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The Subject Matters: Relations Among Types of Anxiety, ADHD Symptoms, Math Performance, and Literacy Performance

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Abstract

In this study, we extended a model of the relations among ADHD symptoms, anxiety, and academic performance. Undergraduates ($N = 515$) completed self-report measures of anxiety (i.e., trait, test, math, and literacy) and ADHD symptoms. During the study, they completed math and literacy measures and reported their current (i.e., state) anxiety three times. There were significant correlations among ADHD symptoms and all measures of anxiety. However, neither ADHD symptoms nor trait anxiety were correlated with math or literacy performance. Test-anxious students reported increasing state anxiety as the study progressed. In contrast, math-anxious students reported increased state anxiety following the math tasks but not the literacy tasks and literacy-anxious students reported increased state anxiety following the literacy tasks but not the math tasks. With respect to performance, math-anxious students had worse math performance and literacy-anxious students had worse literacy performance whereas test anxiety was not directly related to performance on either math or literacy tasks. Patterns of relations did not differ for men and women, but, except for literacy anxiety, women reported higher levels of ADHD symptoms and all types of anxiety. These results could help educators understand how affective responses are related to university students' academic performance.

Word count: 197

Key Words: ADHD symptoms; anxiety; university; academic outcomes

The Subject Matters: Relations Among Types of Anxiety, ADHD Symptoms, Math Performance, and Literacy Performance

Imagine that you are a university student who feels overwhelmed about your classes, assignments, papers, and exams. Are you paying attention in lectures? Do you take good notes? Do you procrastinate on assignments? How do you manage your time? Students' difficulties paying attention, poor time management, and high levels of procrastination may be related to symptoms of disorders that interfere with learning, such as anxiety and attention deficit/hyperactivity disorder (ADHD). University students, even those without diagnosed disorders, report relatively high levels of anxiety (American College Health Association, 2019) and ADHD symptoms (Di Lonardo Burr & LeFevre, 2020; Garnier-Dykstra et al., 2010). There is extensive research showing that academic impairments are associated with diagnoses of anxiety (Duchesne et al., 2008; Singh & Thukral, 2009; Van Ameringen et al., 2003; Woodward & Fergusson, 2001) and ADHD (Barkley et al., 2006; Green & Rabiner, 2012; Mannuzza et al., 1993; Sobanski et al., 2008). However, little is known about how the self-reported symptoms of these disorders relate to academic performance in university students. In this paper we explored the relations among self-reported anxieties, ADHD symptoms, and academic performance for university students. We extended a model proposed by Di Lonardo Burr and LeFevre (2020) in which subject-specific anxiety (i.e., anxiety about mathematics or literacy) is central to understanding how university students' affective symptoms are related to their academic success.

What Types of Anxiety are Common among University Students?

According to the American College Health Association National College Health Assessment (2019), up to 40% of university students in North America reported experiencing debilitating levels of anxiety. Anxiety can be habitual, occurring in many situations, or it can be

transitory. State anxiety is transitory negative emotional arousal that occurs when people feel threatened or are placed in a dangerous situation (Lazarus, 1991; Spielberger, 1972; Spielberger et al., 1983). When the threatening situation ends, so does the state anxiety. In contrast, trait anxiety is a stable tendency to attend to, experience, and report unpleasant emotional arousal across many situations (Lazarus, 1991; Spielberger, 1972; Spielberger et al., 1983). Thus, people with high trait anxiety are anxious even when there is no immediate danger because they anticipate threatening situations.

Anxiety can be specific (e.g., a phobia of spiders) or it can be more general (i.e., a person feels anxious in many situations). Beyond general state and trait anxiety, some students may feel anxious about specific academic situations (Ashcraft, 2002; Maloney, 2016; Seipp, 1991; von der Embse et al., 2018). For example, test anxiety is a particular form of academic anxiety that is defined as excess arousal and negative reactions to tests or exams (Keogh & French, 2001). In the present study, we use the term *subject-specific anxiety* to refer to anxiety about a specific academic subject, such as math, science, reading, or writing.

Math anxiety comprises feelings of worry, tension, and/or fear about mathematics and is negatively correlated with math performance (Ashcraft, 2002; Douglas & LeFevre, 2017; Hembree, 1990; Maloney, 2016; Maloney & Beilock, 2012; Skagerlund et al., 2019). University students who report higher levels of math anxiety are also more likely to avoid coursework and career paths that involve mathematics (Ashcraft & Krause, 2007; LeFevre et al., 1992). Similar to math anxiety, students can experience literacy anxiety, which is comprised of feelings of worry and tension toward literacy-related activities, such as writing (Punaro & Reeve, 2012). Writing anxiety is negatively correlated with university students' grades, quality of writing, and performance on writing skills tests (Daly, 1978; Martinez-Torteya et al., 2011). Subject-specific

anxiety is distinct from test anxiety or trait anxiety but they are often interrelated (Hembree, 1990). In summary, university students may experience anxiety from many sources that may vary in how closely they are tied to particular academic experiences.

How do Different Subtypes of Anxiety Relate to ADHD Symptoms and Academic Performance?

Canu et al. (2017) argued that there is a specific link between ADHD (and ADHD traits) and math anxiety, suggesting that people who are diagnosed with ADHD or those with high levels of ADHD traits are more likely to report high levels of math anxiety. To examine this suggestion, we proposed and tested a model of the relations among ADHD symptoms in university students and math confidence, literacy confidence, and math performance (Di Lonardo Burr & LeFevre, 2020). More specifically, we hypothesized that students who reported higher ADHD symptoms would report low confidence about academic activities, in general, rather than specifically about mathematics. As predicted, we found negative correlations between ADHD symptoms and academic confidence: Students with higher levels of ADHD symptoms lacked confidence in their academic abilities, rated their skills as lower, and reported more negative affect (i.e., nervousness and avoidance) towards academics than those with lower levels of ADHD symptoms. Moreover, state anxiety increased over the course of the study only for students who reported high math anxiety, not for those who reported high levels of ADHD symptoms. We found no direct relations between self-reported ADHD symptoms and math performance. Our results suggested that academic anxiety, rather than general measures of psychological dysfunction such as ADHD symptoms or trait anxiety, should be the central feature in a model of postsecondary students' affective responses to their studies.

ADHD symptoms have been suggested as possible indices of academic dysfunction (e.g., Canu et al., 2017) because *diagnoses* of ADHD are associated with academic impairments (Barkley et al., 2006; Green & Rabiner, 2012; Mannuzza et al., 1993; Sobanski et al., 2008). However, the prevalence rate of diagnosed ADHD in university students is quite low (2%-8%; Dupaul et al., 2009). In contrast, *symptoms* of ADHD are common among university students. In two studies, 11% and 12% of university students reported clinical levels of ADHD symptoms (Di Lonardo Burr & LeFevre, 2020 and Garnier-Dykstra et al., 2010, respectively). The discrepancy between the prevalence of diagnoses of ADHD and self-reported clinical levels of ADHD might result from the overlap of symptoms among ADHD and anxiety. Consistent with this view, students without ADHD diagnoses who reported higher levels of perceived stress, anxiety and depression, who experienced psychological difficulties, or who had diagnosed internalizing disorders were more likely to endorse higher levels of ADHD symptoms (Alexander & Harrison, 2013; Harrison et al., 2013; Suhr et al., 2008; Van Voorhees et al., 2011). Thus, in the present study we proposed that the pattern of relations among ADHD symptoms, subject-specific anxiety, and subject-specific performance will be similar to the patterns of relations among trait anxiety, subject-specific anxiety, and subject-specific performance.

