEA III Grade 6	199	0.88	0.82	0.95	0.71	0.43	0.37	0.84	0.47	0.42
KTEA III Grade 7	199	0.84	0.85	0.95	0.59	0.51	0.31	0.70	0.57	0.34
KTEA III Grade 8	200	0.85	0.83	0.96	0.69	0.43	0.33	0.82	0.48	0.37
KTEA III Grade 9	150	0.87	0.86	0.97	0.71	0.47	0.42	0.82	0.51	0.46
KTEA III Grade 10	150	0.91	0.82	0.96	0.65	0.35	0.28	0.75	0.37	0.32
KTEA III Grade 11	150	0.90	0.83	0.95	0.74	0.57	0.46	0.86	0.62	0.52
KTEA III Grade 12	150	0.91	0.90	0.97	0.76	0.63	0.54	0.84	0.67	0.58

Measure	N	Reliabilities			Observed Correlations			Corrected Correlations		
		RC	LC	DC	RCLC	RCDC	LCDC	RCLC	RCDC	LCDC
ERDA II Grade 1	97	0.79	0.74	0.97	0.40	0.66	0.19	0.52	0.75	0.22
ERDA II Grade 2	100	0.84	0.74	0.92	0.41	0.62	0.22	0.52	0.71	0.27
ERDA II Grade 3	100	0.80	0.74	0.94	0.28	0.48	0.16	0.36	0.55	0.19
WJIV Ages 6–8	825	0.93	0.78	0.94	0.53	0.68	0.50	0.59	0.70	0.56
WJIV Ages 9–13	1572	0.93	0.78	0.94	0.56	0.59	0.43	0.66	0.65	0.50
WJIV Ages 14–19	1685	0.87	0.84	0.88	0.61	0.62	0.49	0.75	0.72	0.59
ITBS Level 6	7128	0.82	0.77	0.84	0.50	0.71	0.60	0.63	0.86	0.75
ITBS Level 7	14870	0.93	0.74	0.87	0.48	0.73	0.52	0.58	0.81	0.65
ITBS Level 8	14870	0.92	0.79	0.89	0.54	0.71	0.52	0.63	0.78	0.62
ITBS Level 9	14978	0.90	0.68	0.82	0.55	0.69	0.59	0.70	0.80	0.79
SAT 10 Grade 1	2189	0.91	0.88	0.86	0.52	0.74	0.54	0.58	0.84	0.62
SAT 10 Grade 2	2550	0.91	0.88	0.86	0.65	0.65	0.52	0.73	0.73	0.60
SAT 10 Grade 3	1680	0.90	0.82	0.83	0.69	0.67	0.53	0.80	0.78	0.64
SAT 10 Grade 4	2336	0.94	0.88	0.87	0.73	0.68	0.57	0.80	0.75	0.65

Note. RC = reading comprehension. LC = listening comprehension. DC = decoding. From Technical Manual Wechsler Individual Achievement Test – Third Edition (WIAT III, 2009), Woodcock Reading Mastery Tests – Third Edition Manual (WRMT III, 2011), Technical & Interpretive Manual Kaufman Test of Educational Achievement, Third Edition (KTEA III, 2014), Early Reading Diagnostic Assessment – Second Edition Technical Manual (ERDA II, 2003), Woodcock-Johnson IV Technical Manual (WJIV IV, 2014), The Iowa Test of Basic Skills Standardization and Validation Manual (ITBS, 2010), and The Stanford Achievement Test Series Tenth Edition Technical Data Report (SAT 10, 2004).

Table 2

Composite Correlation Matrix Based on Observed Correlations (Below Diagonal) and Correlations Disattenuated for Unreliability (Above Diagonal)

Variable	1	2	3
1. Reading Comprehension	–	.599	.610
2. Listening Comprehension	.563	–	.434
3. Decoding	.591	.417	–

Table 3

Percentage of Cases of Poor Reading Comprehension at Four Levels of Severity that Scored Adequate in Decoding at Three Levels of Decoding Performance

	Level of Decoding Adequacy Exceeding		
Level of Poor Reading Comprehension	**50^{th} percentile**	**40^{th} percentile**	**30^{th} percentile**
20^{th} percentile	17%	25%	36%
15^{th} percentile	15%	21%	32%
10^{th} percentile	12%	17%	27%
5^{th} percentile	8%	12%	20%

Table 4

Regression Results from Predicting Reading Comprehension by Decoding, Listening Comprehension, and their Interaction for Data from Generated from Composite Matrices Based on Observed and Disattenuated Correlations

Composite Correlation Matrix from Observed Correlations			Composite Correlation Matrix from Disattenuated Correlations		
Variable	**β**	R^2	**Variable**	**β**	R^2
Decoding	.592***	.350	Decoding	.610***	.372
Decoding	.432***	.471	Decoding	.431***	.510
Listening Comprehension	.383***		Listening Comprehension	.412***	
Decoding	.432***	.471	Decoding	.431***	.510
Listening Comprehension	.383***		Listening Comprehension	.412***	
Interaction	.017(ns)		Interaction	.011(ns)	

*** p < .001