ADHD AND ACADEMIC PERFORMANCE IN A POST-SECONDARY STATISTICS COURSE: MEDIATING FACTORS

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ABSTRACT

Attention-Deficit Hyperactive Disorder (ADHD) is a widely spread phenomenon affecting learning abilities and performance. The aim of the research is to test the mechanism linking ADHD with statistics test performance. We found a significant indirect path linking the ADHD diagnosis and the final grade. ADHD was linked to lower self-efficacy, leading to a more negative attitude towards statistics and lower grades. While treating ADHD is beyond the ability of a course lecturer, its adverse consequences such as impaired performance, can be addressed in the classroom setting. Lecturers should be encouraged to take steps towards increasing the self-efficacy and positive perception of statistics of their students. This may help improve the performance of students with ADHD without having to directly treat the disorder.

Keywords: *Statistics education research; ADHD; Self-efficacy; Attitudes towards statistics; Statistics anxiety*

1. INTRODUCTION

Attention-Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by persistent patterns of inattention, hyperactivity, and impulsivity that significantly impact an individual's daily functioning and academic performance (Prevatt & Young, 2014; Riboldi et al., 2022). While extensive research has explored the effects of ADHD on various aspects of everyday functioning, its influence on academic achievement in specific domains like statistics, remains relatively underexplored.

Statistics education is a vital component of numerous academic disciplines and is increasingly recognized as a critical skill in today's data-driven world. Statistics courses, however, can pose particular challenges for students with ADHD due to the complex nature of the subject matter, its extensive problem-solving requirements, and the need for sustained attention and organization (Weyandt & DuPaul, 2013). Understanding the unique challenges faced by students with ADHD in statistics courses is crucial for developing targeted interventions and support strategies to enhance their academic outcomes.

In this study, we aim to understand the psychological mechanism that students with ADHD undergo when facing a statistics course. Specifically, the current study aims to investigate the mediating role of self-efficacy, statistics anxiety, and attitudes toward statistics in the relationship between ADHD and performance in an undergraduate-level statistics course. By examining these mediating mechanisms, we can gain a deeper understanding of how ADHD affects academic achievement in statistical education and identify potential intervention points to support students with ADHD.

Our research hypotheses posit that students with ADHD experience poorer performance in statistics courses compared to their non-ADHD peers. We also hypothesize that this relationship will be mediated by lower levels of self-efficacy, which may lead to anxiety and negative attitudes towards statistics.

The findings from this study will contribute to the existing literature by elucidating the mechanisms through which ADHD impacts academic achievement in statistics courses. Furthermore, the results will inform the development of targeted interventions and support strategies to enhance the success of

students with ADHD in statistics education. Ultimately, this research aims to promote inclusive educational practices and provide meaningful support for students with ADHD, ensuring their equitable access to statistical education and opportunities for academic success.

2. SCIENTIFIC BACKGROUND

2.1. STUDENTS WITH ADHD AND ACADEMIC ACHIEVEMENT

Students with ADHD often face significant challenges in their academic endeavors (DuPaul et al., 2021; Gormley et al., 2019; Prevatt & Young, 2014). ADHD is characterized by symptoms of inattention, hyperactivity, and impulsivity, which can hinder a student's ability to concentrate, stay organized, manage time effectively, and complete tasks (Barkley et al., 2008). These cognitive and behavioral difficulties can lead to lower grades, increased rates of course repetition, and a higher risk of dropping out of educational programs (DuPaul et al., 2021; Gormley et al., 2019). Furthermore, the comorbidity of ADHD with other mental health disorders can compound these challenges (Bartoli et al., 2023; Posner et al., 2020). To mitigate these issues and support the academic success of students with ADHD, it is crucial for educational institutions to provide tailored interventions, such as suggesting behavioral strategies, recommending medication when appropriate, and creating individualized education plans. By addressing the unique needs of ADHD students and fostering a supportive learning environment, educators and policymakers can help these students achieve their academic potential and long-term success (Riboldi et al., 2022).

Understanding the unique challenges and needs of students with ADHD is of paramount importance in statistical education courses. This knowledge not only promotes inclusive and equitable learning environments but also allows educators to adapt teaching methods, provide appropriate accommodations, and develop strategies that cater to the diverse learning profiles of all students, including those with ADHD. This inclusive approach ensures that every student has the opportunity to excel in statistical education, contributing to their overall academic achievement and future success in data-driven fields.

