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Evaluating the Simple View of Reading for Children With Attention-Deficit/Hyperactivity Disorder

Alissa M. Cole, M.S.,
Florida State University

Elizabeth S.M. Chan, M.A., M.S.,
Florida State University

Fatou Gaye, M.S.,
Florida State University

Jamie A. Spiegel, Ph.D.,
University of South Alabama

Elia F. Soto, Ph.D.,
Florida State University

Michael J. Kofler, Ph.D.
Florida State University

Abstract

The 'simple view of reading' is an influential model of reading comprehension which asserts that children's reading comprehension performance can be explained entirely by their decoding and language comprehension skills. Children with ADHD often exhibit difficulty across all three of these reading domains on standardized achievement tests, yet it is unclear whether the simple view of reading is sufficient to explain reading comprehension performance for these children. The current study was the first to use multiple indicators and latent estimates to examine the veracity of key predictions from the simple view of reading in a clinically-evaluated sample of 250 children with and without ADHD (ages 8–13, M_{age}=10.29, SD=1.47; 93 girls; 70% White/Non-Hispanic). Results of the full-sample structural equation model revealed that decoding and language comprehension explained all (R^2=.99) of the variance in reading comprehension for children with and without ADHD. Further, multigroup modeling (ADHD, Non-ADHD) indicated that there was no difference in the quantity of variance explained for children with ADHD versus clinically-evaluated children without ADHD, and that the quantity of explained variance did not differ from 100% for either group. Sensitivity analyses indicated that these effects were generally robust to control for monomethod bias, time sampling error, and IQ. These findings are consistent with 'simple view' predictions that decoding and language comprehension are both *necessary* and together *sufficient* for explaining children's reading comprehension skills. The findings extend

Corresponding Author: Michael J. Kofler, Ph.D., Florida State University | Department of Psychology, 1107 W. Call Street | Tallahassee, FL, 32306-4301, USA, Phone: (978) 257-0888, Fax: (850) 644-7739, kofler@psy.fsu.edu.

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prior work by indicating that the 'simple view' holds for both children with ADHD and clinically-evaluated children without ADHD.

Keywords

ADHD; simple view of reading; reading comprehension; decoding; language comprehension

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The simple view of reading (SVR) is an influential model that explains individual differences in reading comprehension across development (Gough & Tunmer, 1986; Hoover & Gough, 1990). This model implies that children's reading comprehension performance can be explained entirely by two interrelated skills: decoding and language comprehension (Foorman et al., 2018; Lonigan et al., 2018; Protopapas et al., 2012). The simple view of reading has been validated in developmental samples of children and adolescents as evidenced by replicated findings that latent estimates of decoding and language comprehension account for 77%–100% of the variance in reading comprehension throughout childhood and across reading skill levels and orthographies (Kershaw & Schatschneider, 2012; Kim, 2017; Language and Reading Research Consortium/LARRC & Chiu, 2018; Lonigan et al., 2018). The available evidence also suggests that decoding and language comprehension may account for more modest proportions of the variance (~30–50% or less) in reading comprehension for children with neurodevelopmental disabilities such as ADHD (Mackenzie, 2019), suggesting that the simple view of reading may not strictly hold for these populations and that additional factors may be needed to fully explain reading comprehension difficulties for these children (Brock & Knapp, 1996; Jacobson et al., 2011; Miller et al., 2013; Plourde et al., 2018).

By nature of their neurodevelopmental diagnosis, children with ADHD are at an increased risk for attentional, behavioral, and neurocognitive difficulties that may impact learning, suggesting that reading difficulties in ADHD may be due, at least in part, to interfering behaviors or alternate underlying causes rather than solely the decoding/language comprehension deficits targeted by extant reading interventions (e.g., Aduen et al., 2018; Chan et al., 2023; Kofler et al., 2018). However, evidence for/against the simple view of reading in children with ADHD has been limited by (1) the use of single, manifest-level indicators of decoding and language comprehension; and/or (2) failure to account for both components of the simple view when examining predictors of reading comprehension (i.e., examining decoding *or* language comprehension). The current study addressed these limitations and is the first to test key predictions of the simple view of reading using multiple indicators of decoding, language comprehension, and reading comprehension in a clinically evaluated and carefully phenotyped sample of children with and without ADHD.

Simple View of Reading

As noted above, the simple view of reading suggests that children's reading comprehension skills can be explained entirely by the product of only two components: decoding and language comprehension (Hoover & Gough, 1990). This view accepts that decoding and language comprehension are inherently complex and each consist of multiple subcomponents, but a key testable prediction of this model is that together they should account for all variance in reading comprehension (Kim, 2017; LARRC & Chiu, 2018; Lonigan et al., 2018). The original simple view of reading emphasized that reading comprehension is the product (i.e., interaction between) decoding and language comprehension (Hoover & Gough, 1990), whereas more recent work suggests the product of these component skills may not improve the prediction of reading comprehension over and above the variance explained by the individual components (e.g., Dreyer & Katz, 1992; Tin, Thompson, and Lewis, 2003; Kershaw & Schatschneider, 2012). *Decoding* refers to children's skill at converting printed text to words by translating written symbols to speech sounds (Gough & Tunmer, 1986). Tests used to assess decoding skills typically present the child with a list of words, or phonetically pronounceable non-words, and measure the accuracy and/or speed with which the child pronounces them. *Language comprehension*, originally termed linguistic comprehension, refers to children's skill at understanding language when it is not presented as printed text, such as through oral language (Gough & Tunmer, 1986; Tunmer & Chapman, 2012). The original simple view of reading measured language comprehension as listening comprehension (Hoover & Gough, 1990), a receptive task that involves listening to a sentence or passage and then answering questions based on that passage. However, factor analytic evidence suggests that language comprehension is a multifaceted construct consisting of both expressive and receptive oral language abilities across ages (Foorman et al., 2015, 2018; Tunmer & Chapman, 2012). Therefore, more recent work has included expressive and receptive measures of vocabulary knowledge and verbal proficiency when creating latent estimates of language comprehension given evidence that they are not distinct skills from language comprehension (Kershaw & Schatschneider, 2012; Protopapas et al., 2012, 2013; Savage, 2001; Tilstra et al., 2009; Tunmer & Chapman, 2012; Lonigan & Milburn, 2017).

More recent studies examining the simple view of reading have highlighted the importance of using latent variables and multiple measures to reduce method and error variance, without which studies may be limited to task-specific and/or unclear findings (Kershaw & Schatschneider, 2012; LAARC & Chiu, 2018). Overall, when using latent variables consisting of multiple measures of decoding and language comprehension, these two components account for nearly all (77%–100%) of the variance in reading comprehension in typically developing children (Kershaw & Schatschneider, 2012; Kim, 2017; Lonigan et al., 2018), leading to the 'simple view' that decoding and language comprehension are the only necessary components to explain children's reading comprehension skills (Tilstra et al., 2009; Foorman et al., 2018). Despite this replicated evidence, the simple view of reading has been criticized for its narrow focus on reading comprehension relative to higher-order inferential and analytic skills critical for literacy (e.g., McNamara et al., 2012; Pearson et al., 2014; Snow, 2018), as well as an evidence base that is comprised primarily of developmental samples (e.g., Rickets et al., 2013). Further, as detailed below, alternate models suggest that the 'simple view' is incomplete (e.g., Snow et al., 2018), and the extent to which decoding and language comprehension can *fully* explain reading comprehension for children with neurodevelopmental disorders such as ADHD remains unclear (Mackenzie, 2019).

