2015

Effects of ADHD and Test Anxiety on Reading Comprehension and Test Performance

Sarah Wood

FLORIDA STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

EFFECTS OF ADHD AND TEST ANXIETY ON READING COMPREHENSION AND TEST PERFORMANCE

By

SARAH G WOOD

A Thesis submitted to the
Department of Psychology
in partial fulfillment of the
requirements for the degree of
Master of Science

2015

Sarah G Wood defended this thesis on November 30, 2015.

The members of the supervisory committee were:

Richard K. Wagner
Professor Directing Thesis

Sara Hart
Committee Member

Walter Boot
Committee Member

The Graduate School has verified and approved the above-named committee members, and certifies that the thesis has been approved in accordance with university requirements.

Dedicated to my parents and family who first introduced me to reading.

ACKNOWLEDGMENTS

Thank you to all of the family, educators and friends who have supported me throughout this journey. Lastly, I would like to express a special appreciation to my advisor Richard K. Wagner, committee members, and my lab for all of their support and guidance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Past research suggests that reading comprehension performance relies not solely on cognitive skills such as decoding, vocabulary, and inference skills, but also on attention and behavior. Specifically, the literature has pointed to attention deficit/hyperactivity disorder (ADHD) and test anxiety as possible influences on reading comprehension test performance. Previous work has examined the individual effects of ADHD and test anxiety on reading comprehension test performance. However, there is little research investigating their joint effects on reading comprehension test performance. The proposed study will attempt to answer three questions through a series of structural equation models (SEM). First, do ADHD and test anxiety affect reading comprehension test performance? Second, if so, are these effects independent or redundant? Third, in addition to their main effects, do test anxiety and ADHD interact in affecting reading comprehension test performance? Taken together, these results will inform researchers on the effects of ADHD and test anxiety about reading comprehension test performance.

INTRODUCTION

There is an increasing demand for children to demonstrate their literacy proficiency, including reading comprehension, through high-stakes standardized tests (Afflerbach, 2005; Porter, McMaken, Hwang, & Yang, 2011). High-stakes tests, which are tests determining grade advancement or classroom placement (Afflerbach, 2005), are becoming more important in determining children's success due to new educational policies (von der Embse et al., 2013a). Both No Child Left Behind (NCLB) and Common Core legislation have called for more of these sorts of tests as a means to measure educational learning. This legislation is resulting in high-stakes tests being introduced in more schools and at young ages (Segool, von der Embse, Mata, & Gallant, 2014; Triplett & Barksdale, 2005; Wigfield & Eccles, 1989). Although standardized tests are designed to measure proficiency in specific academic areas, additional nonacademic components may impact test performance (Haladyna, Haas, & Allison, 1998). In particular, there has been substantial research focused on the role of ADHD (Lewandowski, Gathje, Lovett, & Gordon, 2013; Lewandowski, Hendricks, & Gordon, 2012) as well as test anxiety (Haladyna & Downing, 2004; Hannon, 2012; Hannon & McNaughton Cassill, 2011; Segool, Carlson, Goforth, von der Embse, & Barterian, 2013) on standardized test outcomes, including reading comprehension.

Reading comprehension is a complex task involving many components (Cain & Oakhill, 2007; Snow, 2002), including both bottom-up and top-down processes. Bottom-up processes include skills such as decoding, whereas top-down processes include inference skills among others. These skills develop over a student's schooling. Once students transition from beginning to more advanced stages of reading, their reading comprehension becomes more critical to their school success. Classes begin to rely on students' ability to gain knowledge through reading. To measure these students' progress in reading comprehension as well as in other academic skills, standardized tests have been developed and, in many cases, mandated.

The No Child Left Behind Act (NCLB) established that states need to conduct mandatory testing. The Florida Comprehensive Assessment Test (FCAT) is Florida's response to this requirement. Testing begins in third grade and continues through high school. Although this testing enables tracking of students' performance, it is not without complications. Some students may not perform as well as expected based on their true reading comprehension level if construct irrelevant factors, including ADHD and/or test anxiety, impact their test performance (Haladyna & Downing, 2004).

Test Anxiety and Reading Comprehension Test Performance

Test anxiety, a type of "state anxiety" specific to testing situations, is experienced by 10% to 40% of students (McDonald, 2001; Segool et al., 2013; von der Embse, Barterian, & Segool, 2013a). Test anxiety invokes psychological, physiological, and behavioral reactions. These reactions may lead to construct irrelevant test results. For example, test anxiety has been shown to impact test scores, including reading comprehension test performance and related skills. Test anxiety increases as the stakes of the test increase (Segool et al., 2013). As elementary school children experience more standardized tests in connection with NCLB, it becomes increasingly important to understand test anxiety. Test anxiety's relationship to performance in areas such as reading and math is not always straightforward. Some studies show test anxiety lowers performance, yet other studies find no differences in academic performance between people with test anxiety and those without (McDonald, 2001; Segool et al., 2013; von der Embse, Mata, Segool, & Scott, 2013b). Subcomponents of test anxiety – including autonomic reactions, off-task behavior, and thoughts –have been found to impact performance measures differently (Wren & Benson, 2004). According to some studies, gender differences may occur in test anxiety (McDonald, 2001). Lastly, there are many measures of test anxiety, which may contribute to inconclusive results regarding the effect of test anxiety on academic performance (Morris, Davis, & Hutchings, 1981; Sarason, Davidson, Lighthall, & Waite, 1958; Spielberger, 1980; Wren & Benson, 2004).

Studies of the Effects of Test Anxiety and Reading in Children

Test anxiety in children lowers reading comprehension test performance (Gifford & Marston, 1966). However, this effect may be dependent on the severity of test anxiety symptoms (Neville, Pfost, & Dobbs, 1967). For example, Gifford and Marston (1966) studied the effects of high and low test anxiety levels, reading comprehension test performance, reading rate, and task experience (pre-test vs. post-test) in a group of fourth grade boys. They found that high anxiety levels significantly lowered the students' reading comprehension test performance, which was measured through a main idea recall task.

Neville et al. (1967) measured reading comprehension test performance and vocabulary skills growth in three groups of children who differed in levels of test anxiety (high, medium, and low). Children in the high test anxiety group performed lower on standardized tests of reading comprehension than children in the low anxiety group. Students in the medium level anxiety group performed better than both the low anxiety and high anxiety groups (Neville et al., 1967). The authors explained their results in terms of the inverse U effect of test anxiety on performance (Hebb, 1955). Taken together, the results based studies with children suggest that high levels of test anxiety negatively impact children's reading comprehension test performance.

Studies of the Effects of Test Anxiety and Reading in Adults

The negative impact of test anxiety on reading comprehension test performance has mixed support in the adult literature (Calvo & Carreiras, 1993; Calvo & Castillo, 1995; Calvo & Eysenck, 1996; Cassady, 2004; Everson, Smodlaka, & Tobias, 1994; Miesner & Maki, 2007; Richards, French, Keogh, & Carter, 2000). The relationship appears to be complex, depending on how reading comprehension is defined and measured (e.g. inferences, free recall), and there may be possible interactions among types of reading comprehension test performance measures and test anxiety. For example, test anxiety was not found to significantly lower reading comprehension test performance in college students overall (Minnaert, 1999). However, a significant interaction between test anxiety and prior knowledge was found, such that students with high test anxiety and low prior knowledge performed significantly worse than students with more prior knowledge. In contrast, students with low test anxiety and high prior knowledge performed the best (Minnaert, 1999). In another sample of college students, test anxiety levels did not affect overall reading comprehension test performance (Calvo & Carreiras, 1993). Yet students with low test anxiety recalled material in narrative texts significantly higher than students with high test anxiety (Calvo & Carreiras, 1993).

As part of a larger study investigating high stakes and low stakes testing, Cassady (2004) found a significant negative correlation between test anxiety and free recall for passages read, such that college students with lower levels of test anxiety recalled more reading material than students with higher levels of test anxiety. Inferential reasoning, an important skill for reading comprehension test performance, was also explored in that study, and a significant negative correlation was found between inferential reasoning and test anxiety. Inferential reasoning was also tested through a sentence-verification task in which students with high test anxiety were significantly worse at making certain kinds of inferences (Richards et al., 2000).

Test anxiety may impact reading comprehension test performance through metacognitive skills. Metacognitive skills help readers monitor their comprehension and make adjustments when they do not comprehend the material. In one study, metacognitive skill was assessed through two subtasks: a word list task and a vocabulary task (Everson et al., 1994). The hit rate, defined as the number of words respondents said they knew and got correct on the vocabulary test, and false alarm rate, defined as the number of words they said they knew and got wrong on the vocabulary test, were used to measure metacognitive skill. Significantly higher performance levels on a metacognitive knowledge task were found for low anxiety participants than for high anxiety participants. Additionally, in comparison with the high anxiety group, significantly higher reading comprehension test performance levels were found in the low anxiety group (Everson et al., 1994).

In summary, findings vary about the overall effects of test anxiety on reading comprehension test performance. The evidence above indicates that adults with high levels of test anxiety have lower reading comprehension test performance than comparable adults with low levels of test anxiety. However, the effects of test anxiety on reading comprehension test performance appear to be complex.

ADHD and Reading Comprehension Test Performance

ADHD, a disorder characterized by inattention and hyperactivity-impulsivity, is common in children, with a prevalence rate of 9% in the United States (Bloom, Cohen, & Freeman, 2011). Inattention is the inability to stay on task. Hyperactivity-impulsivity refers to a pronounced restlessness (Willcutt, Pennington, & DeFries, 2000). Even though there has been debate in the field on the definition of ADHD, recent reviews support one construct with two subtypes: inattention and hyperactivity (Willcutt et al., 2012). Overall, the literature supports that ADHD has a negative impact on reading comprehension test performance (Brock & Knapp, 1996; Miller et al., 2012; Pham, 2013; Stern & Shalev, 2013) with only one study not supporting this pattern (Ghelani, Sidhu, Jain, & Tannock, 2004).

For example, Brock and Knapp (1996) were interested in effects of ADHD on students' reading comprehension test performance at both macro and micro levels of text processing. The macro level of text processing was measured by asking participants to identify the topic and the main ideas of a passage. The micro level of text processing was measured by recall of story details. Potential participants with reading disabilities or disorders other than ADHD were excluded from the study. An ADHD group with either predominantly inattentive subtype or combined ADHD subtype was matched with a non-ADHD comparison group on age, grade, and parental education levels. Results indicate that children in the ADHD group performed lower on both macro-comprehension and micro-comprehension than the control children, but statistical interactions were not found between the two comprehension levels (macro and micro) and the two groups (ADHD and non-ADHD control).

Ghelani et al. (2004) showed a different pattern of results when they controlled for IQ. They investigated reading comprehension test performance in adolescents aged 14-17 years old in four groups: reading disabled, ADHD, ADHD and reading disabled, and non-afflicted controls. Here we focused our review of their study on differences between the ADHD and non-afflicted control group. Reading comprehension test performance was measured using the Gray Oral Reading Test-Fourth Edition (GORT-4) and the Gray Silent Reading Tests (GSRT). In particular, the ADHD group had significantly lower scores on the GSRT than the non-afflicted control group. Reading rate and accuracy, word reading, rapid word reading efficacy, vocabulary, and intelligence were used as covariates. Significant reading comprehension test performance differences were found between the ADHD and non-afflicted controls for the GSRT but not for the GORT-4. Interestingly, when IQ differences were controlled, the difference was no longer significant. These results are in contrast to the Brock and Knapp (1996) study above, but the two studies are difficult to properly compare due to differences in control variables.

Two recent studies support differences in reading comprehension test performance between students with and without ADHD (Miller et al., 2012; Pham, 2013). American elementary school children, ages eight to eleven years old, participated. In both studies, intelligence was measured through the Weschsler Intellectual Scale for Children-Fourth Edition, with Pham (2013) using the abbreviated version. Additionally, children's measures of attention and hyperactivity were investigated both separately and together. Although both studies investigated the differences in reading comprehension test performance between students with and without ADHD, they used different methodologies. Thus, each study will be reviewed in turn.