Gender, ADHD Symptoms, and Anxiety

Clinically, ADHD is more commonly diagnosed in males than females at all ages (Nussbaum, 2012). However, for self-reported symptoms in university students, no significant gender differences have been found (Flory et al., 2021). With respect to anxiety, clinically, anxiety disorders are much more prevalent in women than men (Christiansen, 2015; Remes et al., 2016). Beyond clinical diagnoses, women typically report higher levels of anxiety than men,

both in relation to mathematics (Dowker et al., 2016; Hembree, 1990; Hopko et al., 2003) and more generally (Feingold, 1994; McLean & Anderson, 2009; Takai et al., 2007; Zsido et al., 2020). In a review of the literature on gender differences, Hyde (2014) reported that, compared to men, women report lower self-esteem, more ruminating thoughts, and higher anxiety. Although gender differences in math anxiety are well documented, that is, women report more math anxiety than men, differences in literacy anxiety are not. In the present study, we explored patterns of gender differences in relation to ADHD symptoms, trait anxiety, and academic anxieties (i.e., test, math, literacy).

The Present Study

The goal of the present research was to examine the relations among types of anxiety, ADHD symptoms, and academic performance in university students by proposing and testing a theoretical model that demonstrates that anxiety specific to academics, rather than anxiety in general or symptoms of ADHD, is related to academic performance. Our theoretical model, shown in Figure 1, was based on a previous version (Di Lonardo Burr & LeFevre, 2020) in which ADHD symptoms were related to confidence about academics in general, not specifically to mathematics, and subject-specific confidence was related to mathematics performance. Although the results of that study supported the model, we did not assess trait anxiety, test anxiety, or measures of literacy performance, and thus the model was incomplete. Furthermore, we used measures of math and literacy affect that were combined indices of anxiety and self-perceived skills and thus were not typical of subject-specific anxiety measures. Because the majority of the measures used in the present study differed from those included in Di Lonardo Burr and LeFevre (2020), we consider our model to be a conceptual replication and expansion. In our expanded model we shift from focusing solely on ADHD symptoms and mathematics to

include predictions about the relations among these constructs as well as academic anxieties and literacy.

The theoretical model outlined in Figure 1 shows the expected relations among types of anxiety, ADHD symptoms and academic performance. Our first core hypothesis was that, even though university students report many types of anxiety, only subject-specific anxiety (i.e., math anxiety and literacy anxiety) would be directly related to performance in math and literacy, respectively. Moreover, our second core hypothesis was that state anxiety would be directly related to participants' experiences with specific academic tasks as they progress through the study. Specifically, we expected math-anxious students to report an increase in state anxiety after completing math tasks and literacy-anxious students to report an increase in literacy anxiety after completing literacy tasks.

(Insert Figure 1 Approximately Here)

Beyond the core hypotheses, our model includes the expected relations among the different types of anxiety. First, we proposed that trait anxiety and self-reports of ADHD would be significantly correlated. Second, we proposed a direct relation between both ADHD symptoms and trait anxiety and each type of academic anxiety (i.e., test, math, and literacy anxiety). That is, we predicted that students who reported higher levels of ADHD symptoms and students who reported higher levels of trait anxiety would also report higher levels of academic anxiety. Third, because of the test-like nature of the study, we predicted that test-anxious students would report increased anxiety as the study progressed (Ping et al., 2008). However, we did not predict direct relations between test anxiety and academic performance. Although a negative correlation exists between test anxiety and academic performance (see Seipp, 1991), the effect size of this relation for university students is very small (η^2 = .02; Chapell et al., 2005).

Thus, we hypothesized that the relations between test anxiety and performance on the math and literacy tasks would not be statistically significant.

Beyond considering the relations among the different types of anxiety, it is important to consider how gender might relate to anxiety. We hypothesized that the pattern of relations among ADHD symptoms, different types of anxieties, and academic performance would be similar for men and women. That is, for both genders, subject-specific anxiety would be related to math and literacy performance. However, although patterns among relations may be similar, reported levels of anxiety can be different. For example, women are more likely than men to report higher levels of all types of anxiety (e.g., Hembree, 1990; Maloney & Beilock, 2012; McLean & Anderson, 2009; Putwain & Daly, 2014; Takai et al., 2007; von der Embse et al., 2018). Thus, we hypothesized that women would report higher levels of trait, test, math, and literacy anxiety. We did not expect to find gender differences in levels of ADHD symptoms (Flory et al., 2021).

Method

Participants

Initially, 785 undergraduate students at a Canadian university accepted the invitation to participate in the study. The study was approved by the Carleton University Research Ethics Board. Students were enrolled in either introductory Psychology or Cognitive Science courses and received partial course credit for their participation. After exclusion criteria were applied (see Supplementary Material for details), data from 515 participants (65.6%) were retained (339 women; M_{age} = 20.5 years, SD = 4.7). Most participants whose data were discarded (n = 188) had failed to complete the survey or had responded “no” to the question “Did you honestly put your best effort into the survey?”

The 515 participants whose data were retained were from a range of programs. Specifically, 290 were enrolled in Bachelor of Arts programs (56.3%; 223 women), 76 were enrolled in Bachelor of Science programs (14.8%; 51 women), 48 were enrolled in a Bachelor of Commerce program (9.3%; 28 women), 35 were enrolled in a Bachelor of Computer Science program (6.8%; 5 women), and 23 were enrolled in a Bachelor of Cognitive Science program (4.5%, 12 women). The remaining 43 participants (8.3%) were enrolled in other programs; no other program had a frequency higher than 1.0% of the total sample. All participants spoke English, with 87.4% identifying English as their first language. The remaining 12.6% of participants reported other first languages. No single other language had a frequency higher than 2.5% of the total.

Procedure

Participants were recruited through an online system. The study was listed under the title "Attention and Academics" on the online system and participants were told they would be completing math tasks, reading tasks, and psychology inventories. Once they logged into the system, they received a link to the study which was created using the Qualtrics online survey tool (*Qualtrics*, 2005). Electronic informed consent was obtained, followed by participants completing the demographic questionnaire. Participants completed the measures in the order they are listed below, with the exception of state anxiety measures which were completed three times (see details below). The study took approximately 60-70 minutes.

Measures

The Math Background and Interests Questionnaire (MBIQ)

The Math Background and Interests Questionnaire (LeFevre et al., 2003) is a 20-item measure that includes demographic information (11 items) and self-reported attitudes towards mathematics (3 items) and reading and writing (6 items).