ADHD and the Simple View of Reading

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder that affects approximately 5% of school-age children (Polanczyk et al., 2014) and portends short- and long-term difficulties in reading (Mayes & Calhoun, 2006; Willcutt & Pennington, 2000), math (Benedetto-Nasho & Tannock, 1999; Mayes & Calhoun, 2006), written language (Mayes & Calhoun, 2006; Soto et al., 2021), and other important aspects of academic functioning (e.g., Loe & Feldman, 2007; Stern & Shalev, 2013). In terms of reading specifically, children with ADHD are more likely to be diagnosed with a reading disorder than are their typically developing peers, at a rate of 25–40% compared with about 5% in the general population (DuPaul et al., 2013; Semrud-Clikeman et al., 1992; Willcutt & Pennington, 2000). This comorbidity is especially notable given that there is no overlap in symptomatology or diagnostic criteria between ADHD and reading disorder (American Psychiatric Association, 2013). Interestingly, even children with ADHD without a comorbid reading disorder exhibit difficulties across all three components of the simple view of reading (Friedman et al., 2017; Korrel et al., 2017; Miller et al., 2013, 2014), and perform worse on standardized measures of reading achievement across these domains (Frazier et al., 2007; Pagirsky et al., 2017)

In terms of *decoding*, the available evidence suggests that decoding skills may partially explain the relation between ADHD symptoms and reading comprehension difficulties, such that this indirect effect explains 11% of the variance in reading comprehension longitudinally through elementary school (Miller et al., 2014). Similarly, a recent study by Friedman et al. (2017) found that a composite estimate of decoding explained 61% of the relation between ADHD diagnostic status and reading comprehension skill. In contrast, reading comprehension difficulties appear to persist in children with ADHD after matching or controlling for decoding skills, suggesting that decoding cannot fully account for impaired reading comprehension (Brock & Knapp, 1996; Ghelani et al., 2004; Jacobson et al., 2011; Martinussen & Mackenzie, 2015; Miller et al., 2013). Taken together, the available evidence suggests that decoding skills are an important but incomplete predictor of reading comprehension skills in children with ADHD, but conclusions regarding the veracity of these predictions of the simple view of reading in ADHD are limited because previous studies have failed to concurrently include estimates of language comprehension to examine whether decoding and language comprehension are the *only* necessary predictors of reading comprehension.

In terms of *language comprehension*, a recent review by Korrel et al. (2017) concluded that children with ADHD show impairments in multiple aspects of language, including expressive, receptive, pragmatic, and overall language skills. Deficits in language comprehension are evident based on listening comprehension task performance among children with vs. without ADHD (McInnes et al., 2003; Papaeliou et al., 2015). Further, evidence suggests that ADHD inattentive symptoms may be more strongly associated with reading comprehension and language comprehension skills than with word reading measures of decoding (Aaron et al., 2002). Expressive vocabulary knowledge, another component of language comprehension, has also been linked with reading comprehension difficulties in children with ADHD (Calub et al., 2019), accounting for 20% of the variance in these children's reading comprehension (Gremillion & Martel, 2012). Thus, it appears that language comprehension reflects another important but incomplete predictor of reading comprehension skills for children with ADHD.

To our knowledge, only one study to date (Mackenzie, 2019) has examined both decoding and language comprehension as concurrent predictors of reading comprehension among youths with ADHD to examine whether together these skills can explain reading comprehension difficulties on standardized achievement tests in this population. Mackenzie (2019) found that these skills together explained 38%–55% of the variance in reading comprehension skills among adolescents with ADHD. These results suggest that decoding and language comprehension are both important predictors of reading comprehension, but also indicate that the simple view of reading may not be *sufficient* to fully explain reading comprehension difficulties on standardized achievement measures in children with ADHD. However, conclusions regarding the simple view of reading in childhood ADHD remain limited given Mackenzie's focus on adolescents and reliance on single indicators of each construct, suggesting that the findings may be task-specific or at the very least attenuated by measurement error. As such, although the findings of Mackenzie (2019) suggest that the simple view of reading does not fully hold for children with ADHD, this conclusion requires further investigation and replication.

Current Study

In sum, there is strong and replicated cross-sectional and longitudinal evidence for the simple view of reading in developmental community-based samples (Kershaw & Schatschneider, 2012; Kim, 2017; LARRC & Chiu, 2018; Lonigan et al., 2018). However, the extent to which this model explains the reading-related achievement difficulties commonly reported in children with ADHD remains unclear (Brock & Knapp, 1996; Miller et al., 2013; Samuelsson et al., 2004). The available evidence suggests that decoding and language comprehension are each important but may be insufficient for fully explaining reading comprehension in children with ADHD. However, conclusions remain limited given the dearth of literature on this topic. The current study is the first to use multiple indicators and latent estimates of decoding, language comprehension, and reading comprehension to test key predictions of the simple view of reading on standardized achievement measures in children with ADHD. The simple view of reading implies that decoding and language comprehension are each *necessary* to explain reading comprehension performance (i.e., that both will be significant predictors), and that together, they are *sufficient* (i.e., the R^2 for the variance in reading comprehension explained by these two predictors will not differ significantly from 100%) in developmental community-based samples (Kershaw & Schatschneider, 2012; Kim, 2017; LARRC & Chiu, 2018; Lonigan & Burgess, 2017). In contrast, based on the limited available evidence we hypothesized that decoding and language comprehension skills would each predict, but not fully explain, reading comprehension performance in a clinically-evaluated and carefully phenotyped sample of children with and without ADHD, and that the proportion of variance explained would be significantly lower for children with ADHD than for clinically-evaluated children without ADHD.

Hypotheses and Exploratory Research Questions

Confirmatory Research Question 1:

When examined within the full sample (i.e., clinically-evaluated children with and without ADHD), to what extent will latent estimates of decoding (Letter & Word Recognition, Nonsense Word Decoding, and Word Recognition Fluency) and language comprehension (Listening Comprehension, Similarities, Vocabulary) skills predict latent reading comprehension performance (Reading Comprehension, Silent Reading Fluency)? We predict that both will explain significant variance in reading comprehension and that the magnitude of such effects will be similar across the two predictors.

Confirmatory Research Question 2:

Will the latent decoding and language comprehension constructs explain all of the variance in reading comprehension for children with and ADHD and clinically-evaluated children without ADHD? We predict that decoding and language comprehension together will explain significantly less than 100% of the variance in reading comprehension for children with ADHD, and the proportion of reading comprehension variance explained will be significantly less for children with versus without ADHD.

Exploratory Research Question 1:

Are the findings robust to control for time sampling error and mono-test bias, different methods/measures for modeling language comprehension, IQ, and protocol modifications implemented in response to the COVID-19 pandemic? We did not have a priori hypotheses given that these exploratory analyses are intended to probe for alternative explanations for the results from Research Questions 1 and 2.

Exploratory Research Question 2 (Added During the Peer Review Process):

Does the pattern of results replicate across older versus younger children in our sample? We did not have an a priori hypothesis for this research question.

Method

Participants

The sample comprised 250 children (93 girls) ages 8 to 13 years (M = 10.29, SD=1.47) from the southeastern United States recruited by or referred to a Children's Learning Clinic (CLC) through community resources (e.g., pediatricians, community mental health clinics, school system personnel, self-referral) between 2013 and 2021 for participation in a larger study of the neurocognitive mechanisms underlying pediatric attention and behavior problems. The CLC is a research-practitioner training clinic known to the surrounding community for conducting developmental and clinical child research and providing *pro bono* comprehensive diagnostic and psychoeducational services. Its client base consists of children with suspected behavioral, learning, or emotional difficulties, as well as typically developing children (those without a suspected psychological disorder) whose parents agreed to have them participate in developmental/clinical research studies. Sample ethnicity was mixed and included 175 White Non-Hispanic (70.0%), 32 Black (12.8%), 17 Hispanic/

Latino (6.8%), 23 multiracial (9.2%), and two Asian (0.8%) children. All parents and children gave informed consent/assent and the Florida State University Institutional Review Board approval was obtained/maintained. All children/families provided informed consent/asset in English and all study procedures were conducted in English.