The overall purpose of the Pham (2013) study was to investigate children's reading abilities and how reading performance is impacted by the different behaviors of ADHD: inattention, hyperactivity, and impulsivity. Reading performance was broken down into fluency and reading comprehension test performance, as measured on the Gray Oral Reading Test-Fourth Edition. Parents and teachers rated ADHD symptoms, and those scores were added and used in statistical analyses. The authors performed a series of multi-step regression analyses to predict reading comprehension test performance from measures of inattention, hyperactivity, and impulsivity. In the first step, confounding background variables of socioeconomic status (SES), IQ, and gender were controlled. Then, in the second step, inattention or hyperactivity was entered. The results of these analyses demonstrated that inattention significantly accounted for variance in reading comprehension test performance, whereas hyperactivity did not. Furthermore, after the background variables of SES, IQ, and gender were entered into the regression, 11% of the variance in total reading comprehension test performance was accounted for by inattention. Interestingly, gender differences were present for reading comprehension test performance and inattention, suggesting that girls displaying inattention symptoms tend to do better on reading comprehension performance tests than boys with inattention symptoms.

The nature of the reading comprehension test performance differences between ADHD and control children was further explored by investigating children's ability to recall central and peripheral information (Miller et al., 2012). Children with and without ADHD were matched on word level reading scores and separated into two groups: ADHD and control. The effect of ADHD status (ADHD or control) and centrality of recalled information (central and peripheral) on performance was explored using a mixed-design analysis of covariance (ANCOVA) with gender as the covariate. The authors state a marginally significant effect of ADHD status group, but with a p-value of 0.07. However, there are a number of interesting additional findings. Children with ADHD were found to have a significantly harder time recalling central information than peripheral information. Also, a correlation was found between the number of ADHD symptoms and the fraction of central ideas recalled, with children who have a greater number of ADHD symptoms recalling less central information. This result is interesting, as central information is key to constructing a mental representation needed in reading comprehension. Taken together, these studies offer support for the view that ADHD lowers reading comprehension test performance.

Studies of ADHD and Test Anxiety Together Impacting Reading Comprehension Test Performance

Currently, most of the literature about people with comorbid conditions of ADHD and test anxiety is focused on adults, rather than children. Additionally, in the adolescent and adult literature only two studies investigated test anxiety, ADHD, and reading comprehension test performance together, within the context of testing accommodations (Lewandowski et al., 2012; 2013). Both studies focused on testing accommodations and test tasking skills for ADHD and non-ADHD students during high stakes tests but with different age groups: the 2012 study used high school students, and the 2013 study used college students. The incorporation of the three variables (ADHD, test anxiety, and reading comprehension) enables an investigation of the interaction between ADHD, test anxiety, and reading comprehension test performance. In the 2012 study with high school students, test anxiety negatively correlated with reading comprehension test performance for students with and without ADHD (Lewandowski et al., 2012). Also, significantly lower reading comprehension test performance accuracy was found for students with ADHD than for the non-ADHD group. In contrast, the 2013 study of college students showed a significant difference among ADHD students' perceptions of anxiety during testing, despite not finding differences in reading comprehension test performance compared to non-ADHD peers (Lewandowski et al., 2013).

However, these studies have a couple of limitations. First, identification of ADHD was based on self-report rather than being objectively determined. In the high school study, students with ADHD self-identified and had a 504 or Individualized Education Plan (IEP), whereas in college, the ADHD symptoms were measured for each participant by a single self-report scale. Thus, differences in findings between the 2012 and 2013 Lewandowski et al. studies could stem from inaccurate self-reporting or school diagnoses of ADHD. Second, a restriction of range problem is created by using only college students because pre-college students with high test anxiety and ADHD may not reach college. The restriction of range may lead to incorrect conclusions, as correlations may appear weaker than the true correlation of the whole population (Wiberg & Sundström, 2009)

In summary, although both test anxiety and ADHD are negatively associated with reading comprehension test performance outcomes, there is a dearth of research exploring test anxiety, ADHD, and reading comprehension test performance together.

The Present Study

The goal of the present study is to examine three questions about test anxiety and ADHD as predictors of reading comprehension test performance using structural equation modeling (SEM) of data provided by a large and representative sample. The three questions are: 1) Do test anxiety and ADHD symptoms both negatively affect reading comprehension test performance? 2) If both test anxiety and ADHD symptoms have significant negative impacts on reading comprehension test performance, are these impacts additive or duplicative? 3) Does the simultaneous presence of both test anxiety and ADHD symptoms have an interactive negative impact on reading comprehension test performance?

This study will contribute to the existing literature in three important ways. First, by measuring both ADHD and test anxiety in the same sample, it will be possible to determine whether ADHD and test anxiety affect reading comprehension test performance, and if so, whether the observed effects are independent or redundant. Second, it will be possible to determine whether ADHD and test anxiety interact to affect reading comprehension test performance. Third, this study will utilize several methodological advances over past research. Latent variables with multiple indicators will be used to represent the constructs of ADHD and test anxiety. This enables a reduction in measurement error over observed variables, which is particularly important for testing possible interaction effects. In this study, ADHD and test anxiety were treated as continuous variables. Artificially dichotomizing continuous variables reduces sensitivity and thus the ability to detect interactions (Cohen, 1983).

METHODS

Participants

Children from fourth grade through seventh grade and their parents participated in this study. Students were grouped into two cohorts, one composed of students from fourth through fifth grade (N=149) and the other composed of students from sixth through seventh grade (N=99). The sample was part of the Florida Twin Project on Reading, which utilizes achievement and progress monitoring data for reading from Florida's Progress Monitoring and Reporting Network (PMRN), a statewide educational database (Taylor, Hart, Mikolajewski, & Schatschneider, 2013a). The state's ethnic and racial profile was reflected within 1% in the sample. The sample consisted of 71% White, 12% African American, 9% mixed race, 2% Asian, 5% other, and 1% unknown due to not reporting race. The population was ethnically 24% Hispanic and 71% non-Hispanic (5% not reporting ethnicity). The study used data from the 2010-2011 school year testing period on the reading comprehension portion of the FCAT.

Procedures and Measures

In summer 2010, ratings of test anxiety and ADHD were collected through questionnaires. After participating, parents and children received $30 and $10 gift cards. These procedures were conducted in accordance with the American Psychological Association (APA) ethical principles for human subject research, including informed consent and assent. All measures produced raw scores and these scores then were z-scored to put them all on the same scale. The original scales for the constructs of interest were either continuous i.e. reading comprehension or on likert scale for the ADHD and test anxiety constructs. Thus, because of the differences in scales the raw scores were z-scored to make the scales comparable. The z-scoring process does not change how the variables are correlated with other variables, but does help the iterative process of model fitting by the Mplus program.

Reading Comprehension: Florida Comprehensive Achievement Test (FCAT) 2.0

Reading comprehension test performance was measured by the Florida Comprehensive Achievement Test (FCAT) 2.0. This criterion-referenced test is group-administered to all Florida students every spring. During this test, students answered short- or long-format multiple choice items depending on the content of the passage (Hart, Soden, Johnson, Schatschneider, & Taylor, 2013). This test had a Cronbach's alpha of 0.90 (Hart et al., 2013).

ADHD: Strengths and Weaknesses of ADHD-Symptoms and Normal-Behavior (SWAN)

Parent questionnaire ratings of attention and activity were taken using the SWAN rating scale (Swanson et al., 2005). Inattention and Hyperactivity/Impulsivity subscales each contained nine items. Each item had a 7-point Likert scale (1=far below, 7=far above). In our analyses, the total SWAN score was multiplied by negative one so that higher scores indicated more ADHD symptoms. The SWAN had a reliability (Cronbach's alpha) of 0.85 (hyperactivity subscale) and 0.90 (inattention subscale) (Taylor, Allan, Mikolajewski, & Hart, 2013b).

Test Anxiety: Children's Test Anxiety Scale (CTAS)

The Children's Test Anxiety Scale (Wren & Benson, 2004) was used to measure test anxiety in children. Each dimension of thoughts, autonomic reactions, and off-task behaviors was measured through 30 total items on a 4-point Likert scale (1=almost never, 4=almost always). "Thoughts" were defined as test irrelevant thoughts, self-critical thoughts and other types of worry. "Autonomic reactions" were defined as somatic changes related to test anxiety (e.g., sweating, upset stomach). "Off-task behaviors" were defined as distracting behaviors or nervous habits invoked by test anxiety. Mean scores from the student's CTAS subscales (Autonomic reactions, off-task and thoughts) were used with higher scores indicating more test anxiety. The reliability of the CTAS was an alpha coefficient of 0.89 (Wren & Benson, 2004).

Power Analysis

A power analysis was conducted to test model fit. This study is underpowered in all of the models. Power estimates for the selected appropriate degrees of freedom and sample size indicated a lack of power for the following models. Models 1a and 1b shown in figure 1 are the most underpowered with 1a only having power of under 0.081 for a not close fit and 1b having no degrees of freedom as they are just identified. The model 2 with 7 degrees of freedom had power between 0.105 and 0.081 for a not close fit and thus underpowered. Model 3 with 15 degrees of freedom had 0.127 power for a not close fit and was the most powered model.

Additionally, the models should have between a couple hundred and 3,000 more participants than the study included.

Our study is underpowered but no more than many of the other studies that have been published. Inadequate statistical power results in the inability to distinguish between good and excellent fitting models. However, if an underpowered model produces statistically significant parameters then those parameters must be interpreted.

RESULTS AND DISCUSSION

Preliminary Analyses

Descriptive statistics, including means, standard deviations, minimum and maximum values, and skewness and kurtosis indexes, are reported for all measures in Table 1. Univariate outliers, as defined by the median plus or minus two interquartile ranges (IQR) criterion, were identified and investigated. Sixty-one univariate outliers were found in all the test anxiety subtypes (autonomic reactions (n=24), offtask (n=15), and thoughts (n=7)) and FCAT variables (n=15), but not in the ADHD (hyperactivity (n=0) and inattention, (n=0)) subtype variables. All univaraite outliers were brought to the fence boundary defined as the median plus or minus two interquartile ranges. No bivariate outliers were identified through the examination of scatterplots. Normality was assessed, including the examination of skewness and kurtosis using the skew index and the kurtosis index. All skewness values were within the normal range with skew index values between 2 and -2. Kurtosis index values between (-.145 to .424) indicate no distribution problems. Nonlinearity was evaluated through examining scatterplots, and the data did not violate the linearity assumption. Additionally, multivariate normality and multivariate outliers were explored through using the Mahalanobis distance formula. Full Information Maximum Likelihood (FIML) was used to handle missing data with the Mplus program. Pearson correlation coefficients are presented in Table 2. The correlations were consistent with the previous findings of test anxiety and ADHD, each being negatively related to reading comprehension test performance.

Mplus Results

To explore the specific questions regarding how test anxiety and ADHD impact reading comprehension test performance, structural equation modeling was carried out using Mplus software (L. K. Muthen & Muthen, 2012). The 4-5th twin 0 group was used as an illustrated example of the models run for each group, (4-5th twin 0, 4-5th twin 1, 6-7th twin 0, 6-7th twin 1) (see figures 1-3).

Model fit assessment. Model fit was assessed through the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), Chi-Square, Chi-square/degrees of freedom, and the Tucker-Lewis Index (TLI). Each model fit is reported in table 4. Model fit was assessed for all over-identified models.

Main effects of ADHD and test anxiety on reading comprehension test performance. To determine whether test anxiety and ADHD symptoms each affect reading comprehension test performance, two separate SEM models were run on each of the four groups: model 1A with test anxiety (Figure 1a) and model 1B with ADHD (Figure 1b) as exogenous variables. ADHD and test anxiety were represented by latent variables with multiple indicators to better represent the constructs and to reduce measurement error (Bollen, 2002). The latent variable of ADHD was composed of the SWAN Hyperactivity and Inattention subscales. The latent variable of test anxiety was composed of CTAS thoughts, off-task behavior, and autonomic reactions subscales. Using the t-rule, scale dependency rule, and the two-indicator rule, the models were identified.