State Trait Anxiety Inventory-6 (STAI-6)

The STAI-6 was used to measure state anxiety (Marteau & Bekker, 1992). Individuals indicate how they are feeling at the time they complete the assessment by rating statements such as "I feel tense" and "I am calm" on a 4-point scale from 1 (Not at all) to 4 (Very much so). Positive phrases are reverse scored. Scores range from 6 to 24, with higher scores indicating greater anxiety. The STAI-6 was administered three times: First, at the beginning of the study (after the MBIQ), second, after the math tasks, and third, after the literacy tasks. The STAI-6 has a reported reliability of .82. Cronbach's alphas for the current sample were .86 at all three time points.

Academic Anxiety Inventory (AAI)

The AAI (Pizzie & Kraemer, 2019) is a 50-item self-report measure of academic anxiety comprised of five subscales, each with 10 items. In the present study, we used four of the subscales: trait anxiety, test anxiety, mathematics anxiety, and literacy (i.e., writing) anxiety. Participants rate statements such as "I feel anxious having a test returned" and "When I hand in an essay, I know I'm going to do poorly" on a 5-point Likert scale with "1" representing strongly disagree and "5" representing strongly agree. Total scores on each subscale were used in the analyses. Pizzie and Kraemer (2019) reported reliabilities for the AAI of .86 (trait), .85 (test), .90 (math), and .84 (writing). Cronbach's alphas for the current sample were very similar: .83 (trait),

.87 (test), .91 (math), and .81 (writing). Positively phrased items are reverse scored. Thus, scores on each subscale range from 10 to 50, with higher numbers indicating greater anxiety.

Adult ADHD Self-Report Scale (ASRS)

The ASRS is an 18-item self-report measure of ADHD symptomology for people aged 18 years or older (Kessler et al., 2005). This scale is based on the World Health Organization (WHO) Composite International Diagnostic Interview© (2001). The items in the ASRS are consistent with the Diagnostic and Statistical Manual of Mental Disorders criteria for ADHD (DSM-IV and DSM-V; American Psychiatric Association, 2013), but the scale alone cannot be used to diagnose ADHD. Participants rate themselves on various ADHD criteria on a 5-point scale, with "0" representing never and "4" representing very often. The 18 items belong to two subscales: Nine items correspond to symptoms of inattention and nine items correspond to symptoms of hyperactivity/impulsivity. People whose scores are between 17-23 on either subscale are classified as "likely to have ADHD". People whose scores are greater than 24 on either subscale are classified as "highly likely to have ADHD". Total scores, with a possible range from 0 to 72, were used in the analyses. The ASRS has high reported internal consistency (e.g., .89) and concurrent validity (e.g., .84; Adler et al., 2006). Cronbach's alpha for this sample was .82.

Basic Arithmetic Fluency

This task was designed to assess speeded arithmetic ability. Participants were presented with one screen of addition (e.g., 4 + 5; 19 + 22), one screen of subtraction (e.g., 8 – 4; 19 – 12), and one screen of multiplication (e.g., 6 × 7; 13 × 8). Participants had one minute to answer as many problems as quickly and accurately as possible on each screen. The sum of correct

responses across all three operations were used in the analyses. Cronbach's alpha based on the three subscales was .78.

Mathematics Knowledge from the Armed Services Vocational Aptitude Battery (ASVAB)

The ASVAB is a multi-aptitude test given to Americans who are interested in enlisting in the armed forces. Outside of the military, it has been used as a proxy measure of intelligence (Herrnstein & Murray, 1994). In the present study, a subset of 14 items were selected from the Mathematics Knowledge section. These 14 items were selected because they were more purely mathematical (e.g., "What is 10^4 x 10^3?") than some of the other Math Knowledge items and thus were unlikely to create confounds between math knowledge and literacy knowledge. All questions are in multiple-choice format. Scoring was total number correct. Cronbach's alpha for these items for the present sample was .77.

Paragraph Comprehension

Two paragraphs from the Nelson-Denny Paragraph Comprehension test (Brown et al., 1993) were administered. For this measure, participants read a short narrative and then answer accompanying comprehension questions. We used two short narratives each with five multiple-choice comprehension questions. The narrative remained visible while participants answered the comprehension questions. Scoring was the sum score across both paragraphs. The complete Nelson-Denny test has a reliability of .81 (Brown et al., 1993). In the present study, Cronbach's alpha based on the scores for the two paragraphs was .67.

Cloze Test

The cloze test is a measure of text comprehension. Participants were presented with paragraphs in which a single word had been removed from the sentence and replaced with a blank space. In the multiple-choice version, participants must choose the most appropriate word

to fill in the blank space from a list of four possible choices. In the open-ended version, participants generate a single word to fill in each blank space. In the present study, participants completed one multiple-choice passage consisting of 20 missing items and one open-ended passage consisting of 14 missing items (*Cambridge Michigan English Test*, n.d.). For the open-ended passage, the response was only considered correct if it was the exact word that originally appeared in the passage. Scoring was the total score across both passages. In the present study, Cronbach's alpha for the reliability based on the two paragraphs was .66.

Analysis Plan

The main goal of this study was to test the theoretical model shown in Figure 1. To do so, we used path analysis with Mplus software (Muthén & Muthén, 1998-2012). Path analysis is closely related to multiple regression and provides estimates of the magnitude and statistical significance of hypothesized connections among variables (Stage et al., 2004). The hypothesized paths are displayed in a path diagram (see Figure 1). Importantly, path analysis cannot determine the direction of causality. Thus, only the presence of a relation between variables can be tested. Nonetheless, path analysis is a useful statistical technique because it allows for the simultaneous testing of both direct and indirect effects with multiple independent and dependent variables.

Prior to conducting path analysis, data were removed for 31 participants for one of the two paragraph comprehension passages and for 18 participants for one of the two cloze test passages because they had inconsistent scores across the passages (see Supplementary Material). These missing data only accounted for a small portion of the total data. To confirm that data were missing completely at random (MCAR), Little's MCAR test was performed; non-significant results indicate that the data are MCAR, χ^2 (535) = 499.22, p = .86. Accordingly, full information maximum likelihood (FIML), which uses all available information, was used to

estimate the model. A combination of the comparative fit index (CFI > .90), root mean square error of approximation (RMSEA < .08), and standardized root mean square residual (SRMR < .08) were used to examine model fit (Kline, 2005).

Results

Descriptive Statistics

Descriptive statistics for all measures are shown in Table 1. Students reported moderate levels of ADHD symptoms and anxiety levels, with reasonable variability. Means on paragraph comprehension were highest, at 80%, compared to 72% on the cloze test, and 69% on the mathematics knowledge measures. As is typical for speeded tasks, arithmetic fluency was positively skewed because there were a few participants who had high scores on this timed measure. All of these measures were originally designed to be used with high school students and thus we expected relatively good performance. Thus, despite some deviations from normality, there was sufficient variability in the scores, reasonable standard deviations, and no obvious floor or ceiling effects.