Group Assignment

All children and caregivers completed a detailed, semi-structured clinical interview using the Kiddie Schedule for Affective Disorders and Schizophrenia for School-Aged Children (K-SADS; Kaufman et al., 1997). The K-SADS (2013 Update) allows differential diagnosis according to symptom onset, course, duration, quantity, severity, and impairment in children and adolescents based on DSM-5 criteria (APA, 2013). Its psychometric properties are well established, including interrater agreement of .93 to 1.00, test-retest reliability of .63 to 1.00, and concurrent (criterion) validity between the K-SADS and psychometrically established parent rating scales (Kaufman et al., 1997). This semi-structured clinical interview was supplemented with parent and teacher ratings scales from the Behavior Assessment System for Children (BASC-2/3; Reynolds & Kamphaus, 2004) and ADHD Rating Scale for DSM-4/5 (ADHD-RS-4/5; DuPaul et al., 2016). A psychoeducational report was provided to parents; participating children selected a small toy (<$5) from a prize box.

One hundred and fifty-four children (51 girls) met all of the following criteria and were diagnosed with ADHD based on the comprehensive psychoeducational evaluation: (1) DSM-5 diagnosis of ADHD combined (105), inattentive (43), or hyperactive/impulsive (6) presentations by the CLC's directing clinical psychologist and multidisciplinary team based on K-SADS and differential diagnosis considering all available clinical information indicating onset, course, duration, and severity of ADHD symptoms consistent with the ADHD neurodevelopmental syndrome; (2) borderline/clinical elevations on at least one parent and one teacher ADHD subscale (i.e., > 90th percentile); and (3) current impairment based on parent report. Children with any current ADHD presentation specifiers were eligible given the instability of ADHD presentations (Lahey et al., 2005; Valo & Tannock, 2010; Willcutt, 2012).

Our standard assessment battery also included norm-referenced child internalizing disorder screeners, and additional standardized measures were administered clinically as needed to inform differential diagnosis and accurate assessment of comorbidities (e.g., child clinical interviews, additional testing). Several children with ADHD also met criteria for common comorbidities based on this comprehensive psychoeducational evaluation, including anxiety disorders (31.8%), oppositional defiant disorder (10.4%)[1], autism spectrum disorders (6.5%), and depressive disorders (5.2%). To improve generalizability given that comorbidity is the norm rather than the exception for children with ADHD (Wilens et al., 2002), these children were retained in the sample. In addition, 34 children with ADHD screened positive for a single (n=29) or multiple (n=5) specific learning disorders in reading (n=28) and/or math (n=11). Positive screens for learning disorders were defined based on scores ≥ 1.5 SD below age-norms on one or more KTEA-3 academic skills battery reading and math

[1]As recommended in the K-SADS, oppositional-defiant disorder (ODD) was diagnosed only with evidence of multi-informant/multi-setting symptoms.

subtests, as specified in DSM-5 (APA, 2013). Given the epidemiological evidence for high comorbidity between ADHD and reading disability as reviewed above (Semrud-Clikeman et al., 1992; Willcutt & Pennington, 2000; DuPaul et al., 2013), and because positive screens in the current study were defined based on scores on our primary outcome variables, these children were retained to provide a broader range of reading scores. In other words, we did not exclude children based on their performance on the current study's primary outcomes of interest. Forty-three (27.9%) of the 154 children with ADHD were prescribed psychostimulant medication. Children prescribed psychostimulant medication received their usual dose on the psychoeducational testing day (i.e., when the tests described in the current study were administered). Sensitivity analyses indicated that the pattern of results below was unchanged when ADHD medication status was added as a covariate.

An additional 96 children (42 girls) completed the same comprehensive psychoeducational assessment, did not meet criteria for ADHD, and were included in the Non-ADHD group. The Non-ADHD comparison group was deliberately recruited to include children who were, and were not, diagnosed with clinical disorders other than ADHD because it controls for the presence of these diagnoses in the ADHD group (i.e., it allows us to draw stronger conclusions about processes implicated in ADHD specifically as opposed to processes that may appear to be impaired in ADHD due to the confounding influence of comorbid conditions). Additionally, given the large number of studies examining the simple view of reading in neurotypical samples, our inclusion of a (primarily) clinical comparison group can be considered a strength in that it extends prior work by testing the veracity of key 'simple view' predictions in not only children with ADHD but also in children with other commonly occurring psychiatric conditions. Thus, participants in this group included both neurotypical children (38.5%) and children with anxiety disorders (36.5%), autism spectrum disorders (15.6%), depressive disorders (6.3%), and borderline/mild intellectual disability[2] (3.1%). Neurotypical children had normal developmental histories and nonclinical parent/teacher ratings, were recruited through community resources, and completed the same evaluation as clinically-referred children. Ten Non-ADHD children screened positive for specific learning disorders in reading (n=9) and/or math (n=2) based on the criteria described above. None of the children presented with gross neurological, sensory, or motor impairments that would preclude valid test administration, history of seizure disorder, moderate or lower intellectual disability (IQ<60), psychosis, or non-stimulant medication that could not be withheld for testing.

Procedures

Children completed a standardized psychoeducational assessment that included the measures described below as the first session of a larger study that involved 2–3 sessions of approximately three hours each. Psychoeducational testing was conducted according to standard clinical practice protocols. The study was closed between March and May 2021 due to the COVID-19 shutdown. For children evaluated after May 2021, testing procedures were modified according to COVID-19 safety protocols (e.g., face masks, increased physical

[2]The pattern of results reported below were highly consistent with cases of intellectual disability excluded, with two minor exceptions in Table 1 noted below.

distancing during testing, increased cleaning/sanitation procedures). As described below, sensitivity analyses indicated that these adjustments minimally affected the results.

Measures

The tests and measures used in the current study were reviewed *a priori* to ensure that our test battery was able to effectively assess the constructs of interest and test key predictions of the simple view of reading. The eight selected measures came from nationally standardized, norm-referenced, and well-validated tests that are commonly used in school and applied clinical settings for the purposes of psychoeducational evaluation, response to intervention/progress monitoring, and identification of learning disabilities/disorders (e.g., Frame et al., 2016) in children ages 4–25. For six of the eight subtests described below (reading comprehension, letter-word identification, nonsense word decoding, listening comprehension, vocabulary, and similarities), children were administered item set(s) with start points based on grade and basal/ceiling rules to ensure accurate and complete assessment of the item response theory-identified skills expected for their grade and skill level (Kaufman & Kaufman, 2014). For the remaining two subtests described below (silent reading fluency and word recognition fluency), all children start at item one and are assessed for the number of items completed correctly within a time limit, which is then compared to the performance of same-aged children in the national standardization sample. For all assessments, standard scores were utilized, which reflect children's relative skill level compared to their same-aged peers in the diverse, national standardization samples. Higher scores indicate greater decoding, language comprehension, or reading comprehension skills.

Reading Comprehension.

The Kaufman Test of Educational Achievement (KTEA-3; Kaufman & Kaufman, 2014) was used to assess reading comprehension. Two reading comprehension subtests were administered: Reading Comprehension and Silent Reading Fluency. *Reading Comprehension* refers to children's skill at processing, understanding, and integrating text and is measured by reading sentences or passages and responding by performing an action, answering literal and inferential questions, or rearranging sentences to form a paragraph. *Silent Reading Fluency* refers to the efficiency of comprehending written text and is measured by reading short sentences and marking yes or no to indicate whether the sentence is true or false within a time limit.

Decoding.

Three KTEA-3 decoding subtests were administered: Letter & Word Recognition, Nonsense Word Decoding, and Word Recognition Fluency. *Letter & Word Recognition* refers to children's skill at identifying letters and words and is measured by reading letters and pronouncing words of increasing difficulty. *Nonsense Word Decoding* refers to children's skill at phonetically decoding non-word strings of letters and is measured by pronouncing nonsense words of increasing difficulty. *Word Recognition Fluency* refers to the speed and accuracy of word reading and is measured by reading aloud a list of words as quickly as possible within a time limit.