More test anxiety symptoms (CTAS) were associated with significantly lower reading comprehension test performance (FCAT) with standardized coefficients ranging from -0.165 to -0.447 (see table 4). Good to moderate model fit was observed except in the model using the 6-7th grade twin 1 (see table 3). Test anxiety accounted for between 10-20% for 4-5th grade and 2-4% for 6-7th grade of the variance in reading comprehension test performance. Overall, these results suggest that higher test anxiety symptoms have a significant negative impact on reading comprehension test performance.

Similarly, more ADHD symptoms (SWAN) were associated with significantly lower reading comprehension test performance (FCAT) with standardized coefficients ranging from -0.359 to -0.478 (see table 4). This was a just-identified model, thus model fit could not be assessed. This model shows the simple effects of ADHD symptoms on reading comprehension test performance and accounted for 13-15% for 4-5th grade and 19-22% for 6-7th grade of the variance in reading comprehension test performance. Collectively, these results suggest that increased ADHD symptoms have a significant negative impact on reading comprehension test performance.

In conclusion, there are significant simple effects of test anxiety and ADHD on reading comprehension test performance. As hypothesized, these simple effects were significant and negative, such that lower performance on the reading comprehension test was associated with more symptoms of test anxiety and ADHD. Although ADHD accounted for a greater amount of variance in reading comprehension test performance than test anxiety, both accounted for a significant amount of variance.

Independence of effects. To determine whether the effects of test anxiety and ADHD symptoms on reading comprehension test performance are redundant or independent, an SEM model was run in which both the latent ADHD and the latent test anxiety variables were included as exogenous variables (see Figure 2). Significant negative structure coefficients were present in both the ADHD and test anxiety latent variables indicating independent contributions on reading comprehension performance.

Both test anxiety symptoms and ADHD symptoms were independently associated with significantly lower reading comprehension test performance (FCAT). Additionally, there was positive and significant correlation between ADHD symptoms and test anxiety symptoms, which ranged from (.226 to .344) except in grade 6th-7th where it was positive but not significant (β = .025). In all the models, except grade 6-7th twin 0, test anxiety symptoms had a significant negative effect on reading comprehension test performance. This may be due to some sample specific variation. Consistently across the models ADHD symptoms were significantly negatively correlated with reading comprehension test performance. Model fit ranged from excellent model fit to moderate model fit.

Collectively these models indicated that the effects of test anxiety and ADHD were independent and thus not redundant effects. These results are congruent with the hypothesis that both test anxiety and reading comprehension uniquely predict reading comprehension test performance.

Interactive effects. To determine whether test anxiety and ADHD symptoms interact to affect reading comprehension test performance, a structural equation model including these latent factors was run. This model 3 is similar to the model 2 but contains the creation of an additional interaction term (see figure 2 and 3). If the models contained significant coefficients for the latent interaction term, that would support an interaction being present between test anxiety and ADHD.

This interaction term was created as a third latent variable representing the interaction of test anxiety and ADHD. There are two main methods for creating an interaction term in a structural equation model (Klein & Moosbrugger, 2000; Marsh, Balla, & McDonald, 1988). One method uses the multiplicative product of the indicator variables to create the interaction term as recommended by Marsh et al. (2007). The other method uses the latent variables themselves to create the interaction as recommended by Klein and Moosbrugger (2000). Each of these methods creates an interaction term: one method uses the multiplicative product of the indicator variables, whereas the other method uses the latent variables themselves for the interaction. By comparing the results from these two methods, overall results can become clear despite some individual model convergence problems. For example, if the results of the ADHD and test anxiety interaction model containing the latent interaction variable described by Klein and Moosbrugger (2000) (figure 3) support an interaction, it may suggest that an interaction is truly present between ADHD and Test anxiety. However, if the other method of creating the interaction term from the indicator variables described by Marsh (2007) results in incomplete conclusions, as not all models successfully converge, it is hard to draw conclusions from this method. Therefore, looking at results from both methods enables us to gain more conclusive results.

First, I will cover the Marsh method used to create the interaction term within the context of this study. The interaction term was created from the multiplicative product of the ADHD and test anxiety indicators. The second method used to create an interaction term was described by Klein and Moosbrugger (2000). Specifically in this research study, latent ADHD and latent test anxiety variables were used directly within Mplus using the XWITH command to create the interaction term. Consequently, the interaction term is not created within the measurement model but at the structural level. Therefore the interaction term does not contain a mean or a variance, and does not covary with other model parameters. The creation of the interaction term should not impact the model fit. Unfortunately, most of the traditional model fit statistics for the second method were not available but the log-likelihood ratio test can still be used (Maslowsky et al., 2014).

Turning to results from both interaction term methods; Marsh (2007) and Klein & Moosbrugger (2000), these models at the 4-5th grade level show no evidence of an interactive effect of test anxiety and ADHD on reading comprehension test performance. The interaction term remained non-significant with the standardized beta weight between (.002 to .309). Similarly, at the 6-7th grade level there was no evidence of an interactive effect of test anxiety and ADHD on reading comprehension test performance. The correlation between test anxiety and ADHD was significant for grades 4-5th and 6-7th except in twin one where it was consistently not significant. Two additional correlations between the interaction term and test anxiety as well as the interaction term and ADHD are produced in the Marsh (2007) method and are reported on here. First, the correlation between interaction term and test anxiety term was not significant in 4-5th grade, however in 6 -7th grade the correlation between interaction term and test anxiety term was mostly significant, with only two models (C and D) showing the non-significant pattern. Second, the correlation between the interaction term and ADHD was not significant in 4-5th grade. However, in the 6-7th grades the results were mixed for the correlation between the interaction term and ADHD as half of the models indicated non-significant correlation while the other half indicated a significant observed correlation. Thus, correlations between test anxiety and the interaction term as well as ADHD and the interaction are not conclusive for the 6-7th grade. Taken together, there is support for a significant correlation between test anxiety and ADHD.

Successful model convergence was found for most models in 4-5th grade and all models in 6-7th grade. Using the 4-5th grade data, there were some problems with model convergence for both the Marsh method and the Klein and Moosbrugger method. The 4-5th grade twin 1 model did not converge using the Klein and Moosbrugger method. Four out of 14 models across both twin groups in 4-5th grades, did not converge using the Marsh method. For example, neither model with twin one or twin zero which used the autonomic reactions by hyperactivity and thoughts by attention produced model convergence. It is unclear why these models did not converge, in that they have met the necessary identification rules: t-rule and scale dependency rule and two-indicator model rule. Taken together these rules indicate that the model was identified. A reason for the models not converging can be explained by the presence of Haywood cases. A Haywood case is when a model estimates negative residual variance in an indicator variable. In this study, Haywood cases were present with a negative residual variance found in the models 1b, 2 as well as model 3. There are several reasons for Haywood cases to be present: model identification and specification problems, bad starting values, presence of outliers, small sample size, and only two indicator variables (Kline, 2011).

However, model specification and model identification were not likely to be the problem. The specification and identification of the models have been thoroughly reviewed and deemed as properly specified and identified. Bad starting values may have contributed to the model problems. On the other hand, the Mplus program is capable of running many iterations with different starting values and in this study the maximum number of iterations were used for running the models. Additionally, starting values were used from similar well fitting models but negative residual variance still remained. Outliers were not likely the cause, as they had been removed prior to the SEM analysis. Lastly and most likely, the combination of a small sample and having only two indicators for the ADHD latent variable may be responsible for this negative variance.

Taken together these results better inform us on the simple effect, independent effect and interactive effect of test anxiety and ADHD on reading comprehension test performance. Based on the data collected from 4-5th grade and 6-7th grade students, test anxiety and ADHD do have significant negative effects on reading comprehension test performance. These significant negative effects are additive and independent of reading comprehension test performance. However, these effects are not interactive as hypothesized. Thus, the data indicates that although test anxiety and ADHD have independent significant negative effects on reading comprehension test performance they do not interact to have an additional negative effect on reading comprehension test performance.

Discussion

The goal of the present study was to examine three questions about test anxiety and ADHD as predictors of reading comprehension using structural equation modeling of data provided by a large and representative sample. Three questions were investigated:
1) Do test anxiety and ADHD symptoms both negatively affect reading comprehension test performance? 2) If both test anxiety and ADHD symptoms have significant negative impacts on reading comprehension test performance, are these impacts additive or duplicative? 3) Does the simultaneous presence of both test anxiety and ADHD symptoms have an interactive negative impact on reading comprehension test performance?

Answering the first question, the results indicate that there were significant independent contributions of ADHD symptoms and test anxiety symptoms on reading comprehension test performance. We found a consistent negative effect of ADHD symptoms on reading comprehension test performance across the two age groups of 4-5th and 6-7th grades. Interestingly, the amount of variance explained by ADHD symptoms increased with age. The ADHD symptoms of the younger children explained around 13% of the variance compared to

ADHD symptoms of the older children explaining around 20% of the variance. Thus, this study adds to previous findings by supporting the results that ADHD symptoms may result in lower reading comprehension test performance. (Brock & Knapp, 1996; Miller et al., 2012; Pham, 2013). Next, test anxiety was negatively associated with reading comprehension test performance and this pattern of results was obtained for 3 (which excluded the twin zero 6-7th grade sample) of the 4 samples we analyzed. This is likely due to specific sample variation but the overall results suggest that test anxiety has a significant and negative impact on reading comprehension test performance.

Previous findings on negative correlation between test anxiety and reading comprehension test performance were based on a categorical classification of test anxiety. This study, on the other hand, is based on a dimensional classification. Thus our results extend and lend support to the previous studies of a significant negative impact of test anxiety on reading comprehension test performance for children with higher levels of test anxiety (Gifford & Marston, 1966; Neville et al., 1967).

Turning toward the second question, significant independent contributions of ADHD symptoms and test anxiety symptoms were found for both 4-5th grade and 6-7th grade. Both ADHD symptoms and test anxiety were negatively correlated with reading comprehension test performance. However, there was not an independent significant negative effect of test anxiety for grades 6-7th twin 0. Overall the models together show that the effects of ADHD symptoms and test anxiety on reading comprehension test performance is negative and additive.

Lastly, interactive effects between ADHD and test anxiety were not found. Two methods were utilized to create the interaction terms and both methods indicate no interactive effects. Not all models converged but for those that did the conclusions are the same, no interactive effect between ADHD and test anxiety.

In summary, the results indicated that both test anxiety and ADHD lower reading comprehension test performance independently. Additionally, there is not a significant interaction between ADHD and test anxiety that further negatively impacts reading comprehension test performance. Thus, the effect of ADHD and test anxiety was additive but not interactive on reading comprehension test performance.

This study contributes to the existing literature in four important ways. First, this current study is one of the only studies to investigate test anxiety and ADHD in elementary and middle school children, whereas all previous studies focused on high school and college students (Lewandowski et al., 2012; 2013). Second, it establishes that ADHD symptoms and test anxiety symptoms each contribute independent rather than redundant components in their relationship to reading comprehension. Third, our analysis enables us to see that test anxiety and ADHD do not interact to lower reading comprehension test performance. Fourth, this study uses updated statistical methodology and a large data set, providing more accurate and powerful modeling than had previously been done.

This methodology has several benefits. In terms of statistical models, this study uses structural equation modeling instead of path analysis. Additionally, using latent variables, created through the use of structural equation modeling, enables a reduction in measurement error over observed variables. In turn, this measurement error will not be amplified during the creation of the interactive latent variable through the multiplicative product. In terms of our data set, the large sample size enables greater sensitivity to detect differences, which is especially important for interactive effects. Lastly, this population sample enables us to explore the symptoms of ADHD and test anxiety as a continuum of symptoms (ranging from high to low) instead of dichotomizing ADHD and test anxiety into symptom levels of only high and low. Dichotomizing variables reduces sensitivity and thus the ability to detect interactions (Cohen, 1983). Measuring along a continuum of symptoms results in improved sensitivity to detecting an interactive effect between ADHD and test anxiety on reading comprehension test performance.