The AAI, our measure of literacy anxiety, focused on questions pertaining to writing but our literacy outcome measures were predominately focused on reading. We had an additional measure, the MBIQ, that has 13 items pertaining to mathematics, reading, and writing self-efficacy, nervousness, and skills. Scores on the AAI literacy anxiety measure were significantly correlated with MBIQ items about reading and writing. Specifically, AAI literacy anxiety scores were correlated with avoiding reading (r = .31), avoiding writing (r = .42), feeling nervous about tasks involving reading (r = .44), and feeling nervous about tasks involving writing (r = .44). Thus, although the AAI literacy anxiety measure has items focused on writing, there is likely a significant overlap between negative feelings about reading and negative feelings about writing.

Principal components analysis (PCA) was used to combine the two literacy outcome measures (i.e., paragraph comprehension and cloze test) to create a single variable, which accounted for 73.9% of the variance. Similar significant correlations were found between literacy performance and literacy anxiety (r = -.18), as measured by the AAI, and literacy performance and feeling nervous about tasks involving reading (r = -.16) and feeling nervous about tasks involving writing (r = -.11), as measured by the MBIQ. Again, this suggests that the AAI literacy anxiety measure is tapping into more general literacy anxiety, not specifically writing anxiety. For consistency with the other measures of anxiety (i.e., trait anxiety and test anxiety) which were measured via the AAI, in the analyses we use the AAI and do not further analyze the 13 items from the MBIQ.

(Insert Table 1 approximately here)

Correlations

People who reported more ADHD symptoms also reported higher levels of anxiety on all anxiety measures, but ADHD symptoms were not significantly correlated with any of the math or literacy outcomes. Similarly, people who reported higher trait anxiety also reported higher levels of anxiety on all other measures of anxiety, but trait anxiety was only weakly correlated with math knowledge and was not significantly correlated with math or literacy outcomes. The two math outcomes were strongly correlated, as were the two literacy outcomes. Additionally, consistent with previous literature, math outcomes and literacy outcomes were moderately correlated (Fuchs et al., 2004; Rutherford-Becker & Vanderwood, 2009).

Participants' performance on both math outcomes was negatively correlated with their reports of math anxiety, but math anxiety was not significantly correlated with literacy performance. In contrast, participants' performance on the literacy outcomes was negatively

correlated with reported literacy anxiety and positively correlated with reported math anxiety. Math anxiety and literacy anxiety were also negatively correlated. These patterns indicate that the subject-specific anxiety measures have construct validity in relation to the outcome measures.

Sixty-two participants indicated that English was not their first language. Students who reported English as their first language reported lower literacy anxiety (26.4 vs. 28.6), $t(499) = -2.48$, $p = .02$, and had higher literacy outcomes (0.09 vs. -0.63), $t(513) = 5.62$, $p < .001$, than students who reported a first language other than English. To ensure that the relations between literacy performance and literacy anxiety were not solely driven by students' first language, a linear regression was conducted with literacy performance as the dependent variable and first language and literacy anxiety as independent variables. Literacy anxiety was a significant predictor of literacy performance ($\Delta R^2 = .03$, $p < .001$), even after language status was controlled. The results indicated that the model with both language and literacy anxiety was a significant predictor of literacy performance, $F(2, 498) = 21.98$, $p < .001$. Thus, in subsequent analyses we used data for all students, regardless of first language.

Path analysis

The final path analysis model is shown in Figure 2. We used confirmatory factor analysis within the model to create latent variables for math performance and literacy performance. Based on the fit criteria outlined above (see Section 2.4), our model had good fit, χ^2 (31) = 52.62, $p = .009$, SRMR = .03, CFI = .99, RMSEA = .04 [.02, .05]. To test whether the patterns of relations were different for men and women, we conducted a multi-group path analysis. Multi-group path analysis is used to determine if the structural parameters are statistically different between groups. We compared an unconstrained model (i.e., coefficients for each path are freely

estimated) to a constrained model (i.e., coefficients for each path are set to be equal across both groups). A chi-square difference test showed that fit did not significantly differ between the constrained and unconstrained models, χ^2 (24) = 23.61, p =.48, indicating that the patterns of relations are not significantly different between men and women. Thus, the single-group path analysis was retained for interpretation, as described below.

(Insert Figure 2 approximately here)

Relations among Subtypes of Anxiety

As predicted, self-reported symptoms of ADHD and anxiety were correlated (r = .50). Thus, consistent with the previous literature, students who reported high levels of anxiety symptoms also reported high levels of ADHD symptoms (Di Lonardo Burr & LeFevre, 2020; Alexander & Harrison, 2013; Harrison et al., 2013). In our previous model, we found that ADHD symptoms related to both math and literacy confidence. In the present study, with the inclusion of trait anxiety, ADHD symptoms were directly related to test and literacy anxiety, but not to math anxiety. Trait anxiety was directly related to test, math, and literacy anxiety. In general, students who reported higher levels of trait anxiety and students who reported higher levels of ADHD symptoms also reported higher levels of subject-specific anxiety. Thus, the model shows that students who felt anxious in general also felt anxious about academics.

Relations among Academic Anxiety and Academic Performance

The relations between academic anxieties and academic performance were explored. Consistent with our hypothesis, subject-specific anxiety was only related to subject-specific performance. Students who reported higher levels of math anxiety had lower math performance. Similarly, people who reported higher levels of literacy anxiety had lower literacy performance. Moreover, trait anxiety was indirectly related to math performance through math anxiety (B =

-.079, *SE* = .031, *p* = .012) and to literacy performance through literacy anxiety (*B* = -.054, *SE* = .017, *p* = .001). There were no significant direct or indirect relations between reported levels of ADHD symptoms or test anxiety and either math or literacy performance. Thus, only subject-specific anxiety directly predicted performance of a specific academic subject.

Changes in State Anxiety

We explored the relations among academic anxiety and state anxiety during the time of the study. Consistent with our hypotheses, math anxiety and literacy anxiety were both directly related to state anxiety at the beginning of the study (Time 1), presumably because participants anticipated doing academic tasks. Test anxiety was related to state anxiety at Times 1, 2, and 3, reflecting the test-like nature of the students' experience in the study. Math anxiety was positively related to state anxiety at Time 2, just after the math measures had been completed, whereas literacy anxiety positively related to state anxiety at Time 3, just after the literacy measures had been completed. Math anxiety was negatively related to state anxiety at Time 3 and the path between literacy anxiety and state anxiety at Time 2 was not significant. Because these paths control for earlier state anxiety, they indicate that changes in state anxiety were related to higher levels of math anxiety (Time 2), higher levels of literacy anxiety (Time 3), and higher levels of test anxiety (Times 2 and 3). Overall, the model shows that subject-specific anxiety leads to an increase in state anxiety when people are asked to complete subject-specific tasks.

Gender Differences

The pattern of relations among ADHD symptoms, anxiety, and academic performance were similar for men and women. However, we conducted additional analyses to explore

potential gender differences in reported levels of ADHD symptoms, trait anxiety, and academic anxieties (i.e., test, math, literacy).