Language Comprehension.

The three measures used to assess language comprehension were KTEA-3 Listening Comprehension, WISC-V Vocabulary, and WISC-V Similarities (Wechsler, 2014). *Listening Comprehension* refers to children's skill at understanding oral language and is measured by listening to a passage and responding orally to questions about the passage. *Vocabulary* is a measure of expressive language skills and verbal comprehension that asks children to define verbally presented words. *Similarities* measures expressive language and verbal reasoning by verbally presenting children with word pairs and asking them to describe how the two words are alike. As described below, sensitivity analyses indicated that the results were robust to control for *g* (global IQ) as well as modeling language comprehension as a single-indicator latent variable without Vocabulary and Similarities.

Socioeconomic Status (SES) and Demographic Covariates

Hollingshead SES was estimated based on caregiver(s)' education and occupation (Cirino et al., 2002). SES, child age (months/12), and sex (0=girls, 1=boys) were covaried in all analyses.

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Data were analyzed using the R package lavaan (Rosseel, 2012) as implemented in JASP v.0.16 (JASP Team, 2021). The study was not pre-registered; however, all measure inclusion/exclusion decisions and analytic plans were made *a priori*, prior to accessing the data. Data/code are available by emailing the corresponding author.

Data Analysis

Structural equation modeling was used to assess latent relations between decoding, language comprehension, and reading comprehension using the R package lavaan (Rosseel, 2012) as implemented in JASP v.0.16 (JASP Team, 2021). Age, sex, and SES were controlled in all analyses. Sensitivity analyses that controlled for IQ were also included as noted below. First, the measurement model was created with each of the three constructs of interest (decoding, language comprehension, reading comprehension). All indicators were standardized, norm-referenced subscale scores. Decoding and language comprehension each consisted of three indicators, and reading comprehension consisted of two indicators, as described above.

Next, we created the full-sample structural model with the latent decoding and language comprehension estimates predicting the latent reading comprehension estimate for the full sample. We then created a multigroup model to directly compare the ADHD and Non-ADHD groups. This involved invariance testing followed by hypothesis testing. The multigroup invariance testing involved testing whether model fit was significantly degraded by constraining the decoding/language to reading pathways to equality across groups. The multigroup hypothesis testing directly addressed simple view of reading predictions by determining whether decoding and language comprehension together account for the same proportion of variance for children with ADHD and clinically-evaluated children without ADHD. This involved constraining the reading comprehension R^2 values (i.e., disturbance terms) for the ADHD and Non-ADHD samples, first to equality and then to each equal .00 (i.e., R^2 = 100% for both groups).

We then used the chi-square difference test ($\Delta\chi^2$) to compare the fit of these constrained models with the unconstrained model that allowed the ADHD and Non-ADHD groups to explain different proportions of variance in reading comprehension. A non-significant $\Delta\chi^2$ difference test would indicate that forcing the groups to explain the same proportion of variance does not significantly worsen model fit (i.e., the R^2 values do not differ significantly between groups, and neither group's R^2 differs significantly from 100%, respectively; Satorra & Bentler, 2010). The above analyses were pre-specified, prior to accessing the data, and thus would be considered confirmatory (hypothesis-testing) in the open science framework (Nosek, 2015).

Finally, a series of sensitivity analyses was added to (a) probe the impact of our *a priori* decision to include measures from an IQ test as part of our language comprehension latent estimate; (b) examine the extent to which the large R^2 values reported below were inflated by using tests from the same battery completed on the same day (i.e., mono-method bias and time-sampling errors); (c) probe the extent to which the addition of COVID safety protocols influenced the results; and (d) examine the extent to which the results replicated across older versus younger children in our sample. This involved repeating the primary analyses described above, (a) controlling for the WISC-V fluid reasoning composite, the strongest contributor to overall IQ (Canivez et al., 2016); (b) removing the WISC-V subtests from the model and creating a single-indicator latent estimate of language comprehension based on the KTEA-3 Listening Comprehension subtest's published test-retest and internal consistency reliabilities; (c) controlling for the KTEA-3 Math Composite that was completed during the same session as the tests of primary interest described above; (d) adding COVID protocol status as an additional covariate; and (e) testing whether the pattern of results differed for older and younger children in our sample. These sensitivity analyses were added after inspecting the data to probe for alternative explanations for study results, and thus would be considered exploratory (hypothesis-generating) in the open science framework (Nosek, 2015).

For all confirmatory models, absolute and relative fit were tested. Adequate model fit is indicated by CFI and TLI ≥ .90, and RMSEA ≤ .10. All indicators showed the expected range of scores and were screened for normality (all skewness < |1|; all kurtosis < |5|; Brown, 2006). Delta scaling with maximum likelihood estimation with robust standard errors (MLR) was used to handle any non-normality (Kline, 2016). Standardized residuals were inspected for magnitude (all positive and < 1, indicating no evidence of localized ill fit). Directionality of parameter estimates were inspected. The Q-Q plot was suggestive of multivariate normality, skewness/kurtosis was in range for all variables for both groups (Table 1), and there was no evidence for violations of the collinearity or homoscedasticity assumptions.

Power Analysis

A Monte Carlo simulation was run using Mplus7 (Muthén & Muthén, 2012) to estimate the power of our proposed model for detecting relations of the expected magnitude for decoding and language comprehension predicting reading comprehension, given power (1-β) ≥ .80, α=.05, and 10,000 simulations per model run. Briefly, this process compiles the percentage of model runs that result in statistically significant estimates of model parameters. Standardized factor loadings and expected residual variances for observed variables, informed by published studies using latent constructs to examine the simple view of reading in children (Kershaw & Schatschneider, 2012; Kim, 2017; Lonigan & Burress, 2017; Lonigan et al., 2018), were imputed iteratively to delineate the proposed model. Based on these parameters, our sample size of 250 is sufficiently powered to detect standardized β-weights of ≥ .30 for decoding and language comprehension predicting reading comprehension. This estimate falls well below the βs for these relations in previous ‘simple view’ studies (Kershaw & Schatschneider, 2012; Kim, 2017; Lonigan & Burress, 2017; Lonigan et al., 2018); thus, the current study is sufficiently powered to address our primary (confirmatory) aims.

Results

Preliminary Analyses

Outliers beyond 3.00 *SD* were winsorized relative to the within-group distribution (ADHD, Non-ADHD). This affected nine data points (0.23%) from the ADHD group and nine data points from the non-ADHD group (0.35%). Missing data was low for both the ADHD group (6.5%) and non-ADHD group (6.9%) and was handled using full information maximum likelihood estimation. Task data from subsets of the current battery have been reported for subsets of the current sample to examine conceptually unrelated hypotheses in Carames et al. (2022), Condo et al. (2022), Kofler et al. (2018), and Soto et al. (2021).

As shown in Table 1, the ADHD and Non-ADHD groups did not differ in terms of sex, race/ethnicity, IQ, or SES (all p>.09), whereas the ADHD group was slightly younger (M=10.11 vs. 10.58; p=.01) than the Non-ADHD group. All parent and teacher ADHD symptom ratings were higher for the ADHD than Non-ADHD group as expected (p<.001). Interestingly, the ADHD group showed significantly lower decoding skills than the Non-ADHD group (d=0.28–0.80, all p<.03), whereas their descriptively lower scores on the reading (both d=0.23) and listening (d=0.03–0.16) comprehension subtests did not reach significance (p>.08; Table 1). Exploratory analyses indicated that the ADHD/Non-ADHD between-group differences in Table 1 became significant for KTEA-3 silent reading fluency (d=0.30) and KTEA-3 reading comprehension (d=0.31) with the four cases of borderline/mild intellectual disability excluded. Intercorrelations among study variables are shown in Table 2. The eight SVR-relevant subtests were significantly intercorrelated as expected. In addition, most showed small positive associations with SES but in most cases did not covary with age or sex. Separate correlation matrices for the ADHD and Non-ADHD groups are included in Supplementary Tables 1 and 2.