Future directions. One important future direction is to understand the causal mechanism(s) behind the influences of ADHD and test anxiety on reading comprehension. An example of one such mechanism may be working memory. Test anxiety, ADHD, and reading comprehension are known to be affected by individual differences in working memory (Cassady, 2004; Kofler, Rapport, Bolden, Sarver, & Raiker, 2010; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Richards et al., 2000). Working memory includes the visual spatial sketchpad, the phonological loop, and the central executive processor (Baddeley, 1992). The visual spatial sketchpad processes and manipulates incoming visual information, and the phonological loop processes and manipulates incoming verbal information. The central executive processor controls and manages the visual sketchpad and phonological loop. It is possible that the effects underlying both test anxiety and ADHD on reading comprehension are mediated by working memory.

An association between working memory and reading comprehension abilities has been established in children (Cain, Oakhill, & Bryant, 2004; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000). Higher levels of working memory are associated with higher levels of reading comprehension, according to the capacity theory of comprehension (Daneman & Merikle, 1996; Just & Carpenter, 1992). It postulates that working memory is an underlying mechanism necessary for achieving reading comprehension (Daneman & Carpenter, 1980; Just & Carpenter, 1992).

In addition, test anxiety has also been associated with working memory (e.g., (Hadwin, Brogan, & Stevenson, 2005; Ikeda, Iwanaga, & Seiwa, 1996). Test anxious individuals use the phonological loop to bolster their performance during reading comprehension tasks, contrary to non-afflicted children who do not have this higher cognitive load associated with low working memory (Calvo & Castillo, 1995).

ADHD is also associated with working memory deficits (Martinussen et al., 2005; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). There is a variety of possibilities for these deficits, including the fact that brain regions associated with ADHD overlap with central executive functions, including working memory (Martinussen et al., 2005). Furthermore, a study found working memory deficits to mediate the relationship between ADHD symptoms and the recall of central ideas (Miller et al., 2012). In other words, working memory deficits associated with ADHD symptoms may be a mechanism contributing to increased difficulty of recalling central ideas. Taken together, reading comprehension, test anxiety, and ADHD are all impacted by working memory. Both test anxiety and ADHD are known to decrease working memory capacity, and working memory capacity is necessary for reading comprehension. Working memory may be the process underlying the relationship between ADHD and test anxiety and their impact on students' reading comprehension performance and thus possibly mediate the relationship between ADHD and test anxiety to reading comprehension test performance.

A variety of mechanisms, including executive functioning, may be underlying both test anxiety and ADHD effects on reading comprehension test performance. Executive functioning of adults with ADHD was found to result in lower reading scores (Miranda, Mercader, Fernández, & Colomer, 2013). Executive functioning and its different subcomponents such as working memory may be such mechanisms. Focusing on executive functioning and attention, the authors of one study found higher levels of anxiety, including state anxiety, predicted lower levels of executive functioning (Ursache & Raver, 2014). However, there were differences in the type of anxiety, state vs trait, and how it relates to the Stoop task, supporting the conclusion that higher levels of state anxiety are related to better performance on the Stoop task. Thus, it may be important to explore the differences in attention and anxiety types interactions (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). Taken together, executive functioning impacts both anxiety and ADHD, which then impact reading.

The working memory component of executive functioning is the most explored in relation to reading and test anxiety. Test anxiety lowers working memory capacity (for review see (Mowbray, 2012)). Reading comprehension improves with working memory interventions for children (García Madruga et al., 2013). Specifically, metacognition can be improved during working memory training (Carretti, Caldarola, Tencati, & Cornoldi, 2013). Additionally, mindfulness training has improved working memory and lowered mind wandering resulting in higher reading comprehension scores on the GRE (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013). Another skill needed in reading comprehension is comprehension monitoring. This enables readers to monitor their understanding while reading a text and to make appropriate adjustments to their reading (Oakhill, Hartt, & Samols, 2005), although the purpose of the reading may be important in this effect of working memory on comprehension (Linderholm & van den Broek, 2002). Unfortunately for children with ADHD it does not show that working memory training will improve academic outcomes (Rapport, Orban, Kofler, & Friedman, 2013).

The impacts of test anxiety and working memory capacity on the ability to make inferences during reading comprehension has been well documented in both native and foreign language reading (Rai, Loschky, Harris, Peck, & Cook, 2011). Working memory also has been shown to be critical in generating predictive inferences over a range of text content (Estevez & Calvo, 2000). Inferential processing by children with ADHD is lower than by children in the control group. Additionally, their comprehension monitoring abilities are far lower as well (Berthiaume, Lorch, & Milich, 2010; Miranda et al., 2013). Importantly, children's low performance on a national high stakes test in the UK was connected to low executive functioning and working memory (Gathercole & Pickering, 2000; Gathercole, Pickering, Knight, & Stegmann, 2004).

Limitations

There are several methodological limitations to this study. First, the study was cross-sectional and thus cannot answer questions of how the relationship between ADHD symptoms and test anxiety changes over development. Thus, longitudinal studies are needed to fully understand this relationship (Owens, Stevenson, Norgate, & Hadwin, 2008). Second, in this study the test anxiety and ADHD symptoms were reported through parent reports and not directly by the students (Kolko & Kazdin, 1993; Kraemer et al., 2003). Third, this study used a sample of students representative of Florida and the conclusions' relevance to other populations may be limited. Lastly, medication use was not assessed or controlled for in this study and this may have impacted the study's results. A study using adult ADHD patients demonstrated a decrease in their state anxiety after receiving methylphenidate, a drug used to treat ADHD symptoms, thus further supporting the link between state anxiety and ADHD (Bloch et al., 2013).

APPENDIX A

TABLES

Table 1

Descriptive Statistics. Number of Subjects (N), Means (M), Standard Deviations (SD), Minimums (Min), Maximums (Max), Skewness (Skew) and Kurtosis for Grades 4 and 5 (Twin 0) Test Anxiety, ADHD and FCAT Scores. Both Raw Scores and Z-scores are Presented.

		Raw scores				Z scores					
Variables	N	M	SD	Min	Max	M	SD	Min	Max	Skew	Kurtosis
4-5th Twin 0											
Autonomic Reactions[a]	153	1.60	0.50	1	3	0	1	-1.19	2.34	0.87	-0.12
Off-Task Behavior[a]	157	1.91	0.61	1	3	0	1	-1.49	2.40	0.69	-0.02
Thoughts[a]	156	2.14	0.67	1	4	0	1	-1.69	2.76	0.35	-0.63
Hyperactivity[b]	157	-4.64	1.06	-7	-2	0	1	-2.22	2.80	-0.21	-0.32
Inattention[b]	153	-4.53	1.01	-7	-2	0	1	-2.44	2.06	-0.36	-0.50
FCAT[c]	157	326.11	56.34	180	486	0	1	-2.59	2.84	-0.06	0.06
4-5th Twin 1											
Autonomic Reactions[a]	154	1.60	0.54	1	3	0	1	-1.12	2.20	0.909	-0.308
Off-Task Behavior[a]	157	1.86	0.62	1	3	0	1	-1.40	2.65	0.705	-0.21
Thoughts[a]	156	2.14	0.68	1	4	0	1	-1.68	2.65	0.549	-0.102
Hyperactivity[b]	158	-4.71	1.08	-7	-2	0	1	-2.12	2.91	-0.105	-0.277
Inattention[b]	154	-4.67	0.95	-7	-2	0	1	-2.45	2.82	-0.23	-0.317
FCAT[c]	158	325.66	58.76	164	490	0	1	-2.75	2.81	0.079	0.002
6-7th Twin 0											
Autonomic Reactions[a]	108	1.56	0.50	1	3	0	1	-1.13	2.23	0.922	-0.333
Off-Task Behavior[a]	108	1.91	0.65	1	3	0	1	-1.40	2.41	0.84	0.048
Thoughts[a]	108	2.06	0.60	1	4	0	1	-1.78	2.57	0.775	0.146
Hyperactivity[b]	107	-4.68	1.12	-7	-3	0	1	-2.07	1.95	-0.427	-0.577

Table 1 – continued

Variables	N	Raw scores M	SD	Min	Max	Z scores M	SD	Min	Max	Skew	Kurtosis
Inattention[b]	108	-4.58	0.96	-7	-2	0	1	-2.29	2.22	-0.205	-0.505
FCAT[c]	108	332.21	50.19	205	470	0	1	-2.53	2.75	-0.075	0.35
6-7th Twin 1											
Autonomic Reactions[a]	101	1.60	0.53	1	3	0	1	-1.12	3.05	1.135	0.707
Off-Task Behavior[a]	101	2.08	0.74	1	4	0	1	-1.45	2.59	0.602	-0.161
Thoughts[a]	101	2.15	0.64	1	4	0	1	-1.67	2.54	0.668	-0.136
Hyperactivity[b]	100	-4.61	1.23	-7	-1	0	1	-1.94	2.67	-0.133	-0.249
Inattention[b]	100	-4.45	1.10	-7	-1	0	1	-1.98	2.94	-0.046	-0.347
FCAT[c]	101	329.25	59.42	200	476	0	1	-2.18	2.47	-0.291	0.424

Note.
[a]Children's Test Anxiety Scale (CTAS)
[b]Strengths and Weaknesses of ADHD Symptoms and Normal Behavior (SWAN)
[c]Florida Comprehensive Achievement Test (FCAT)

Table 2

Correlations Between Test Anxiety, ADHD and FCAT Scores.

4-5th Grade Correlations	1	2	3	4	5	6	7	8	9	10	11	12
1. Autonomic Reactions[a]	1	0.622	0.749	0.13	0.266	-0.276	-0.568	-0.572	-0.775	-0.8	-0.418	-0.454
2. Off-Task Behavior[a]	0.518	1	0.623	0.227	0.265	-0.1	-0.4	-0.463	-0.411	-0.456	-0.801	-0.747
3. Thoughts[a]	0.743	0.572	1	0.215	0.339	-0.326	-0.748	-0.787	-0.535	-0.561	-0.418	-0.422
4. Hyperactivity[b]	0.188	0.185	0.159	1	0.709	-0.271	0.452	0.229	0.496	0.3	0.231	0.44
5. Inattention[b]	0.24	0.151	0.206	0.74	1	-0.374	0.15	0.283	0.183	0.332	0.333	0.203

Table 2 – continued

4-5th Grade Correlations												
	1	2	3	4	5	6	7	8	9	10	11	12
6. FCAT[c]	-0.425	-0.214	-0.379	-0.245	-0.38	1	0.127	0.083	0.081	0.073	-0.127	-0.085
7. Thoughts[a] X Hyperactivity[b]	-0.528	-0.412	-0.772	0.473	0.284	0.149	1	0.884	0.802	0.696	0.532	0.68
8. Thoughts[a] X Inattention[b]	-0.516	-0.451	-0.761	0.308	0.447	0.099	0.891	1	0.665	0.773	0.644	0.573
9. Autonomic[a] X Hyperactivity[b]	-0.758	-0.381	-0.593	0.468	0.251	0.21	0.815	0.695	1	0.89	0.517	0.678
10. Autonomic[a] X Inattention[b]	-0.752	-0.413	-0.584	0.294	0.431	0.159	0.707	0.813	0.876	1	0.629	0.58
11. Off-task Behavior[a] X Inattention[b]	-0.313	-0.782	-0.405	0.277	0.465	-0.028	0.574	0.713	0.495	0.641	1	0.889
12. Off-task Behavior[a] X Hyperactivity[b]	-0.353	-0.755	-0.436	0.475	0.334	0.027	0.714	0.639	0.654	0.57	0.89	1
6-7th Grade Correlations												
	1	2	3	4	5	6	7	8	9	10	11	12
1. Autonomic Reactionsa	1	0.491	0.736	0.116	0.123	-0.304	-0.402	-0.421	-0.685	-0.709	-0.291	-0.29
2. Off-Task Behaviora	0.636	1	0.609	0.16	0.016	0.057	-0.297	-0.405	-0.248	-0.366	-0.761	-0.701
3. Thoughtsa	0.727	0.619	1	-0.018	0.006	-0.202	-0.718	-0.716	-0.573	-0.578	-0.464	-0.493
4. Hyperactivityb	0.201	0.208	0.195	1	0.701	-0.392	0.675	0.461	0.61	0.373	0.288	0.538
5. Inattentionb	0.289	0.215	0.293	0.731	1	-0.416	0.487	0.661	0.411	0.576	0.597	0.477
6. FCATc	-0.116	-0.023	-0.219	-0.353	-0.406	1	-0.102	-0.123	-0.018	-0.007	-0.27	-0.324
7. Thoughtsa X Hyperactivityb	-0.44	-0.317	-0.673	0.563	0.308	-0.092	1	0.859	0.817	0.667	0.539	0.727
8. Thoughtsa X Inattentionb	-0.426	-0.356	-0.683	0.363	0.465	-0.092	0.872	1	0.678	0.815	0.748	0.669
9. Autonomica X Hyperactivityb	-0.717	-0.384	-0.479	0.509	0.264	-0.161	0.786	0.643	1	0.848	0.447	0.63
10. Autonomica X Inattentionb	-0.728	-0.429	-0.466	0.312	0.414	-0.165	0.64	0.741	0.877	1	0.659	0.564
11. Off-task Behaviora X Inattentionb	-0.375	-0.77	-0.335	0.25	0.428	-0.231	0.449	0.594	0.5	0.649	1	0.862
12. Off-task Behaviora X Hyperactivityb	-0.424	-0.754	-0.389	0.457	0.301	-0.218	0.634	0.551	0.676	0.603	0.89	1