First, there was no significant difference in self-reported ADHD symptoms for men (M = 29.7) and women (M = 31.3), $t(501) = -1.95$, $p = .051$, $d = -.18$. These results are consistent with the findings of Flory et al. (2021). Although boys are more often diagnosed with ADHD than girls, the self-reported symptoms of ADHD did not differ for men and women.

Second, anxiety ratings were analyzed in a 4(Anxiety Type: Trait, Test, Math, Literacy) by 2(Gender: Men, Women) mixed ANOVA. Reported values are Greenhouse-Geisser corrected, where appropriate. There were significant main effects of anxiety, $F(2.32, 1084.69) = 92.42$, $p < .001$, $\eta_P^2 = .17$, and gender, $F(1, 468) = 41.54$, $p < .001$, $\eta_P^2 = .08$. The main effects were qualified by a significant anxiety by gender interaction, $F(2.32, 1084.69) = 20.54$, $p < .001$, $\eta_P^2 = .04$ (see Figure 3). Interactions shown in Figure 3 were interpreted using 95% inferential confidence intervals as recommended by Jarmasz and Hollands (2009).

(Insert Figure 3 approximately here)

In comparison to men, women reported significantly higher levels of trait anxiety, test anxiety, and math anxiety. In contrast, women and men did not report significantly different levels of literacy anxiety. Examining the pattern within gender, men reported significantly higher levels of test anxiety than trait, math, or literacy anxiety, but there were no significant differences in levels of trait, math, or literacy anxiety. Women had a more complicated pattern. Similar to men, they reported higher levels of test anxiety than trait, math, or literacy anxiety. However, they also reported significantly lower levels of literacy anxiety than both trait and math anxiety. The subject-specific findings are consistent with the findings of Di Lonardo Burr and LeFevre (2020) and support the construct validity of the subject-specific anxiety measures. Overall, these

findings align with the literature that suggests that women report experiencing more anxiety than men. However, they also suggest that subject-specific anxiety varies between men and women. More specifically, women reported similar levels of literacy anxiety as men, but reported significantly lower levels of literacy anxiety than any other anxiety.

Discussion

In the present study, we explored the relations among ADHD symptoms, different types of anxiety, and academic performance. Extending our previous model (Di Lonardo Burr & LeFevre, 2020), we proposed that subject-specific anxiety would predict subject-specific performance and that anxiety about specific subjects would mediate the relations between general anxiety and academic performance. The findings supported a model in which the relations between specific academic experiences and specific types of anxiety are central features.

Academic Anxiety and Performance

In a meta-analysis, Seipp (1991) found that the size of the correlation between anxiety and academic performance was small ($\bar{r}_w$ = -.21) and moderated by several factors, including the specificity of the anxiety measure and whether anxiety was measured before or after the achievement outcome. In the present study, we explored the complex relation between anxiety and academic performance by testing a comprehensive model that included trait, state, test, math, and literacy anxiety.

We found non-significant correlations between trait anxiety and math performance (r = -.08) and literacy performance (r = .01). Moreover, test anxiety was only weakly correlated with math performance (r = -.13) and was not significantly correlated with literacy performance (r = -.03). Within the path model, the direct paths between test anxiety and academic performance

were not significant. Only math anxiety was directly related to math performance and only literacy anxiety was directly related to literacy performance. This pattern replicates and extends the findings of Di Lonardo Burr and LeFevre (2020) and aligns with findings from the broader literatures on math and literacy anxiety, respectively.

Negative correlations are commonly found between math anxiety and math performance (e.g., Hembree, 1990; Maloney, 2016; Suárez-Pellicioni et al., 2016). Negative correlations have also been found between reading anxiety and reading achievement (Ramirez et al., 2019) and between writing anxiety and writing skills (Daly, 1978; Martinez-Torteya et al., 2011). Similarly, subject-specific measures of self-efficacy and self-concept have been linked to math (Lee, 2009; McMullan et al., 2012) and writing performance (Huerta et al., 2017; Lee, 2009; McMullan et al., 2012; Pajares, 1996, 2003), respectively. Thus, subject-specific anxiety is the proximal factor for understanding links between affect and performance among university students.

In this study, completing subject-specific academic tasks had a direct effect on the levels of anxiety that students reported after each task. Test-anxious, math-anxious and literacy-anxious students reported similar levels of state anxiety at the beginning of the study. For test-anxious students, state anxiety increased after both the math tasks and literacy tasks. However, students who reported higher levels of math anxiety reported increased state anxiety following math but not literacy tasks whereas students who reported higher levels of literacy anxiety reported increased state anxiety following literacy but not math tasks. Other studies have found some evidence for a direct relation between state anxiety and math anxiety (e.g., Di Lonardo Burr & LeFevre, 2020; Ashcraft, 2002; Canu et al., 2017) but the present study is the first to show an immediate link between state anxiety and literacy anxiety. Further research would be useful in

understanding the connections among students' subject-specific anxiety, their immediate affective experience, and their performance in university settings.

ADHD Symptoms and Anxiety

Di Lonardo Burr and LeFevre (2020) examined the relations among ADHD symptoms, math anxiety, and math performance. They found that students who exhibited ADHD symptoms were more anxious about academic activities in general, not just about mathematics. In the present study we extended this question and examined a more comprehensive model, considering both ADHD symptoms and trait anxiety because of the known overlap in symptoms of ADHD and anxiety (Alexander & Harrison, 2013; Harrison et al., 2013). We proposed that a strong correlation would exist between self-reports of ADHD symptoms and trait anxiety and that, although both would be related to academic anxieties, neither would be directly related to academic performance. As expected, ADHD symptoms and trait anxiety were significantly correlated.

The overlap between ADHD symptoms and anxiety in non-clinical samples has implications for researchers. Diagnosed ADHD is associated with significant academic impairments (Loe & Feldman, 2007) but the prevalence of diagnosed ADHD among university students is low (Dupaul et al., 2009). Although we would expect that students with diagnoses of ADHD would have lower academic performance, the current research supports the view that self-reported ADHD symptoms are not significantly correlated with mathematics and literacy outcomes. Thus, researchers who collect self-reports of ADHD symptoms in non-clinical university samples need to be aware that these reports may reflect students' anxiety in the academic context, rather than behaviours associated with clinical ADHD.

Anxiety and Gender

Our findings also extend research on gender differences and academic anxiety, considering test anxiety, math anxiety, and literacy anxiety. We conducted a multi-group path analysis and found that the patterns of relations were similar for men and women. Moreover, both men and women reported higher levels of test anxiety than any other type of anxiety. This finding likely reflects the timing of the study and the nature of university life. Students may have reported strong feelings of test anxiety because many were currently experiencing the pressures of completing midterm examinations.