Impact of Missing Data

Additional analyses were added to probe the pattern and impact of missing data. These analyses were not specified *a priori* but were added during the peer review process; results should therefore be considered exploratory. As noted above, missing data rates were low for both groups. However, Little's MCAR test indicated that these data were not missing at random (p<.001). Exploratory correlation analyses indicated that children with and without any missing data did not differ in age, SES, sex, IQ, or ADHD group membership (all r < |.10|, all p>.10). In contrast, more recent assessment battery year (r=.68, p<.001) and testing during the COVID protocol (r=.31, p<.001) were associated with increased likelihood of missing data. Exploratory analyses indicated that the results below were unchanged with either or both of these missingness factors added to the full sample and multigroup models (all ΔR=.00, all Δβ<.01, all model fit indices remained good/excellent). We therefore report the analyses below as originally planned.

Measurement Models

As shown in Table 3, all eight indicators loaded significantly onto their respective latent reading comprehension, decoding, or language comprehension factors (β=.72-.96, all p<.001) and the model showed adequate fit in the full sample and for the ADHD and Non-ADHD groups separately (Table 3; all CFI ≥ .97, TLI ≥ .96, RMSEA ≤ .08).

Research Question 1: Decoding and Language Comprehension Predicting Reading Comprehension in the Full Sample

The structural model based on the full sample is shown in Figure 1. All indicators loaded significantly onto their respective latent variable (β=.74-.96, all p<.001) and the model showed adequate fit (Table 3; CFI = .98, TLI = .96, RMSEA = .06). Decoding (β=.52) and language comprehension (β=.52; both p<.001) each uniquely predicted reading comprehension. Exploratory analyses constraining these pathways to equality did not significantly degrade model fit ($\Delta\chi^2[1]$ =0.51, p=.48), indicating equivalent decoding and language comprehension contributions to the prediction of reading comprehension. Together, the latent decoding and language comprehension estimates explained 99% of the variance in reading comprehension (R^2=.99). Constraining the R^2 (disturbance term) to 100% did not significantly degrade model fit ($\Delta\chi^2[2]$=0.04, p=.85), supporting 'simple view' predictions that decoding and language comprehension fully explain individual differences in children's reading comprehension skills.

Research Question 2: Multigroup Structural Model to Test the Simple View for Children with ADHD Specifically

Next, we repeated the model above, this time using a multigroup model (ADHD, Non-ADHD) to directly test the extent to which the results hold for children with ADHD specifically. The unconstrained multigroup model fit the data well (Table 3; CFI = .97, TLI = .95, RMSEA = .06). For the ADHD group, decoding (β=.46) and language comprehension (β=.59) explained 94% of variance in reading comprehension. Similarly, for the non-ADHD group, decoding (β=.50) and language comprehension (β=.54) explained 100% of variance in reading comprehension.[3] Constraining the β-weights to be equal for

[3]The disturbance term for the Non-ADHD group was 1.05 in the initial solution (i.e., R^2 = 105%). However, the negative residual variance in reading comprehension was small, suggesting that this was not due to model misspecification, but rather sampling fluctuations. We thus followed recommendations to constrain the disturbance term's error variance to zero to reduce bias in parameter estimation (Chen, Bollen, Paxton, Curran, & Kirby, 2001).

both groups did not significantly worsen the overall model fit ($\Delta\chi^2$ [1]=2.16, *p*=.14), indicating that decoding and language comprehension contributed approximately equally to reading comprehension for both children with ADHD and clinically-evaluated children without ADHD. Constraining the reading comprehension R^2 (disturbance terms) to be equal across ADHD and Non-ADHD groups also did not significantly worsen the overall model fit ($\Delta\chi^2$ [1]= 1.46, *p*=.23). Further, constraining the reading comprehension R^2 to 100% for both groups did not significantly degrade model fit ($\Delta\chi^2$ [2]=1.57, *p*=.46), indicating that decoding and language comprehension fully explained reading comprehension skills for children with ADHD as well as clinically evaluated children without ADHD.

Exploratory Research Questions: Structural Models to Test Alternate Competing Models (Sensitivity Analyses)

Finally, a series of exploratory analyses was conducted to examine (a) the influence of time sampling error and our *a priori* decision to follow prior ‘simple view’ studies and include indicators from an IQ test as part of our latent language comprehension estimate; and (b) the potential impact of protocol modifications made to maximize child and examiner safety during the COVID-19 pandemic. Reporting is truncated for readability. First, given that two of our three language comprehension indicators were verbal subtests from the WISC-V, it seemed reasonable to hypothesize that the βs for language comprehension predicting reading comprehension may have been inflated by intellectual functioning. To test this hypothesis, we repeated the initial structural model twice: once with overall IQ (‘*g*’) included as a covariate, and once with the WISC-V verbal subtests removed from our latent language comprehension estimate. For the first test of IQ as a potential confound, we added the WISC-V fluid reasoning composite as a covariate. As shown by Canivez et al. (2015), WISC-V fluid reasoning provides the strongest contribution and may even be redundant with overall intelligence (i.e., β=1.0 from ‘*g*’ to FRI). As expected, IQ was a significant predictor of both decoding (β=.51) and language comprehension (β=.64; both *p*<.001). However, IQ failed to uniquely predict reading comprehension (β=–.03, *p*=.64) and the magnitude of the regression coefficients for decoding (β= .54) and language comprehension (β= .52) predicting reading comprehension, as well as the percentage of variance in reading comprehension explained by the model (R^2=.99), was highly consistent with the initial model.

For the second test of IQ as a potential confound, we created a single-indicator latent estimate of language comprehension based on the listening comprehension subtest, once with its error variance fixed based on the subtest’s published split-half reliability (.85) and once with it fixed based on the subtest’s alternate-form (test-retest) reliability (.75; Kaufman & Kaufman, 2014). Both models showed adequate fit, decoding (β =.72) and language comprehension (β =.30) each uniquely predicted reading comprehension, and together they explained 95% of the variance in reading comprehension. Constraining the R^2 values to 100% did not reduce model fit ($\Delta\chi^2$ [1]=1.14, *p*=.29) in either case, consistent with the primary findings above that decoding and language comprehension together fully explain children’s reading comprehension performance. Interestingly, constraining the β-weights for decoding and language comprehension to be equal significantly degraded model fit (β=.72 vs .30, respectively; $\Delta\chi^2$ [1] ≥ 22.85, *p*<.001); this pattern was apparent for both the ADHD and Non-ADHD groups. Thus, confounding effects of IQ do not appear to be a viable alternative explanation for the obtained results, with the minor exception that reducing the number of language comprehension indicators appeared to reduce its power relative to decoding for predicting reading comprehension.

Next, given that our predictor and outcome indicators were administered on the same day and from the same assessment battery and publisher, we hypothesized that the relations reported above may have been artificially inflated by time-sampling error and/or shared test-related variability. Thus, we repeated the initial structural model again, this time covarying the KTEA-3 math composite, which was administered on the same day as the KTEA-3 reading subtests. Consistent with a mono-test hypothesis, the math composite significantly predicted decoding (β=.68) and language comprehension (β=.48; both p<.001). Importantly, however, KTEA-3 math was not a significant predictor of reading comprehension (β=.06, p=.42). In addition, the magnitude of the regression coefficients for decoding (β=.51) and language comprehension (β=.49) predicting reading comprehension, as well as the percentage of variance in reading comprehension explained by the model (R^2=.99), was highly consistent with the main results, indicating that mono-test bias is not likely a viable explanation for the pattern of results reported above.