Note. The correlations above the diagonal are for twin 1 and the correlations below the diagonal are for twin 0.
[a]Children's Test Anxiety Scale (CTAS)

Table 2 - continued

[b]Strengths and Weaknesses of ADHD Symptoms and Normal Behavior (SWAN)

[c]Florida Comprehensive Achievement Test (FCAT)

Table 3

Model Fit Statistics

	df	χ2	p(χ2)	CFI	TLI	RMSEA	90% CI of RMSEA	log-likelihood H0	log-likelihood H1
4-5th Grade Twin 0									
Simple effect of test anxiety	2	3.292	0.193	0.994	0.982	0.064	0.000 0.183	-772.425	-770.779
Simple effect of ADHD	NA	NA	NA	NA	NA	NA	NA	NA	NA
Independence of Effects	7	7.138	0.415	1	0.999	0.011	0.000 0.099	-1137.089	-1133.52
A)	14	26.74	0.021	0.97	0.94	0.076	0.029 0.120	-1540.03	-1526.663
B)	NC	NC	NC	NC	NC	NC	NC	NC	NC
C)	15	22.18	0.103	0.982	0.967	0.055	0.000 0.101	-1571.108	-1560.019
D)	15	28.03	0	0.968	0.941	0.074	0.028 0.117	-1559.43	-1545.416
E)	15	21.3	0.128	0.985	0.973	0.052	0.000 0.098	-1528.605	-1517.957
F)	15	22.38	0.098	0.981	0.965	0.056	0.000 0.101	-1548.909	-1537.721
latent variable Interaction								-1137.76	

Table 3 – continued

	df	χ2	p(χ2)	CFI	TLI	RMSEA	90% CI of RMSEA	log-likelihood H0	log-likelihood H1
4-5th Grade Twin 1									
Simple effect of test anxiety	2	5.153	0.076	0.979	0.936	0.121	0.000 0.255	-536.203	-533.627
Simple effect of ADHD	NA	NA	NA	NA	NA	NA	NA	NA	NA
Independence of Effects	7	7.859	0.345	0.997	0.993	0.034	0.000 0.126	-785.193	-781.264
A)	NC	NC	NC	NC	NC	NC	NC	NC	NC
B)	15	15.82	0.394	0.997	0.995	0.023	0.000 0.095	-1066.313	-1058.402
C)	15	17.78	0.275	0.991	0.983	0.041	0.000 0.104	-1075.458	-1066.569
D)	NC	NC	NC	NC	NC	NC	NC	NC	NC
E)	15	21.49	0.122	0.98	0.963	0.063	0.000 0.119	-1068.434	-1057.688
F)	15	26.14	0.037	0.964	0.933	0.083	0.021 0.135	-1061.128	-1048.059
latent variable Interaction								-785.172	
6-7th Grade Twin 0									
Simple effect of test anxiety	2	7.75	0.021	0.975	0.926	0.135	0.045 0.241	-768.565	-764.69
Simple effect of ADHD	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 3 – continued

	df	χ2	p(χ2)	CFI	TLI	RMSEA	90% CI of RMSEA		log-likelihood H0	log-likelihood H1
Independence of Effects	7	12.69	0.08	0.985	0.967	0.072	0.000	0.134	-1138.428	-1132.083
A)	15	16.01	0.382	0.997	0.994	0.025	0.000	0.096	-1065.005	-1057.001
B)	15	22.81	0.088	0.981	0.964	0.057	0.000	0.102	-1550.107	-1538.703
C)	15	21.57	0.12	0.984	0.969	0.053	0.000	0.099	-1569.197	-1558.411
D)	15	26.61	0.032	0.963	0.931	0.085	0.025	0.136	-1067.839	-1054.535
E)	15	25.03	0.05	0.976	0.955	0.065	0.003	0.108	-1559.671	-1547.157
F)	15	26.56	0.033	0.971	0.946	0.07	0.020	0.112	-1573.412	-1560.131
latent variable Interaction									-785.172	
6-7th Grade Twin 1										
Simple effect of test anxiety	2	12.37	0.002	0.924	0.773	0.227	0.117	0.355	-505.847	-499.665
Simple effect of ADHD	NA	NA	NA	NA	NA	NA	NA		NA	NA
Independence of Effects	7	27.83	0	0.91	0.808	0.172	0.108	0.241	-744.4	-730.484
A)	15	48.63	0	0.886	0.787	0.149	0.103	0.197	-1027.41	-1003.097
B)	15	38.06	0	0.919	0.848	0.123	0.075	0.173	-1020.898	-1001.867
C)	15	41.1	0	0.909	0.831	0.131	0.084	0.180	-1025.137	-1004.587

Table 3 – continued

	df	χ2	p(χ2)	CFI	TLI	RMSEA	90% CI of RMSEA	log-likelihood H0	log-likelihood H1
D)	15	44.18	0	0.894	0.803	0.139	0.092 0.187	-1048.107	-1026.016
E)	15	40.79	0	0.911	0.835	0.13	0.083 0.179	-1020.711	-1000.317
F)	15	35.7	0	0.923	0.856	0.117	0.068 0.167	-1037.902	-1020.054
latent variable									
Interaction								-744.28	

Note. NA= not applicable as the model was just identified, NC= no convergence, JI=just identified. Comparative Fit Index (CFI), Root Mean Square Error (RMSEA), 90% Confidence Intervals of RMSEA, Tucker-Lewis index (TLI), Chi-Square Test of Model (λ^2), Degrees of Freedom (DF), 95% significance p-value, Chi-Square/degrees of freedom (λ^2/df). All observed variables are z-scored in these models. Models 3a and 3b had problems converging and thus no model fit reported. Each model is lettered and the following variables were used to create the interaction term: (a) Autonomic[a] X Hyperactivity[b] and Thoughts[a] X Inattention[b] (b) Off-task Behavior[a] X Inattention[b] and Autonomic[a] X Hyperactivity[b] (c) Off-task Behavior[a] X Inattention[b] and Thoughts[a] X Hyperactivity[b] (d) Thoughts[a] X Inattention[b] and Off-task Behavior[a] X Hyperactivity[b] (e) Thoughts[a] X Hyperactivity[b] and Autonomic[a] X Inattention[b] (f) Off-task Behavior[a] X Hyperactivity[b] and Autonomic[a] X Inattention[b].

Table 4

Simple Effects

	β	B	SE	CI of β	R2 of FCAT
Test Anxiety					
4-5th Grade Twin 0	-0.447	-0.525	0.07	(-0.585, -0.309)	0.2
4-5th Grade Twin 1	-0.316	-0.366	0.078	(-0.469, -0.164)	0.1
6-7th Grade Twin 0	-0.165	-0.192	0.102	(-0.365, 0.034)	0.027
6-7th Grade Twin 1	-0.219	-0.281	0.101	(-0.417, -0.022)	0.048
ADHD					
4-5th Grade Twin 0	-0.359	-0.526	0.079	(-0.513, -0.204)	0.129
4-5th Grade Twin 1	-0.386	-0.55	0.077	(-0.537, -0.235)	0.149
6-7th Grade Twin 0	-0.44	-0.555	0.087	(-0.610, -0.270)	0.194
6-7th Grade Twin 1	-0.478	-0.592	0.088	(-0.650, -0.306)	0.228

Table 5

Independence of Effects

	β	B	SE	CI of β	R2 of FCAT
4-5th Grade Twin 0					0.275
ADHD	-0.28	-0.403	0.071	(-0.420, -0.140)	
Test Anxiety	-0.384	-0.45	0.073	(-0.527, -0.241)	
4-5th Grade Twin 1					0.183
ADHD	-0.307	-0.443	0.081	(-0.466, -0.148)	
Test Anxiety	-0.211	-0.246	0.084	(-0.376, -0.046)	
6-7th Grade Twin 0					0.186
ADHD	-0.425	-0.553	0.098	(-0.617, -0.234)	
Test Anxiety	-0.017	-0.019	0.104	(-0.221, 0.188)	
6-7th Grade Twin 1					0.27
ADHD	-0.473	-0.585	0.087	(-0.643, -0.303)	
Test Anxiety	-0.204	-0.264	0.09	(-0.380, -0.028)	

Table 6

Interactive Effects Using a Manifest Interaction Variable

	B	B	SE	CI of β	R^2 of FCAT
A)					
4-5th Grade Twin 0					0.274
ADHD	-0.275	-0.4	0.101	(-0.416, -0.135)	
Test Anxiety	-0.389	-0.451	0.093	(-0.532, -0.245)	
Interaction TA&ADHD	-0.004	-0.007	0.111	(-0.069, 0.061)	
4-5th Grade Twin 1					NC
ADHD					
Test Anxiety					
Interaction TA&ADHD					
6-7th Grade Twin 0					0.186
ADHD	-0.426	-0.553	0.098	(-0.619, -0.233)	
Test Anxiety	-0.017	-0.019	0.116	(-0.243, 0.210)	
Interaction TA&ADHD	0.002	0.003	0.113	(-0.219, 0.223)	
6-7th Grade Twin 1					0.278
ADHD	-0.476	-0.587	0.088	(-0.648, -0.304)	
Test Anxiety	-0.233	-0.287	0.1	(-0.428, -0.038)	
Interaction TA&ADHD	0.091	0.075	0.094	(-0.093, 0.275)	

Table 6 – continued

	B	B	SE	CI of β	R^2 of FCAT
B)					
4-5th Grade Twin 0					NC
ADHD					
Test Anxiety					
Interaction TA&ADHD					
4-5th Grade Twin 1					0.192
ADHD	-0.3	-0.434	0.084	(-0.464, -0.136)	
Test Anxiety	-0.227	-0.261	0.086	(-0.394, -0.059)	
Interaction TA&ADHD	0.104	0.161	0.101	(-0.094, 0.302)	
6-7th Grade Twin 0					0.182
ADHD	-0.418	-0.55	0.099	(-0.613, -0.224)	
Test Anxiety	-0.04	-0.047	0.131	(-0.297, 0.218)	
Interaction TA&ADHD	0.027	0.031	0.134	(-0.235, 0.289)	
6-7th Grade Twin 1					0.291
ADHD	-0.498	-0.629	0.093	(-0.680, -0.316)	
Test Anxiety	-0.266	-0.328	0.105	(-0.473, -0.060)	
Interaction TA&ADHD	0.168	0.22	0.131	(-0.089, 0.426)	

Table 6 – continued

	B	B	SE	CI of β	R^2 of FCAT
C)					
4-5th Grade Twin 0					0.276
ADHD	-0.277	-0.397	0.074	(-0.423, -0.132)	
Test Anxiety	-0.394	-0.471	0.084	(-0.558, -0.229)	
Interaction TA&ADHD	-0.064	-0.063	0.143	(-0.344, 0.217)	
4-5th Grade Twin 1					0.196
ADHD	-0.431	-0.298	0.082	(-0.459, -0.137)	
Test Anxiety	-0.257	-0.223	0.085	(-0.388, -0.057)	
Interaction TA&ADHD	0.149	0.117	0.108	(-0.095, 0.329)	
6-7th Grade Twin 0					0.181
ADHD	-0.417	-0.551	0.1	(-0.821, -0.280)	
Test Anxiety	-0.045	-0.054	0.129	(-0.355, 0.248)	
Interaction TA&ADHD	0.033	0.038	0.13	(-0.251, 0.327)	
6-7th Grade Twin 1					0.297
ADHD	-0.449	-0.615	0.104	(-0.899, -0.331)	
Test Anxiety	-0.207	-0.266	0.091	(-0.500, -0.031)	
Interaction TA&ADHD	0.051	0.035	0.083	(-0.094, 0.164)	