Although the relations among different anxieties and academic performance were similar, the levels of anxiety reported by men and women were different. As expected, women were more anxious in general, reporting higher levels of test anxiety (Hembree, 1988; Putwain & Daly, 2014; von der Embse et al., 2018) and trait anxiety (McLean & Anderson, 2009; Takai et al., 2007). These findings are consistent with clinical research in which the prevalence of anxiety disorders is much higher in women than men (Christiansen, 2015; Remes et al., 2016). However, the findings may also reflect the nature of self-reports of anxiety. Self-reports have been found to vary by gender as a result of factors such as the greater willingness of women to report anxiety, social stereotypes, and perceived confidence (Ashcraft, 2002; Beilock et al., 2007; McLean & Anderson, 2009).

With respect to subject-specific anxiety, we found that women reported higher levels of math anxiety than men (Di Lonardo Burr & LeFevre, 2020; Hembree, 1990; Maloney & Beilock, 2012). Moreover, women reported higher levels of math anxiety than literacy anxiety, whereas men reported similar levels of math and literacy anxiety. Overall, women reported lower levels of literacy anxiety than any other type of anxiety and literacy anxiety was the only measure of

anxiety that did not differ between men and women. Given that literacy anxiety is not well researched, with respect to subject-specific anxiety, we cannot conclude whether there is something special about literacy anxiety and gender or whether there is something special about math anxiety and gender. More research is needed to untangle these gender relations. Nonetheless, the general pattern of women reporting higher levels of anxiety than men is consistent with the broader literature.

Limitations and Future Research

In the present study we did not counterbalance the order in which students completed the math and literacy tasks. If both orders of the academic tasks had been included, an even stronger case could be made for the conclusion that state anxiety is directly linked to participants' subject-specific experiences of anxiety. Nevertheless, the cross-over pattern in which changes in state anxiety were directly related to the subject-specific anxiety immediately after participants completed the subject-specific measures is good support for the hypothesis that state and subject-specific trait anxiety are closely linked for university students.

The literacy tasks were relatively easy for most participants. It is possible that a direct relation between trait anxiety and outcomes would occur if the tasks were more difficult or more representative of the activities that students experience in their courses. In future studies, researchers should consider different types of academic outcomes and collect information about students' grade point averages and course performance so that the relations between ADHD symptoms, anxiety, and university achievement could be explored in more depth.

The study was administered online and thus it is unclear whether the results can be generalized beyond the experimental situation. It is possible that the relations between anxiety and performance would be exacerbated during classic exam situations in which there are

additional social pressures and consequences of poor performance. However, it is not uncommon for university students to complete online quizzes, tests, and examinations. Thus, the results of the present study are transferrable to the environment that students experience during their university studies.

Finally, in the present study, we used a measure of trait anxiety for mathematics: Students were asked to reflect on their past math experiences. This type of assessment dominates research in this area. However, for some students, relevant experiences may have occurred recently whereas for others, their last math course was two or more years prior. Previous studies have found a trait-state discrepancy in self-reports of state and trait anxiety; trait emotions are overestimated compared to state emotions (Buehler & McFarland, 2001). This pattern has also been found for math anxiety, with students overestimating their trait math anxiety (Roos et al., 2015) in relation to their experienced levels of state math anxiety. In future research, additional questions that ask students how they feel about math and literacy in the moment (i.e., state measures) would provide useful information about how feelings towards specific academic subjects are related to completing subject-specific tasks. Moreover, such assessments would allow researchers to compare current and retrospective reports of subject-specific anxiety to determine how accurately students are able to reflect on their previous experiences with these subjects.

Conclusions and Implications

In the present study we found that university students who reported general feelings of anxiety were also likely to report anxiety related to academics (i.e., test anxiety, math anxiety, literacy anxiety). However, only subject-specific trait anxiety was directly related to students' performance: Students who were more anxious about math had worse math performance whereas

students who were more anxious about literacy had worse literacy performance. The pattern of change in state anxiety across the study was of particular interest. Students who were math anxious experienced an increase in state anxiety as a result of doing math-related tasks and students who were literacy anxious experienced an increase in state anxiety as a result of doing literacy-related tasks.

The findings of the present research may be helpful for educators and mental health professionals. Carey et al. (2017) found that secondary students (i.e., ages 11-13) with elevated academic anxiety showed lower academic performance than their peers who had elevated general anxiety. Similarly, in the present study we found that university students reported both general and academic anxiety, but that only subject-specific anxiety was related to their academic performance. Thus, identifying the emergence of subject-specific anxiety may be particularly important in identifying students who are at risk for poorer academic performance in particular disciplines. Moreover, awareness that students have an immediate negative response to math or literacy activities highlights the importance of immediate mitigation strategies. For example, expressive writing about their anxiety is a useful treatment for university students with test anxiety and math anxiety, although it may be less useful for those with literacy anxiety (cf. Maloney & Beilock, 2012). More generally, interventions aimed at reducing anxiety may be beneficial so that negative feelings about certain subjects do not hinder academic success.