Next, as noted above children who completed testing during the COVID-19 pandemic (n= 48 of 250) were evaluated using a modified safety protocol. To test whether these modifications influenced the results, the initial structural model was repeated once again, this time using protocol type as a covariate (dichotomized as pre/pari COVID). Children tested using the COVID safety protocols demonstrated slightly lower decoding skills (β=−0.15, Cohen’s d=0.38, p=.02) but not language comprehension (β=−.03, p=.60) or reading comprehension skills (β=−.04, p=.31). Importantly, the magnitude of the regression coefficients for decoding (β=.52) and language comprehension (β=.52) predicting reading comprehension, as well as the percentage of variance in reading comprehension explained by the model (R^2=.99), were once again highly consistent with the initial structural model, supporting our *a priori* decision to include children tested under the modified COVID-19 safety protocol.

Finally, given evidence that the relative contribution of decoding and language comprehension changes across age (e.g., Kim, 2017), we examined the extent to which the primary findings replicate across older versus younger children in our sample. This analysis was added during the peer review process and thus should be considered exploratory. Briefly, this involved repeating the initial structural model, this time using a multi-group model based on dichotomous/median split age cohorts (younger, age<9.98, n=125 vs. older, age >9.98; n=125). Consistent with the primary results above, constraining the disturbance terms for both cohorts to be equal across groups did not significantly degrade model fit, and the variance explained for both groups did not differ from 100% (all p>.65). Similarly, constraining the decoding/language to reading pathways to be equal across age groups and equal to each other did not reduce model fit ($\Delta\chi^2$ [3]=3.88; p=.27). In other words, decoding and language comprehension were equally necessary (all β=.39-.63) and together fully explain reading comprehension performance for both younger and older children in the full sample of clinically-evaluated children with and without ADHD.

Discussion

The current study was the first to use multiple indicators and latent estimates of reading comprehension, decoding, and language comprehension to examine key predictions from the simple view of reading in a clinically evaluated and carefully phenotyped sample of children with and without ADHD. The study's strengths include the inclusion of children with disorders other than ADHD in both groups to improve generalizability and position the study as one of the first to examine the veracity of the SVR in clinically evaluated children more broadly, as well as the use of multi-group modeling to examine the veracity of the 'simple view' predictions for children with ADHD specifically. Overall, latent estimates of decoding and language comprehension accounted for all (94–100%) of the variance in reading comprehension performance for children with ADHD as well as clinically evaluated children without ADHD. These findings were particularly striking given that the ADHD group demonstrated below average decoding skills relative to both the Non-ADHD group and normative expectations. However, the findings were consistent with the large body of research supporting the simple view of reading's assumption that decoding and language comprehension are the only necessary predictors of reading comprehension (Gough & Tunmer, 1986) as well as previous literature suggesting that decoding and language comprehension are the only necessary components for explaining children's reading comprehension performance (LARRC & Chiu, 2018; Lonigan et al., 2018). Further, the results extend previous findings by demonstrating that the quantity of variance in reading comprehension that can be explained by the model does not differ among clinically evaluated children with versus without ADHD.

Interestingly, we also found that decoding and language comprehension explain equal proportions of the variance in reading comprehension for children with ADHD and likely for clinically evaluated children without ADHD. Previous literature has suggested that the proportion of reading comprehension variance explained by decoding and language comprehension changes with age and reading skill, such that decoding is a stronger predictor for younger children and children with less developed decoding skills, whereas language comprehension is a stronger predictor for older children and more skilled readers (Garcia & Cain, 2014; Tilstra et al., 2009). Although the results of our exploratory analyses indicated no significant age-related differences in the relative importance of decoding and language comprehension, the age range in the present study encompassed 2nd–7th grades. As such, our results are consistent with previous findings which suggest that decoding and language comprehension predict reading comprehension approximately equally in this age group (Braze et al., 2016; Foorman et al., 2020; Kershaw & Schatschneider, 2012; Kim, 2017; LAARC & Chiu, 2018; Lonigan et al., 2018). Future research would benefit from an examination of the extent to which these findings replicate in older (adolescent) and younger (early childhood) samples of children with ADHD.

At first glance, the current study's finding that decoding and language comprehension skills fully explain reading comprehension for children with ADHD appears inconsistent with several studies finding that other skills contribute to reading comprehension in ADHD and other neurodevelopmental populations (Gaboury, 2012; Mackenzie, 2019; Ricketts et al., 2013). For example, previous literature suggests that cognitive variables including attentional control (Conners, 2009; Plourde et al., 2015; Stern & Shalev, 2013), executive functions (Butterfuss & Kendeou, 2018; Cirino 2019; Follmer, 2018; Friedman et al., 2017; Kofler et al., 2018; Savage et al., 2007), performance IQ (Kershaw & Schatschneider, 2012), and processing speed (Georgiou, Das, & Hayward, 2009; Johnston & Kirby, 2006; Joshi & Aaron, 2000) significantly predict reading comprehension in children with ADHD above and beyond decoding or language comprehension. Importantly, however, as noted above, this evidence is based on studies that only included one simple view of reading predictor (i.e., decoding or language comprehension) and/or used single indicators rather than latent estimates of each construct, which may explain the discrepant findings (Lonigan et al., 2018; Mackenzie et al., 2019). Given the current findings indicating that there is no additional variance in reading comprehension to explain after accounting for latent estimates of decoding and language comprehension, we hypothesize that these additional skills may contribute to reading comprehension indirectly via their influence on decoding and/or language comprehension (Christopher et al. 2012; Kim, 2017; Spencer et al., 2020; Friedman et al., 2017). This hypothesis is of course speculative, as the current study did not examine neurocognitive predictors of reading comprehension, but is generally consistent with evidence that skills and abilities such as executive functions may compensate for poor decoding (Cirino et al., 2019; Ebert & Scott, 2016; Wagner et al., 2021). Alternatively, others have hypothesized that these constructs may be part of the broader linguistic comprehension construct described in the original ‘simple view’ model (Gough & Tunmer, 1986) – in other words, *components* of linguistic comprehension rather than ‘predictors of the predictors’ as we are conceptualizing them (Rapp et al., 2007). Examining the mechanisms and processes that support and comprise decoding and language comprehension skills within the ‘simple view’ framework is an important direction for future research to further elucidate how difficulties in foundational skills may explain reading comprehension difficulties in children with ADHD.

Limitations and Future Directions

Despite the strengths of this study described above, the following limitations should be considered when interpreting results. First, all study measures were administered on the same day, and were subtests from the same test battery and publisher, which could have artificially inflated the regression coefficients and R^2 values. Sensitivity analyses suggested that this hypothesis was unlikely given that covarying non-reading-related measures administered on the same day and from the same test battery did not significantly alter the pattern or interpretation of results. Nonetheless, replication of our findings using a counterbalanced series of subtests from multiple batteries/publishers completed across multiple testing days – ideally within each timepoint of a longitudinal design – would be helpful to confirm the veracity of key ‘simple view of reading’ predictions for children with ADHD.