Table 6 – continued

	B	B	SE	CI of β	R^2 of FCAT
D)					
4-5th Grade Twin 0					0.286
ADHD	-0.273	-0.39	0.072	(-0.414, -0.133)	
Test Anxiety	-0.404	-0.48	0.076	(-0.553, -0.254)	
Interaction TA&ADHD	-0.111	-0.181	0.088	(-0.284, 0.062)	
4-5th Grade Twin 1					NC
ADHD					
Test Anxiety					
Interaction TA&ADHD					
6-7th Grade Twin 0					0.186
ADHD	-0.42	-0.551	0.099	(-0.614, -0.227)	
Test Anxiety	-0.058	-0.069	0.138	(-0.329, 0.213)	
Interaction TA&ADHD	0.064	0.077	0.142	(-0.215, 0.343)	
6-7th Grade Twin 1					0.24
ADHD	-0.449	-0.615	0.104	(-0.654, -0.245)	
Test Anxiety	-0.207	-0.266	0.091	(-0.385, -0.028)	
Interaction TA&ADHD	0.051	0.035	0.083	(-0.112, 0.215)	

Table 6 – continued

	B	B	SE	CI of β	R^2 of FCAT
E)					
4-5th Grade Twin 0					0.28
ADHD	-0.285	-0.402	0.071	(-0.424, -0.147)	
Test Anxiety	-0.382	-0.445	0.074	(-0.526, -0.238)	
Interaction TA&ADHD	-0.035	-0.009	0.235	(-0.496, 0.426)	
4-5th Grade Twin 1					0.185
ADHD	-0.302	-0.438	0.082	(-0.463, -0.141)	
Test Anxiety	-0.219	-0.251	0.086	(-0.387, -0.051)	
Interaction TA&ADHD	0.062	0.132	0.101	(-0.137, 0.261)	
6-7th Grade Twin 0					0.186
ADHD	-0.427	-0.556	0.098	(-0.619, -0.236)	
Test Anxiety	-0.026	-0.03	0.118	(-0.256, 0.204)	
Interaction TA&ADHD	0.029	0.039	0.11	(-0.187, 0.244)	
6-7th Grade Twin 1					0.292
ADHD	-0.502	-0.641	0.091	(-0.680, -0.324)	
Test Anxiety	-0.248	-0.311	0.096	(-0.437, -0.059)	
Interaction TA&ADHD	0.174	0.247	0.106	(-0.034, 0.382)	

Table 6 – continued

	B	Β	SE	CI of β	R^2 of FCAT
F)					
4-5th Grade Twin 0					0.279
ADHD	-0.281	-0.4	0.071	(-0.421, -0.141)	
Test Anxiety	-0.39	-0.464	0.076	(-0.539, -0.242)	
Interaction TA&ADHD	-0.074	-0.064	0.088	(-0.245, 0.098)	
4-5th Grade Twin 1					0.188
ADHD	-0.308	-0.443	0.083	(-0.470, -0.146)	
Test Anxiety	-0.22	-0.252	0.086	(-0.388, -0.052)	
Interaction TA&ADHD	0.072	0.138	0.094	(-0.112, 0.257)	
6-7th Grade Twin 0					0.189
ADHD	-0.421	-0.549	0.098	(-0.614, -0.228)	
Test Anxiety	-0.069	-0.08	0.148	(-0.360, 0.223)	
Interaction TA&ADHD	0.082	0.131	0.154	(-0.220, 0.384)	
6-7th Grade Twin 1					0.292
ADHD	-0.505	-0.642	0.092	(-0.684, -0.325)	
Test Anxiety	-0.252	-0.316	0.098	(-0.444, -0.061)	
Interaction TA&ADHD	0.173	0.258	0.106	(-0.034, 0.381)	

Note. ADHD and test anxiety terms were created from manifest variables. Each model is lettered and the following variables were used to create the interaction term: (a) Autonomic[a] X Hyperactivity[b] and Thoughts[a] X Inattention[b] (b) Off-task Behavior[a] X Inattention[b] and Autonomic[a] X Hyperactivity[b] (c) Off-task Behavior[a] X Inattention[b] and Thoughts[a] X Hyperactivity[b]

Table 6 – continued
(d) Thoughts[a] X Inattention[b] and Off-task Behavior[a] X Hyperactivity[b] (e) Thoughts[a] X Hyperactivity[b] and Autonomic[a] X Inattention[b] (f) Off-task Behavior[a] X Hyperactivity[b] and Autonomic[a] X Inattention[b], NC=non-convergence for the model.

Table 7

Interactive Effects Using a Latent Interaction Variable

	B	SE	CI of B
4-5th Grade Twin 0			
ADHD	-0.372	0.105	(-0.578, -0.167)
Test Anxiety	-0.431	0.092	(-0.611, -0.250)
Latent Interaction	-0.093	0.118	(-0.324, 0.138)
4-5th Grade Twin 1			
ADHD			
Test Anxiety			
Latent Interaction			
Correlation			
ADHD&TA			
6-7th Grade Twin 0			
ADHD	-0.554	0.137	(-0.823, -0.286)
Test Anxiety	-0.031	0.131	(-0.288, 0.227)
Latent Interaction	0.03	0.14	(-0.245, 0.304)

Table 7 - continued

	B	SE	CI of B
6-7th Grade Twin 1			
ADHD	-0.598	0.137	(-0.866, -0.330)
Test Anxiety	-0.271	0.121	(-0.507, -0.034)
Latent Interaction	0.071	0.146	(-0.215, 0.357)

Note. The latent variable was created in Mplus.

APPENDIX B

FIGURES

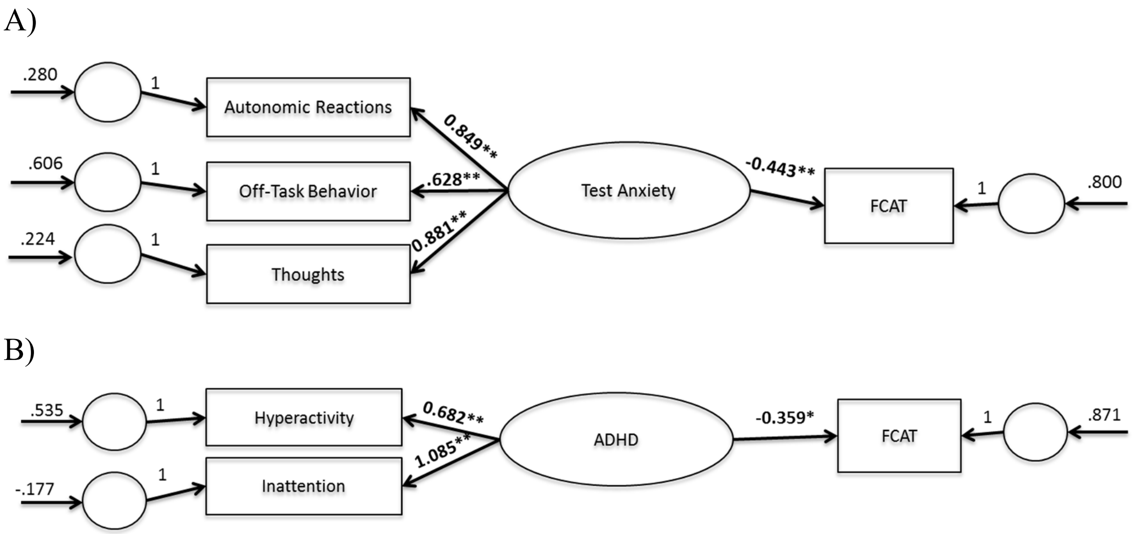

Figure 1. Simple effects of test anxiety and ADHD on reading comprehension test performance. A) Test anxiety. Test anxiety includes three dimensions: autonomic reactions, off-task behaviors, and thoughts. Does test anxiety contribute significantly to reading comprehension test performance? B) ADHD. ADHD includes two dimensions: hyperactivity and inattention. Does ADHD contribute significantly to reading comprehension test performance?

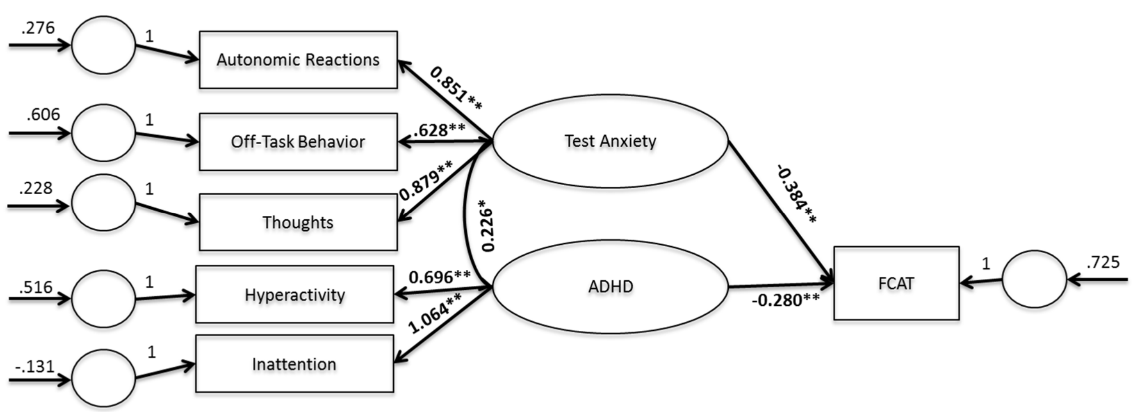

Figure 2. Does the simultaneous presence of both test anxiety and ADHD symptoms have a significant negative impact on reading comprehension test performance above their independent contributions?