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Table 1

Correlations and Descriptive Statistics for All Measures

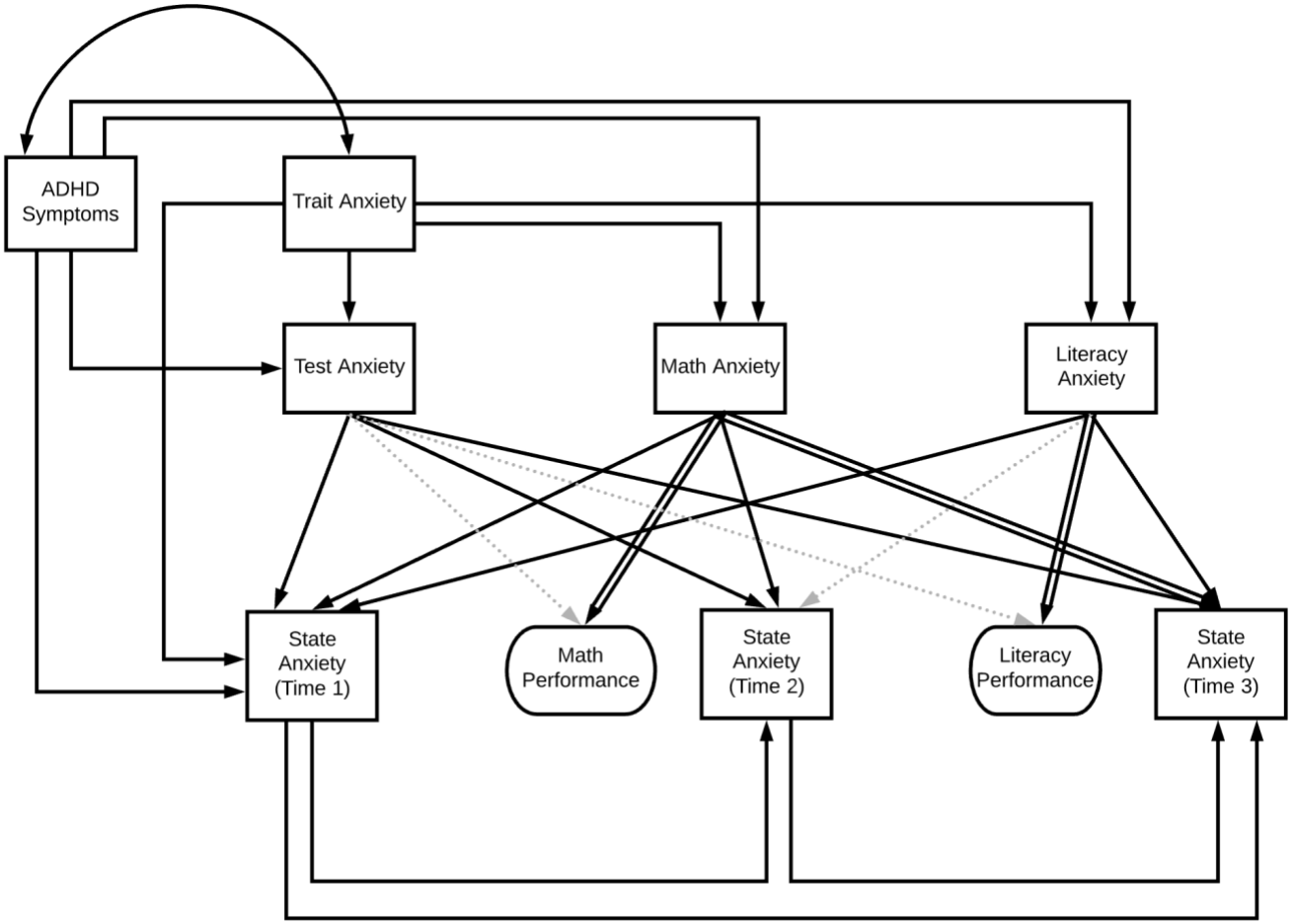
	1	2	3	4	5	6	7	8	9	10	11	12
1. ADHD Symptoms	***.82***	.50**	.35**	.14**	.22**	.31**	.30**	.29**	-.05	-.06	-.06	-.03
2. Trait Anxiety	.25	***.83***	.51**	.17**	.28**	.51**	.44**	.46**	-.04	-.09*	.03	-.00
3. Test Anxiety	.12	.26	***.87***	.24**	.21**	.43**	.42**	.44**	-.10*	-.13**	-.00	-.05
4. Math Anxiety	.02	.03	.06	***.91***	-.19**	.19**	.47**	.12*	-.35**	-.52**	-.03	-.07
5. Writing Anxiety	.05	.08	.04	.04	***.81***	.22**	.06	.28**	.10*	.10*	-.15**	-.18**
6. State Anxiety T1	.10	.26	.18	.04	.05	***.86***	.51**	.53**	-.06	-.15**	-.02	-.10*
7. State Anxiety T2[a]	.09	.19	.18	.22	.00	.26	***.86***	.58**	-.19**	-.31**	.01	-.04
8. State Anxiety T3[b]	.08	.21	.20	.01	.08	.28	.33	***.86***	-.05	-.08	-.08	-.17**
9. Arithmetic Fluency	.00	.00	.01	.12	.01	.00	.04	.00	***.78***	.49**	*.15***	.22**
1. Math Knowledge	.00	.01	.02	.27	.01	.02	.09	.01	.24	***.77***	.15**	.18**
11. Paragraph	.00	.00	.00	.00	.02	.00	.00	.01	.02	.02	***.67***	.50**
12. Cloze Test	.00	.00	.00	.00	.03	.01	.00	.03	.05	.03	.25	***.66***
N per measure	503	494	506	498	501	512	508	509	515	515	483	497
Mean	30.79	29.84	34.83	30.80	26.71	11.85	14.23	13.35	50.51	9.60	7.96	23.02
SD	9.20	7.07	7.00	9.53	6.54	3.95	4.24	4.08	12.09	3.14	1.81	4.30
Skew	.105	.073	-.561*	-.131	.072	.335*	.088	.202	.422*	-.603*	-1.26*	-.772*
Actual Range	3-59	11-49	10-49	10-50	10-47	6-24	6-24	6-24	13-90	0-14	2-10	8-32
Possible Range	0-72	10-50	10-50	10-50	10-50	6-24	6-24	6-24	0-162	0-14	0-10	0-34

Note. Reliability of the measure (details in the Method) is shown on the diagonal. R^2 values are shown below the diagonal. *$p < .05$.

**$p < .01$. [a]Measured after mathematics tasks; [b]Measured after literacy tasks

Figure 1

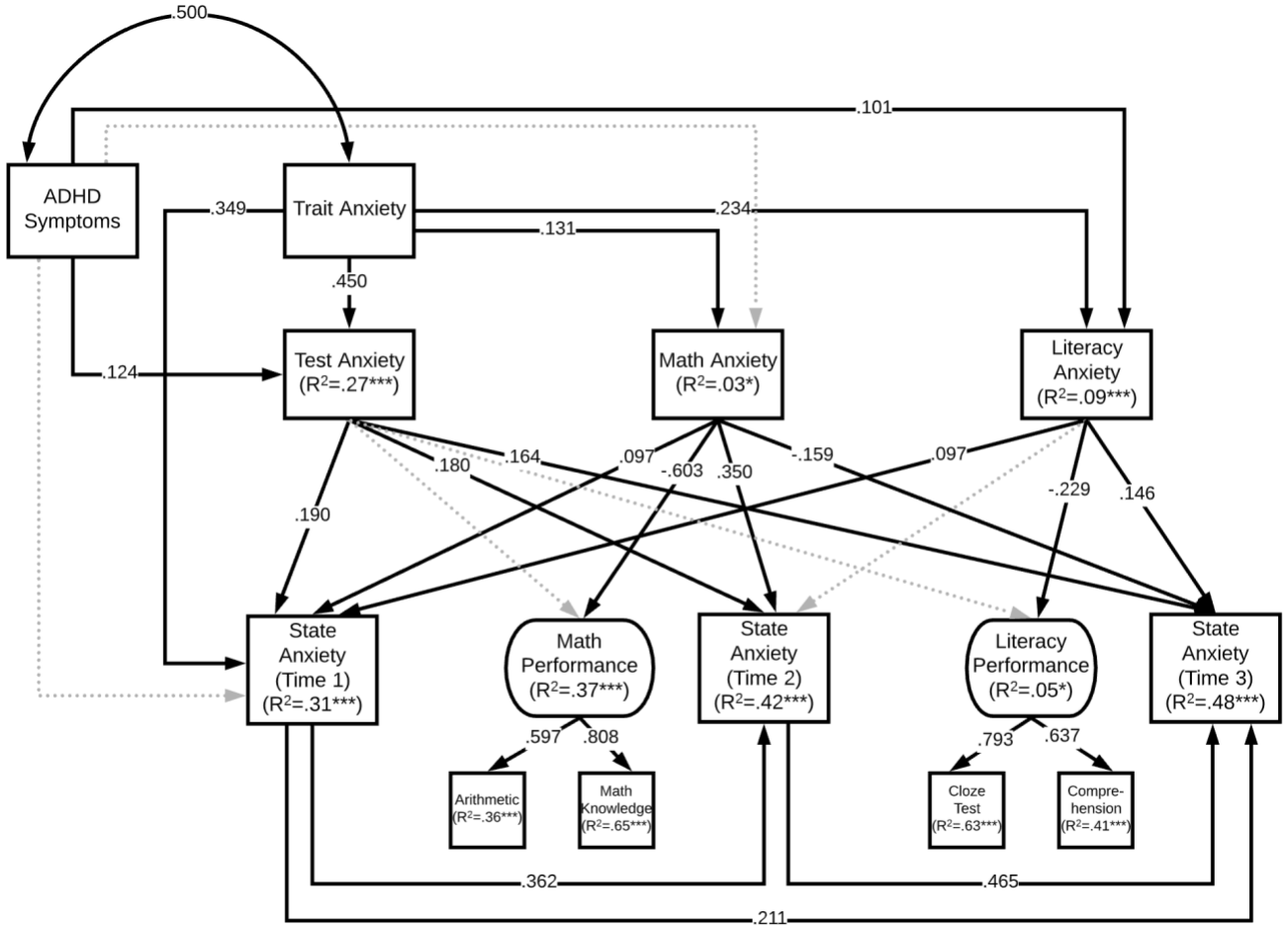
Theoretical Model Summarizing Expected Relations Among ADHD Symptoms, Anxiety, and Academic Performance