Next, as the first latent investigation of the applicability of the simple view of reading for children with neurodevelopmental disorders such as ADHD, we focused on select predictions with a goal of replicating or refuting foundational work on this model, using the same standardized/norm-referenced tests that are used for identifying eligibility for additional reading services and identifying reading disabilities/disorders in schools and applied clinical settings. As such, we did not test more complex models of reading or address recent criticisms regarding the model's completeness for neurotypical/ developmental samples. For example, several research groups have expanded on the 'simple view' to focus on shared/unique components and/or predictors of decoding and language comprehension, specific text characteristics, broader/higher-level reading comprehension skills beyond understanding the literal meaning of printed text, and psychological, cognitive, and ecological factors (Francis et al., 2018; Duke & Cartwright, 2021; Kim, 2017; Aaron et al., 2008; Li et al., 2020; Snow et al., 2018). In that context, we did not include specific measures of skills and abilities that have been linked with reading comprehension and shown to be impaired in children with ADHD, such as executive functioning, processing speed, or cognitive attentional processes (e.g., Follmer, 2018; Kershaw & Schatschneider, 2012; Georgiou et al., 2009; Johnston & Kirby, 2006; Joshi & Aaron, 2000; Tilstra et. al., 2009). Given our finding that decoding and language comprehension fully explain children's reading comprehension skills, this appears to have been a prudent decision. In other words, there is no unique variance for these additional constructs to explain as argued previously (e.g., Lonigan et al., 2018) – although the extent to which these reflect additional/unique constructs as opposed to subcomponents of the broad linguistic comprehension system remains an open area of inquiry as noted above. Future studies should consider examining additional skills that may influence decoding and language comprehension in children with ADHD. This line of research appears particularly important given emerging meta-analytic evidence that training decoding skills produces greater improvements in reading comprehension for children with ADHD than does directly training reading comprehension (Chan et al., 2023).

In addition, although our age range (8–13) is prototypical for studies of childhood ADHD, it covers a relatively large grade range (2^{nd} – 7^{th}). Despite the consistency in results across older and younger children in our current sample, future studies with larger samples may consider examining the extent to which the predictions of the simple view of reading vary across age/grade in children with ADHD. Similarly, our exclusion of older children/ adolescents may limit conclusions regarding the extent to which decoding and language comprehension can fully explain the more complex reading skills (e.g., synthesis, analysis, critique; e.g., Snow, 2018) despite the inclusion of items measuring inferential reading and listening skills in our subtest battery.

Next, despite the current study's position as the largest and most comprehensive test of the simple view of reading for children with ADHD to date, our sample size was nonetheless insufficient to test more fine-grained predictions from the model, including changes in the valence of the decoding/language comprehension relation from positive to negative for children with better vs. less developed reading comprehension skills; that language comprehension skills become stronger predictors of reading comprehension skills as children demonstrate mastery in decoding skills; and that the product of these component skills may (or may not) better predict reading comprehension relative to the variance explained by the individual components (Hoover & Gough 1990; Kershaw & Schatschneider, 2012). Future work with larger, longitudinal samples of children with ADHD and quantile regression methods are needed to determine the extent to which decoding and language comprehension contribute differently, and potentially multiplicatively, across ages and reading skills levels.

Finally, despite the benefits of including children with clinical disorders other than ADHD in the Non-ADHD group (e.g., improved specificity for conclusions regarding ADHD as noted above) this approach may be considered a limitation in that our Non-ADHD group may not inform our understanding of the 'simple view' in typically developing children despite the consistency between their reading scores shown in Table 1 (*M*=100–103, *SD*=15–16) and scores expected for neurotypical samples (i.e., *M*=100, *SD*=15). Therefore, future studies may consider replicating and extending these findings with additional comparison groups of typically developing children as well as groups comprised exclusively of each of the specific disorders represented in our Non-ADHD sample.

Practitioner Implications

Taken together, the current findings were highly consistent with predictions from the simple view of reading and previous literature indicating that decoding and language comprehension fully explain children's reading comprehension skills (e.g., Lonigan et al., 2018), and extended this line of inquiry by demonstrating that these findings hold both for children with ADHD and clinically evaluated children more broadly. These findings have implications for remediating reading difficulties in children with ADHD. They suggest that evidence-based reading interventions are likely to be just as effective for at-risk readers with ADHD as they are for at-risk readers without ADHD; although this conclusion is of course speculative because this was not an intervention study. Indeed, emerging meta-analytic evidence indicates that (a) targeting decoding skills produces improvements in reading comprehension that are as large, if not larger, for at-risk readers with ADHD as they are for at-risk readers without ADHD; and (b) adding ADHD-specific treatments (e.g., medication, behavioral therapy) to reading interventions does not produce incremental gains in reading for children with ADHD (Chan et al., 2023). From a curriculum development/policy standpoint, these findings emphasize the importance of explicit instruction and practice in both foundational decoding and higher-level language/linguistic comprehension skills (as well as deliberate practice applying these skills to understand printed language; Hoover & Tunmer, 2018). Future work is needed to further elucidate knowledge, skills, and abilities that contribute to the complexities of decoding (e.g., Friedman et al., 2017) and language comprehension (e.g., Kim, 2016) in this population to investigate how more complex models of reading comprehension may or may not differ for children with ADHD.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Educational Impact and Implications

The current findings indicate that the ‘simple view of reading’ is helpful for understanding reading comprehension difficulties in children with ADHD. We found that reading comprehension performance is fully explained by skill at converting printed words to speech sounds (decoding) and skill at understanding spoken language (language comprehension) amongst children with ADHD. Future studies are needed to understand why children with ADHD have difficulties with decoding and language comprehension.

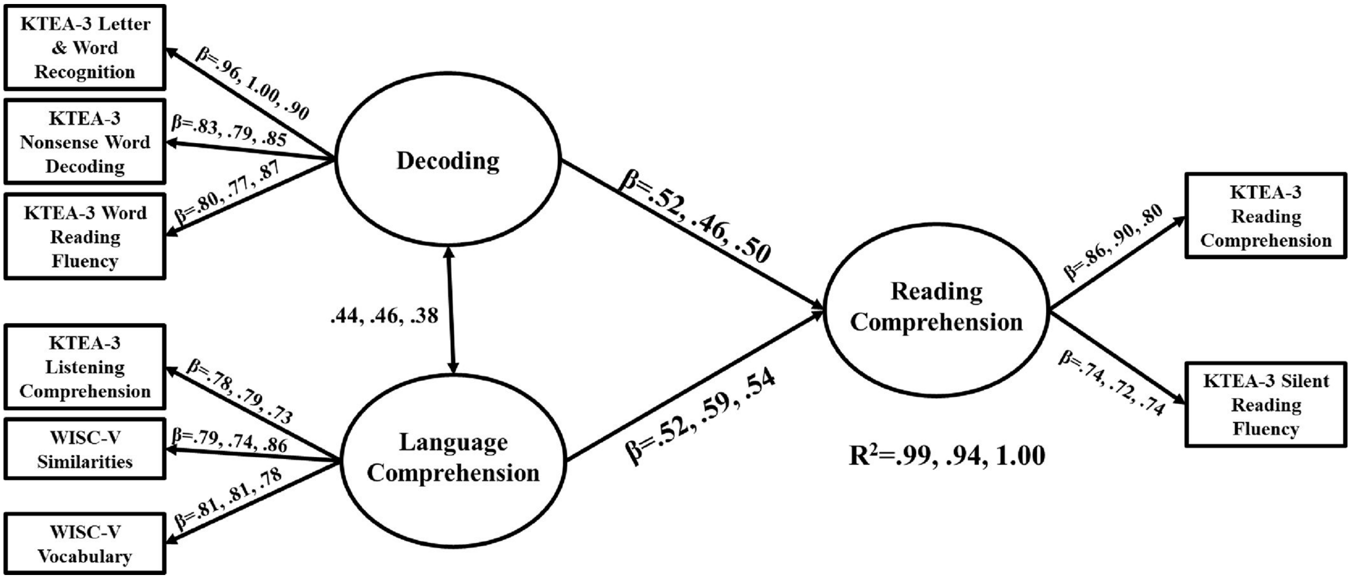

Figure 1.

Whole-group structural equation model of decoding and language comprehension predicting reading comprehension. Standardized loadings are shown for the full sample, ADHD subgroup, and non-ADHD subgroup, respectively (all p<.01). Age, sex, and SES are controlled for but not depicted for clarity.

Table 1.