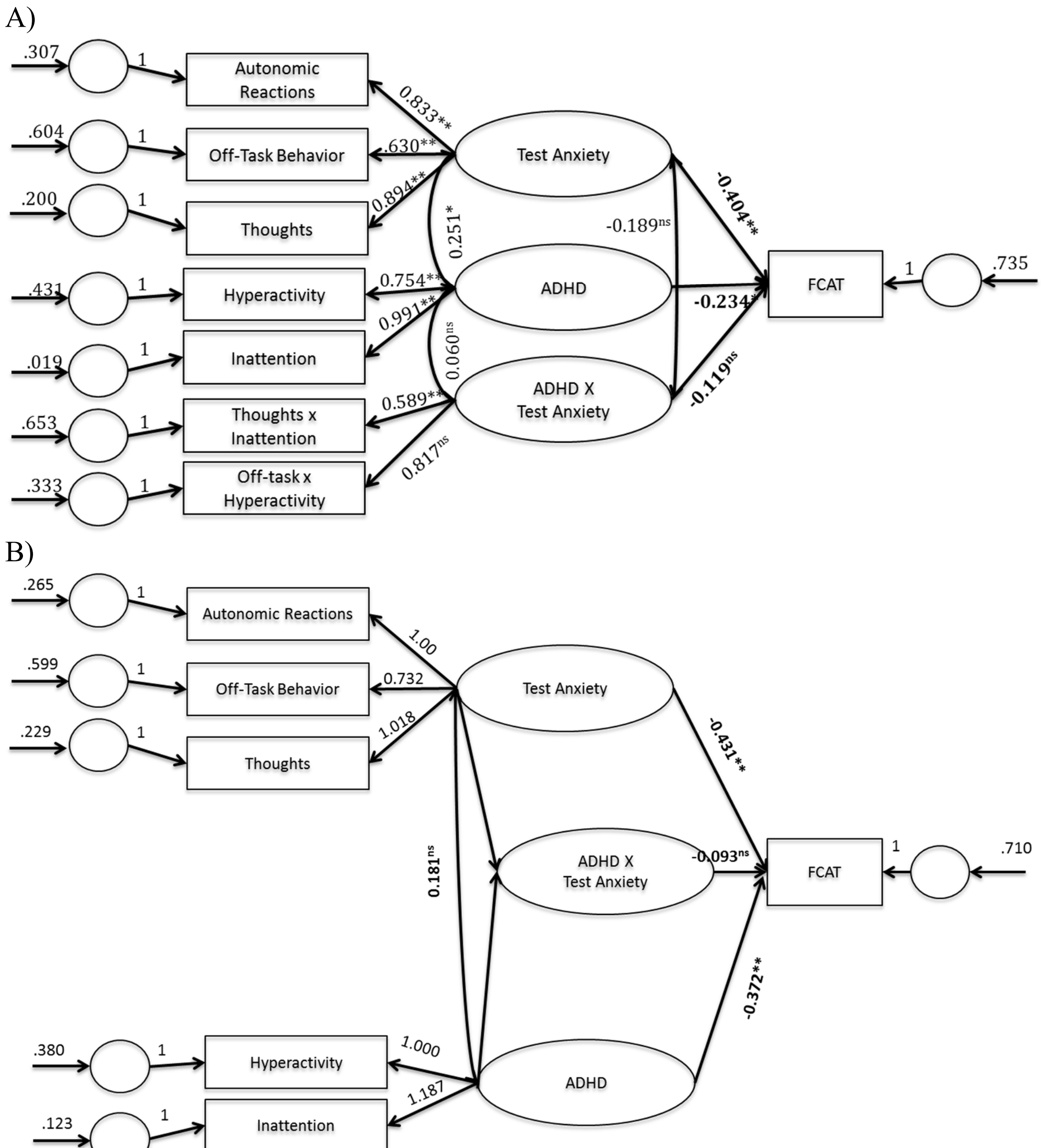

Figure 3. Is there an interactive negative impact of test anxiety and ADHD on reading comprehension test performance? A) The interaction term was created from the multiplicative product of the ADHD and test anxiety indicators. B) Latent ADHD and latent test anxiety variables were used directly within Mplus using the XWITH command to create the interaction term.

APPENDIX C

QUESTIONNAIRES

Test Attitude Survey Questions

Test Attitude Survey Questions are grouped together by the test's subcategories of autonomic reactions, thoughts and off-task behavior. They were answered on a 4-point likered scale: almost never (1), some of the time (2), most of the time (3), almost always (4). The numbers on each question refer to the order each question was presented in the survey to participants.

Instructions. Please read each question below and respond about how you think, feel, or act, when you are taking a test.

Autonomic reactions.
2. While I am taking tests my heart beats fast.
4. While I am taking tests I feel nervous.
8. While I am taking tests my face feels hot.
10. While I am taking tests my belly feels funny.
17. While I am taking tests my head hurts.
20. While I am taking tests I feel warm.
23. While I am taking tests my hand shakes.
25. While I am taking tests I have to go to the bathroom.
28. While I am taking tests I feel scared.

Thoughts.
1. While I am taking tests I wonder if I will pass.
5. While I am taking tests I think I am going to get a bad 1 grade.
6. While I am taking tests it is hard for me to remember the answers.
9. While I am taking tests I worry about failing.
11. While I am taking tests I worry about doing something wrong.
15. While I am taking tests I wonder if my answers are right.
16. While I am taking tests I think that I should have studied more.
19. While I am taking tests I think most of my answers are wrong.
21. While I am taking tests I worry about how hard the test is.
24. While I am taking tests I think what will happen if I fail.
27. While I am taking tests I think about how poorly I am doing.
29. While I am taking tests I worry about what my parents will say.

Off-Task.
3. While I am taking tests I look around the room.
7. While I am taking tests I play with my pencil.
12. While I am taking tests I check the time.
13. While I am taking tests I think about what my grade will be.
14. While I am taking tests I find it hard to sit still.

18. While I am taking tests I look at other people.
22. While I am taking tests I try to finish up fast.
26. While I am taking tests I tap my feet.
30. While I am taking tests I stare.

SWAN Survey Questions

SWAN questions grouped together by the test's subcategories of inattention and hyperactivity. They were answered on a 7-point likered scale: far below (1), below (2), slightly below (3), average (4), slightly above (5), average (6), slightly above (7), above (8), far above (9) . The numbers on each question refer to the order each question was presented in the survey to participants.

Instructions. Children differ in their abilities to focus attention, control activity, and inhibit impulses. For each item listed below, how does each twin compare to other children of the same age? Please select the best rating based on your observations over the past month.

Inattention.

1. Give close attention to detail and avoid careless mistakes.
2. Sustain attention on tasks or play activities.
3. Listen when spoken to directly.
4. Follow through on instructions and finish school work/chores.
5. Organize tasks and activities.
6. Engage in tasks that require sustained mental effort.
7. Keep track of things necessary for activities.
8. Ignore extraneous stimuli.
9. Remember daily activities.

Hyperactivity.

10. Sit still (control movement of hands/feet or control squirming).
11. Stay seated (when required by class rules/social conventions).
12. Modulate motor activity (inhibit inappropriate running/climbing).
13. Play quietly (keep noise level reasonable).
14. Settle down and rest (control constant activity).
15. Modulate verbal activity (control excess talking).
16. Reflect on questions (control blurting out answers).
17. Await turn (stand in line and take turns).
18. Enter into conversations and games (control interrupting/intruding).

APPENDIX D

HUMAN SUBJECTS APPROVAL

Florida State UNIVERSITY

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 06/11/2015

To: Sarah Wood [redacted]

Address: [redacted]

Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Effects of ADHD and Test Anxiety on Reading Comprehension Test Performance.

The application that you submitted to this office in regard to the use of human subjects in the research proposal referenced above has been reviewed by the Human Subjects Committee at its meeting on 06/10/2015
Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 06/08/2016 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Richard Wagner <[redacted]>, Advisor
HSC No. 2015.15631

REFERENCES

Afflerbach, P. (2005). National Reading Conference policy brief: High stakes testing and reading assessment. Journal of Literacy Research, 37(2), 151–162. doi:10.1207/s15548430jlr3702_2

Baddeley, A. (1992). Working memory. Science, 255(5044), 556–559.

Berthiaume, K. S., Lorch, E. P., & Milich, R. (2010). Getting clued in inferential processing and comprehension monitoring in boys with ADHD. Journal of Attention Disorders, 14(1), 31–42. doi:10.1177/1087054709347197

Bloch, Y., Aviram, S., Segev, A., Nitzan, U., Levkovitz, Y., Braw, Y., & Bloch, A. M. (2013). Methylphenidate reduces state anxiety during a continuous performance test that distinguishes adult adhd patients from controls. Journal of Attention Disorders, 1–6. doi:10.1177/1087054712474949

Bloom, B., Cohen, R. A., & Freeman, G. (2011). Summary health statistics for US children: National Health Interview Survey, 2010. Vital Health Stat, 10(250), 1–80.

Bollen, K. A. (2002). Latent variables in psychology and the social sciences. Annual Review of Psychology, 53, 605–634.

Bottsford-Miller, N., Thurlow, M. L., Stout, K. E., & Quenemoen, R. F. (2006). A comparison of IEP/504 accommodations under classroom and standardized testing conditions: A preliminary report on SEELS data. Synthesis Report 63. National Center on Educational Outcomes, University of Minnesota.

Brock, S. E., & Knapp, P. K. (1996). Reading comprehension abilities of children with Attention-Deficit/Hyperactivity Disorder. Journal of Attention Disorders, 1(3), 173–185. doi:10.1177/108705479600100305

Cain, K., & Oakhill, J. (2007). Children's comprehension problems in oral and written language: A cognitive perspective. (K. Cain & J. Oakhill). New York: The Guilford Press.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: concurrent prediction by working memory, verbal ability, and component skills. Journal of Educational Psychology, 96(1), 31–42. doi:10.1037/0022-0663.96.1.31

Calvo, M. G., & Carreiras, M. (1993). Selective influence of test anxiety on reading processes. British Journal of Psychology, 84(3), 375.

Calvo, M. G., & Castillo, M. D. (1995). Phonological coding in reading comprehension: The importance of individual differences. European Journal of Cognitive Psychology, 7(4), 365–382. doi:10.1080/09541449508403104

Calvo, M. G., & Eysenck, M. W. (1996). Phonological working memory and reading in test anxiety. Memory, 4(3), 289–305.

Carretti, B., Caldarola, N., Tencati, C., & Cornoldi, C. (2013). Improving reading comprehension in reading and listening settings: The effect of two training programmes focusing on metacognition and working memory. British Journal of Educational Psychology, 84(2), 194–210. doi:10.1111/bjep.12022

Cassady, J. C. (2004). The impact of cognitive test anxiety on text comprehension and recall in the absence of external evaluative pressure. Applied Cognitive Psychology, 18(3), 311–325. doi:10.1002/acp.968

Cohen. (1983). The cost of dichotomization. Applied Psychological Measurement, 7(3), 249–253. doi:10.1177/014662168300700301

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behavior, 19(4), 450–466.

Daneman, M., & Merikle, P. M. (1996). Working memory and language comprehension: A meta-analysis. Psychonomic Bulletin & Review, 3(4), 422–433. doi:10.3758/BF03214546

Estevez, A., & Calvo, M. G. (2000). Working memory capacity and time course of predictive inferences. Memory, 8(1), 51–61. doi:10.1080/096582100387704

Everson, H. T., Smodlaka, I., & Tobias, S. (1994). Exploring the relationship of test anxiety and metacognition on reading test performance: A cognitive analysis. Anxiety, 7(1), 85–96. doi:10.1080/10615809408248395

García Madruga, J. A., Elosúa, M. R., Gil, L., Gómez Veiga, I., Vila, J. Ó., Orjales, I., et al. (2013). Reading comprehension and working memory's executive processes: An intervention study in primary school students. Reading Research Quarterly, 48(2), 155–174. doi:10.1002/rrq.44

Gathercole, S. E., & Pickering, S. J. (2000). Working memory deficits in children with low achievements in the national curriculum at 7 years of age. British Journal of Educational Psychology, 70, 177–194.

Gathercole, S. E., Pickering, S. J., Knight, C., & Stegmann, Z. (2004). Working memory skills and educational attainment: evidence from national curriculum assessments at 7 and 14 years of age. Applied Cognitive Psychology, 18(1), 1–16. doi:10.1002/acp.934

Ghelani, K., Sidhu, R., Jain, U., & Tannock, R. (2004). Reading comprehension and reading related abilities in adolescents with reading disabilities and attention-deficit/hyperactivity disorder. Dyslexia, 10(4), 364–384. doi:10.1002/dys.285

Gifford, E. M., & Marston, A. R. (1966). Test anxiety, reading rate, and task experience. The Journal of Educational Research, 59(7), 303–306. doi:10.2307/27531725

Hadwin, J. A., Brogan, J., & Stevenson, J. (2005). State anxiety and working memory in children: A test of processing efficiency theory. Educational Psychology, 25(4), 379–393. doi:10.1080/01443410500041607

Haladyna, T. M., & Downing, S. M. (2004). Construct-irrelevant variance in high-stakes testing. Educational Measurement: Issues and Practice, 23(1), 17–27. doi:10.1111/j.1745-3992.2004.tb00149.x

Haladyna, T., Haas, N., & Allison, J. (1998). Continuing tensions in standardized testing. Childhood Education, 74(5), 262–273.

Hannon, B. (2012). Test anxiety and performance-avoidance goals explain gender differences in SAT-V, SAT-M, and overall SAT scores. Personality and Individual Differences, 53(7), 816–820. doi:10.1016/j.paid.2012.06.003

Hannon, B., & McNaughton Cassill, M. (2011). SAT performance: Understanding the contributions of cognitive/learning and social/personality factors. Applied Cognitive Psychology, 25(4), 528–535. doi:10.1002/acp.1725

Hart, S. A., Soden, B., Johnson, W., Schatschneider, C., & Taylor, J. (2013). Expanding the environment: gene × school-level SES interaction on reading comprehension. Journal of Child Psychology and Psychiatry, 54(10), 1047–1055. doi:10.1111/jcpp.12083

Hebb, D. O. (1955). Drives and the C. N. S. (conceptual nervous system). Psychological Review, 62(4), 243–254.