Note. Double lines represent negative predicted pathways. Grey dashed lines represent paths that were hypothesized to be non-significant.

Figure 2

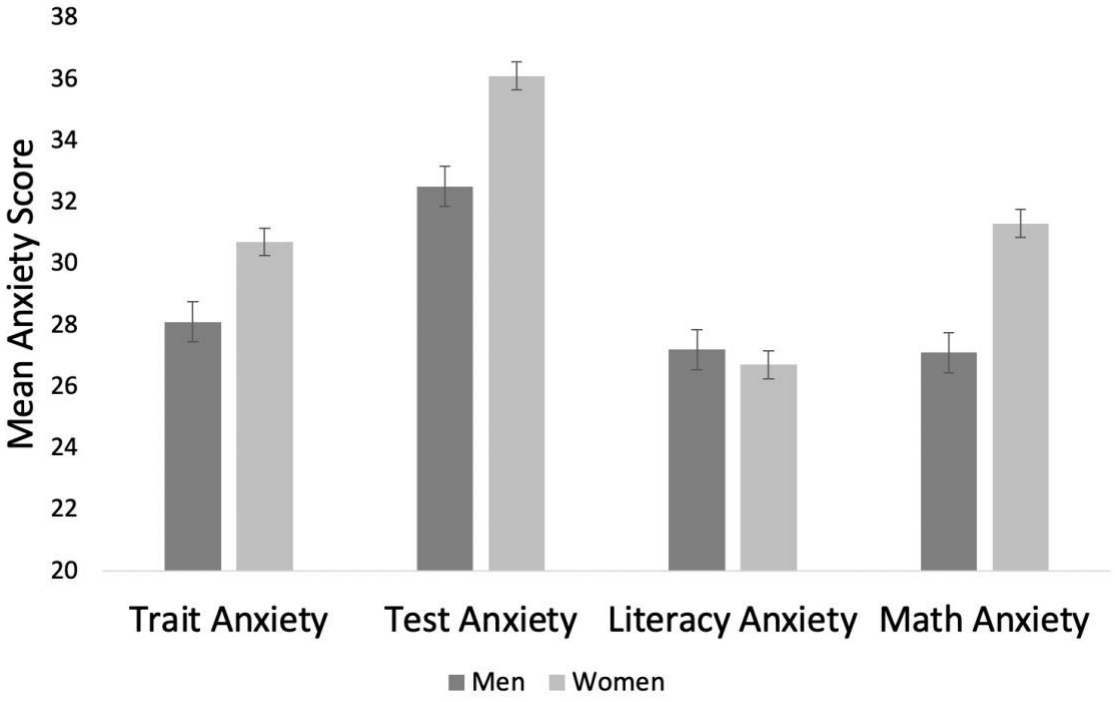
Path Model Predicting Relations Among ADHD Symptoms, Anxiety, and Math Performance



Note. Model fit statistics: χ^2 (31) = 52.62, p = .009, SRMR = .03, CFI = .99, RMSEA = .04 [.02, .05]. Numbers on direct paths are standardized coefficients. Solid lines represent significant paths; dashed grey lines represent tested paths that were not significant.

Figure 3

Mean Anxiety Levels for Men versus Women



Note. Error bars represent 95% inferential confidence intervals.

Supplementary Material

Data Exclusion

Seven-hundred and eighty-five undergraduate students responded to the survey. Responses were screened to ensure that they accurately reflected performance. Participants were removed from the survey if they met the following criteria. First, 54 participants did not complete the survey in its entirety (i.e., they exited the survey before completing any math or literacy performance measures), so their data were removed. Second, participants were asked at the end of the survey "Did you honestly put your best effort into your responses?" If they responded "No", their data were removed from analyses. This criterion resulted in the removal of 134 participants. Third, because the arithmetic fluency measure was very simple, participants who had a total score of 10 or less were removed (n = 7), because this level of performance suggested they had either randomly filled in numbers or did not put forth their best effort. Fourth, participants who scored 0 on the paragraph comprehension or cloze test were removed (n = 4), as were those who spent less than 30 seconds on either of these tests (n = 37) because this level of performance suggested they were not attempting to perform well. Fifth, participants who had an average score of less than 40% on both math or both literacy performance measures were removed (n = 24) because the sample was well-educated (i.e., university students) and the math and literacy tasks ranged from elementary to high school level difficulty. Finally, data from participants who had large discrepancies between their scores on the two paragraphs for the paragraph comprehension task (i.e., a difference > 60%) and or the two cloze tests (i.e., a difference > 40%) were removed (n = 10) because these discrepancies suggested that participants did not exert similar effort throughout the task. If participants had large discrepancies on only one measure (i.e., only paragraph comprehension or only cloze test) but scores on the other tasks

were consistent, then the measure with the large discrepancy was coded as missing data (n = 49). In total, data from 515 participants (65.6%) were used in the analyses.

Participants were asked if they had a current or previous diagnosis of ADHD or any learning disability. Frequencies for self-reported ADHD or learning disabilities are reported in Table S1. The focus of this study was on ADHD symptoms regardless of diagnoses. Thus, data from all participants including those with self-reported ADHD and learning disability diagnoses were included in the analyses.

Table S1

Percentage of Students Reporting a Diagnosis of ADHD or a Learning Disability

Diagnoses	Percent
ADHD	5.6
Reading Disability	1.4
ADHD + [Math or Reading or Other Learning Disability][1]	1.4
Other Learning Disability[1]	1.0
Reading + Other Learning Disability[1]	0.4
Math + [Reading or Other Learning Disability][1]	0.2

Note. [1]Other Learning Disability is any learning disability other than Math or Reading