Sample and Demographic Variables

Variable	ADHD (N=154)		Non-ADHD (N=96)		Cohen's *d*	*P*	Possible Range	Obtained Range		Skewness		Kurtosis	
	M	*SD*	*M*	*SD*				ADHD	Non-ADHD	ADHD	Non-ADHD	ADHD	Non-ADHD
Sex (% Boys/Girls)	67/33		56/44		--	.09, *ns*	--	--	--	--	--	--	--
Ethnicity (% B/A/W/H/M)	14/0/72/5/8		11/2/67/8/11		--	.34, *ns*	--	--	--	--	--	--	--
Age	10.11	1.44	10.57	1.46	0.32	.01	8.00–13.92	8.10–13.34	8.12–13.37	0.60	0.29	−0.82	−1.05
SES	47.49	11.09	47.47	12.44	−0.001	.99, *ns*	8–66	14–66	13–66	−0.51	−0.66	−0.33	−0.04
FRI (Standard Scores)	100.18	15.65	102.66	15.28	0.16	.23, *ns*	45–155	67–137	58–140	−0.03	−0.51	−0.59	0.35
COVID Protocol (% Y/N)	19/81		20/80		--	.85, *ns*	--	--	--	--	--	--	--
ADHD Symptoms													
BASC-3 Attention Problems													
Parent (T-score)	68.27	6.42	61.52	10.47	−0.82	<.001	10–120	48–81	36–81	−0.54	−0.19	0.17	−0.82
Teacher (T-score)	65.56	8.23	57.04	11.16	−0.90	<.001	10–120	37–83	34–81	−0.61	−0.25	0.82	−0.74
BASC-3 Hyperactivity													
Parent (T-score)	69.29	12.21	59.51	13.40	−0.77	<.001	10–120	42–99	38–93	0.01	0.65	−0.30	−0.06
Teacher (T-score)	64.38	14.39	52.60	12.14	−0.87	<.001	10–120	39–110	39–85	0.41	1.02	−0.32	−0.03
Reading Measures													
Reading Comprehension													
KTEA-3 Reading Comprehension	97.56	14.41	100.91	15.58	0.23	.08, *ns*	40–160	58–139	54–133	0.02	−0.17	0.05	0.13
KTEA-3 Silent Reading Fluency	96.93	13.34	100.24	15.56	0.23	.08, *ns*	40–160	60–126	53–139	−0.41	−0.29	−0.05	1.05
Decoding													
KTEA-3 Letter & Word Recognition	97.25	14.45	101.44	16.13	0.28	.03	40–160	53–144	51–148	0.03	−0.36	1.55	1.11
KTEA-3 Nonsense Word Decoding	87.59	14.40	99.67	15.79	0.80	<.001	40–160	64–131	62–141	0.60	0.03	−0.10	0.09
KTEA-3 Word Reading Fluency	91.88	16.77	99.51	16.44	0.46	.01	40–160	41–160	49–132	0.40	−0.47	4.01	0.53
Language Comprehension													

Variable	ADHD (N=154)		Non-ADHD (N=96)		Cohen's *d*	*P*	Possible Range	Obtained Range		Skewness		Kurtosis	
	M	***SD***	***M***	***SD***				**ADHD**	**Non-ADHD**	**ADHD**	**Non-ADHD**	**ADHD**	**Non-ADHD**
KTEA-3 Listening													
Comprehension	102.41	14.85	102.86	14.95	0.03	.84, *ns*	40–160	68–141	71–135	0.09	−0.04	−0.50	−0.81
WISC-V Similarities	10.21	2.94	10.69	2.89	0.16	.22, *ns*	1–19	1–18	2–19	0.03	0.05	0.10	0.16
WISC-V Vocabulary	10.84	2.76	11.22	2.59	0.14	.28, *ns*	1–19	5–17	5–19	−0.01	−0.15	−0.81	0.33

Note KTEA-3 = Kaufman Test of Educational Achievement – 3rd Edition (standard scores). WISC-V = Wechsler Intelligence Scale for Children – Fifth Edition (scaled scores). BASC = Behavior Assessment System for Children. Ethnicity: B = Black/African American, A = Asian, W = White Non-Hispanic, H = Hispanic/Latino, M = Multiracial. FRI = Fluid Reasoning Index (WISC-V), SES = Hollingshead socioeconomic status.

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Table 2.

Zero-order correlations among reading and demographic variables

	KTEA-3 RC	KTEA-3 SRF	KTEA-3 LWR	KTEA-3 NWD	KTEA-3 WRF	KTEA-3 LC	WISC-V Sim	WISC-V Voc	Age	Sex (F/M)	SES	ADHD (N/Y)
KTEA-3 Reading Comprehension	--											
KTEA-3 Silent Reading Fluency	.58**	--										
KTEA-3 Letter & Word Recognition	.73**	.63**	--									
KTEA-3 Nonsense Word Decoding	.63**	.57**	.81**	--								
KTEA-3 Word Reading Fluency	.66**	.65**	.77**	.64**	--							
KTEA-3 Listening Comprehension	.64**	.40**	.54**	.43**	.42**	--						
WISC-V Similarities	.63**	.44**	.53**	.44**	.40**	.59**	--					
WISC-V Vocabulary	.64**	.39**	.53**	.39**	.44**	.64**	.65**	--				
Age	.11	.14*	.11	.18	.28**	−.12	.04	−.02	--			
Sex (Female/Male)	−.09	−.17**	.01	−.03	−.05	.04	−.06	−.05	.07	--		
Socioeconomic Status	.32**	.26**	.28**	.17	.27**	.28**	.27**	.28**	.03	−.01	--	
ADHD Status (No/Yes)	−.11	−.11	−.13*	−.37**	−.22*	−.02	−.08	−.07	−.16*	.11	<.001	--

Note KTEA-3 = Kaufman Test of Educational Achievement – 3rd Edition (standard scores). WISC-V = Wechsler Intelligence Scale for Children – Fifth Edition (scaled scores). RC = reading comprehension; SRF = silent reading fluency; LWR = letter & word recognition; NWD = nonsense word decoding; WRF = word reading fluency; LC = listening comprehension; Sim = similarities; Voc = vocabulary; Sex (Female = 0, Male = 1); SES = Hollingshead socioeconomic status; ADHD (No = 0, Yes = 1). Correlation matrices for the ADHD and Non-ADHD groups separately can be found in Supplementary (Online) Tables X and Y.

* $p \leq .05$,

** $p \leq .01$

Table 3.

Model Fit

Model	AIC	BIC	CFI	TLI	RMSEA (90% CI)[1]	SRMR	χ^2	*df*	*p*	*Factor loadings*
Measurement Model										
Full sample	3801.56	3896.64	.98	.97	.07 (.04, .11)	.04	35.70	17	.01	β= .72−.96, all $p<.001$
ADHD subgroup	2354.86	2436.86	.97	.96	.08 (.04, .12)	.06	33.61	17	.01	β= .70–1.00, all $p<.001$
Non-ADHD subgroup	1495.01	1564.25	.99	.98	.05 (.00, .11)	.04	20.95	17	0.23	β= .70–1.00, all $p<.001$
Full Sample Structural Model	5895.15	6053.61	.98	.96	.06 (.03, .08)	.04	56.67	32	.01	β= .72−.91, all $p<.001$
Multigroup Model (ADHD, Non-ADHD)										
Unconstrained	5967.99	6284.92	.97	.95	.06 (.04, .09)	.05	95.23	64	.01	β= .73−.90, all $p<.001$
Constrained	5967.45	6280.86	.97	.95	.06 (.04, .09)	.05	96.68	65	.01	β= .72−.99, all $p<.001$

Note . AIC = Akaike's Information Criteria, BIC = Bayesian Information Criteria, CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, TLI = Tucker-Lewis index.

[1] T-sized RMSEA values (Yuan et al., 2016) were also computed as requested during the peer review process, and are identical to the upper bound of each model's 90% CI in the Table above. Interpretation of model fit based on T-sized RMSEA values varies according to model degrees of freedom and *N*; all models showed adequate (fair or close) fit based on the cutoff values recommended by Yuan et al. (2016).