Ikeda, M., Iwanaga, M., & Seiwa, H. (1996). Test anxiety and working memory system. Perceptual and Motor Skills, 82, 1223–1231. doi:10.2466/pms.1996.82.3c.1223

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. Psychological Review, 99(1), 122–149.

Klein, A., & Moosbrugger, H. (2000). Maximum likelihood estimation of latent interaction effects with the LMS method. Psychometrika, 65(4), 457–474. doi:10.1007/BF02296338

Kline, R. B. (2011). Principles and practice of structural equation modeling. (3rd ed.). New York: Guilford press.

Kofler, M. J., Rapport, M. D., Bolden, J., Sarver, D. E., & Raiker, J. S. (2010). ADHD and working memory: The impact of central executive deficits and exceeding storage/rehearsal capacity on observed inattentive behavior. Journal of Abnormal Child Psychology, 38(2), 149–161. doi:10.1007/s10802-009-9357-6

Kolko, D. J., & Kazdin, A. E. (1993). Emotional/behavioral problems in clinic and nonclinic children: correspondence among child, parent and teacher reports. Journal of Child Psychology and Psychiatry, 34(6), 991–1006. doi:10.1111/j.1469-7610.1993.tb01103.x

Kraemer, H. C., Measelle, J. R., Ablow, J. C., Essex, M. J., Boyce, W. T., & Kupfer, D. J. (2003). A new approach to integrating data from multiple informants in psychiatric assessment and research: mixing and matching contexts and perspectives. American Journal of Psychiatry, 160(9), 1566–1577. doi:10.1176/appi.ajp.160.9.1566

Lewandowski, L., Gathje, R. A., Lovett, B. J., & Gordon, M. (2013). Test-taking skills in college students with and without ADHD. Journal of Psychoeducational Assessment, 31(1), 41–52. doi:10.1177/0734282912446304

Lewandowski, L., Hendricks, K., & Gordon, M. (2012). Test-taking performance of high school students with ADHD. Journal of Attention Disorders, XX(X), 1–XX. doi:10.1177/1087054712449183

Linderholm, T., & van den Broek, P. (2002). The effects of reading purpose and working memory capacity on the processing of expository text. Journal of Educational Psychology, 94(4), 778. doi:10.1037/0022-0663.94.4.778

Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodness-of-fit indexes in confirmatory factor analysis: The effect of sample-size. Psychological Bulletin, 103(3), 391–410. doi:10.1007/BF01102761

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. Journal of the American Academy of Child & Adolescent Psychiatry, 44(4), 377–384. doi:10.1097/01.chi.0000153228.72591.73

Maslowsky, J., Jager, J., & Hemken, D. (2014). Estimating and interpreting latent variable interactions: A tutorial for applying the latent moderated structural equations method. International Journal of Behavioral Development, 39(1), 87–96. doi:10.1177/0165025414552301

McDonald, A. S. (2001). The prevalence and effects of test anxiety in school children. Educational Psychology, 21(1). doi:10.1080/01443410020019867

Miesner, M. T., & Maki, R. H. (2007). The role of test anxiety in absolute and relative metacomprehension accuracy. European Journal of Cognitive Psychology, 19(4-5), 650–670. doi:10.1080/09541440701326196

Miller, A. C., Keenan, J. M., Betjemann, R. S., Willcutt, E. G., Pennington, B. F., & Olson, R. K. (2012). Reading comprehension in children with ADHD: Cognitive underpinnings of the centrality deficit. Journal of Abnormal Child Psychology, 41(3), 473–483. doi:10.1007/s10802-012-9686-8

Minnaert, A. E. (1999). Individual differences in text comprehension as a function of test anxiety and prior knowledge. Psychological Reports, 84(1), 167–177. doi:10.2466/pr0.1999.84.1.167

Miranda, A., Mercader, J., Fernández, M. I., & Colomer, C. (2013). Reading performance of young adults with ADHD diagnosed in childhood: Relations with executive functioning. Journal of Attention Disorders, 1087054713507977. doi:10.1177/1087054713507977

Morris, L. W., Davis, M. A., & Hutchings, C. H. (1981). Cognitive and emotional components of anxiety: Literature review and a revised worry–emotionality scale. Journal of Educational Psychology, 73(4), 541. doi:10.1037/0022-0663.73.4.541

Mowbray, T. (2012). Working memory, test anxiety and effective interventions: A review. The Australian Educational and Developmental Psychologist, 29(02), 141–156. doi:10.1017/edp.2012.16

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. Psychological Science, 24(5), 776–781. doi:10.1177/0956797612459659

Muthen, L. K., & Muthen, B. O. (2012). Mplus User's Guide, 1–856.

Neville, D., Pfost, P., & Dobbs, V. (1967). The relationship between test anxiety and silent reading gain. American Educational Research Journal, 4(1), 45–50. doi:10.3102/00028312004001045

Oakhill, J., Hartt, J., & Samols, D. (2005). Levels of comprehension monitoring and working memory in good and poor comprehenders. Reading and Writing, 18(7-9), 657–686. doi:10.1007/s11145-005-3355-z

Owens, M., Stevenson, J., Norgate, R., & Hadwin, J. A. (2008). Processing efficiency theory in children: Working memory as a mediator between trait anxiety and academic performance. Anxiety, Stress & Coping, 21(4), 417–430. doi:10.1080/10615800701847823

Pacheco-Unguetti, A. P., Acosta, A., Callejas, A., & Lupiáñez, J. (2010). Attention and anxiety different attentional functioning under state and trait anxiety. Psychological Science, 21(2), 298–304. doi:10.1177/0956797609359624

Pham, A. V. (2013). Differentiating behavioral ratings of inattention, impulsivity, and hyperactivity in children: Effects on reading achievement. Journal of Attention Disorders, 1–10. doi:10.1177/1087054712473833

Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common Core Standards the new U.S. intended curriculum. Educational Researcher, 40(3), 103–116. doi:10.3102/0013189X11405038

Rai, M. K., Loschky, L. C., Harris, R. J., Peck, N. R., & Cook, L. G. (2011). Effects of stress and working memory capacity on foreign language readers' inferential processing during comprehension. Language Learning, 61(1), 187–218. doi:10.1111/j.1467-9922.2010.00592.x

Rapport, M. D., Orban, S. A., Kofler, M. J., & Friedman, L. M. (2013). Do programs designed to train working memory, other executive functions, and attention benefit children with ADHD? A meta-analytic review of cognitive, academic, and behavioral outcomes. Clinical Psychology Review, 33(8), 1237–1252. doi:10.1016/j.cpr.2013.08.005

Richards, A., French, C. C., Keogh, E., & Carter, C. (2000). Test-Anxiety, inferential reasoning and working memory load. Anxiety, Stress & Coping, 13(1), 87–109. doi:10.1080/10615800008248335

Sarason, S. B., Davidson, K., Lighthall, F., & Waite, R. (1958). A test anxiety scale for children. Child Development, 29(1), 105. doi:10.2307/1126274

Segool, N. K., Carlson, J. S., Goforth, A. N., von der Embse, N., & Barterian, J. A. (2013). Heightened test anxiety among young children: elementary school students' anxious responses to high-stakes testing. Psychology in the Schools, 50(5), 489–499. doi:10.1002/pits.21689

Segool, N. K., von der Embse, N., Mata, A. D., & Gallant, J. (2014). Cognitive behavioral model of test anxiety in a high-stakes context: An exploratory study. School Mental Health, 6(1), 50–61. doi:10.1007/s12310-013-9111-7

Seigneuric, A., Ehrlich, M. F., Oakhill, J. V., & Yuill, N. M. (2000). Working memory resources and children's reading comprehension. Reading and Writing, 13(1-2), 81–103. doi:10.1023/A:1008088230941

Snow, C. E. (2002). Reading for understanding: Toward a research and development program in reading comprehension. (pp. 1–174). Arlington, VA: RAND.

Spielberger, C. D. (1980). Test Anxiety Inventory. (C. D. Spielberger). Hoboken, NJ, USA: John Wiley & Sons, Inc. doi:10.1002/9780470479216.corpsy0985

Stern, P., & Shalev, L. (2013). The role of sustained attention and display medium in reading comprehension among adolescents with ADHD and without it. Research in Developmental Disabilities, 34(1), 431–439. doi:10.1016/j.ridd.2012.08.021

Swanson, J., Schuck, S., Mann, M., Carlson, C., Hartman, K., Sergeant, J., et al. (2005). Categorical and dimensional definitions and evaluations of symptoms of ADHD: The

SNAP and the SWAN ratings scales. To Access. Retrieved September 30, 2013, from http://www.adhd.net/SNAP_SWAN.pdf

Taylor, J. E., Hart, S. A., Mikolajewski, A. J., & Schatschneider, C. (2013a). An update on the Florida State Twin Registry. Twin Research and Human Genetics, 16(01), 471–475. doi:10.1017/thg.2012.74

Taylor, J., Allan, N., Mikolajewski, A. J., & Hart, S. A. (2013b). Common genetic and nonshared environmental factors contribute to the association between socioemotional dispositions and the externalizing factor in children. Journal of Child Psychology and Psychiatry, 54(1), 67–76. doi:10.1111/j.1469-7610.2012.02621.x

Triplett, C. F., & Barksdale, M. A. (2005). Third through sixth graders' perceptions of high-stakes testing. Journal of Literacy Research, 37(2), 237–260. doi:10.1207/s15548430jlr3702_5

Ursache, A., & Raver, C. C. (2014). Trait and state anxiety: Relations to executive functioning in an at-risk sample. Cognition & Emotion, 28(5). doi:10.1080/02699931.2013.855173

von der Embse, N., Barterian, J., & Segool, N. (2013a). Test anxiety interventions for children and adolescents: A systematic review of treatment studies from 2000–2010. Psychology in the Schools, 50(1), 57–71. doi:10.1002/pits.21660

von der Embse, N., Mata, A. D., Segool, N., & Scott, E.-C. (2013b). Latent profile analyses of test anxiety: A pilot study. Journal of Psychoeducational Assessment, 32(2), 165–172. doi:10.1177/0734282913504541

Wiberg, M., & Sundström, A. (2009). A comparison of two approaches to correction of restriction of range in correlation analysis. Practical Assessment, 14(5), 1–9.

Wigfield, A., & Eccles, J. S. (1989). Test anxiety in elementary and secondary school students. Educational Psychologist, 24(2), 159–183. doi:10.1207/s15326985ep2402_3

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. Biological Psychiatry, 57(11), 1336–1346. doi:10.1016/j.biopsych.2005.02.006

Willcutt, E. G., Nigg, J. T., Pennington, B. F., Solanto, M. V., Rohde, L. A., Tannock, R., et al. (2012). Validity of DSM-IV attention deficit/hyperactivity disorder symptom dimensions and subtypes. Journal of Abnormal Psychology, 121(4), 991–1010. doi:10.1037/a0027347

Willcutt, E. G., Pennington, B. F., & DeFries, J. C. (2000). Etiology of inattention and hyperactivity/impulsivity in a community sample of twins with learning difficulties. Journal of Abnormal Child Psychology, 28(2), 149–159. doi:10.1023/A:1005170730653

Wren, D. G., & Benson, J. (2004). Measuring test anxiety in children: Scale development and internal construct validation. Anxiety, Stress & Coping, 17(3), 227–240. doi:10.1080/10615800412331292606

BIOGRAPHICAL SKETCH

Sarah G. Wood completed her primary education in the San Lorenzo Valley School district located in California. Next, she attended Humboldt State University and throughout the school year she worked on numerous research projects and university service projects. During the summers, she participated in two NSF and one NIH research experiences for undergraduates. In the fall of 2011, after receiving a Bachelor of Science degree with honors, she spent one year in an NIH Postbaccalaureate Research Education Program.

In 2012, Sarah entered the developmental psychology graduate program. Under the guidance of her advisor Dr. Richard K. Wagner she studies reading disabilities. Her research is focused on reading comprehension. After completing the requirements for a Master of Science degree, she will pursue a doctoral degree in the developmental psychology graduate program at Florida State University.