2.2. SELF-EFFICACY

One potential mediating factor that may explain the impact of ADHD on academic achievement is self-efficacy. Self-efficacy, as defined by Bandura (1997), refers to an individual's confidence in their ability to excel at a specific task. Bandura identified four primary sources from which self-efficacy beliefs are derived: personal achievements, learning from others, persuasive communication, and emotional responses. This concept of self-efficacy plays a crucial role in human agency, serving as a powerful resource to help individuals manage psychological stressors and influence how they perceive potential threats.

Academic self-efficacy, a subset of the broader concept of self-efficacy, specifically relates to students' confidence in their ability to complete their academic work (Midgley et al., 2000). Bandura (1997) emphasized that a student's success in a task is profoundly influenced by their belief in their own ability to accomplish it. Numerous studies have revealed the intricate relationship between self-efficacy and various academic and learning tasks. For example, Cheng and Chiou (2010) established a positive link between self-efficacy and the test performance of accounting students. Doménech-Betoret et al. (2017) concluded that motivational factors mediate the relationship between self-efficacy and academic achievement. Honicke and Broadbent (2016) conducted a comprehensive review spanning 12 years and found a moderate correlation between academic self-efficacy and academic achievement, with other factors acting as mediators. Köseoğlu (2015) observed that academic self-efficacy significantly predicted academic performance. Notably, Lai Mooi (2006) discovered that students who underestimated their examination scores performed better than those who expected high grades, a phenomenon explained by the increased effort exerted by the former group. Additionally, Christensen et al. (2011) found that lower self-efficacy scores were associated with higher final examination scores and course grades. They concluded that lower expectations prompted efforts to improve performance, while higher expectations led to subsequent performance decline.

Self-efficacy carries significance beyond academic achievements; it also holds implications for statistics anxiety. Bandalos et al. (1995) identified an inverse relationship between perceived self-efficacy and the worry component of statistics anxiety. In Benson et al.'s (1994) study, perceived self-efficacy, defined as confidence in successfully navigating a statistics course, exhibited a negative correlation with general test anxiety. However, this connection did not extend to statistics test anxiety, suggesting that students may overestimate their competence in mathematics or math-related subjects. Notably, there was a statistically significant link between self-efficacy and statistics anxiety, highlighting the importance of graduate students' belief in their ability to overcome the challenges of learning statistics. Specifically, Perepiczka et al. (2011) established a negative correlation between self-efficacy for learning statistics and statistics anxiety among graduate students. In a broader context, self-efficacy was generally found to be positively associated with students' statistics performance (Finney & Schraw, 2003; Lane & Lane, 2001) but negatively associated with test anxiety (Ubaka et al., 2015) and statistics anxiety (Chiesi et al., 2011; Macher et al., 2012). Furthermore, it is not unexpected that students' self-efficacy in statistics tended to increase as they progressed in their statistics education (Finney & Schraw, 2003).

Research has shown that students with ADHD often have lower levels of self-efficacy compared to their non-ADHD peers (Almasi, 2016; Newark et al., 2016). This lower self-efficacy may undermine students' confidence in their ability to manage the demands of statistics courses, leading to negative attitudes towards the subject and subsequently lower grades.

2.3. CONCEPTUALIZATION OF ATTITUDES TOWARDS STATISTICS AND STATISTICS ANXIETY

Understanding and measuring attitudes toward statistics is crucial for educators and researchers to improve teaching methods and course designs, ultimately fostering positive attitudes and enhancing learning outcomes in statistics education (Gal & Ginsburg, 1994). In spite of this, much diversity exists in the literature regarding how attitiudes and anxiety should be concepualized. Ramirez et al. (2012) present a thourogh review of different factors used in the general context of attitudes towards statistics. These factors include meausers such as anxiety, self-worth, difficulty, sense of value and more, as will be presented in the following sections.

Attitudes toward statistics. Attitudes toward statistics encompass various dimensions, including cognitive competence, affect, value, and perceived difficulty (Emmioğlu & Capa-Aydin, 2012; Gundlach et al., 2015; Ramirez et al., 2012; Schau et al., 2012). Researchers have employed several instruments to measure attitudes toward statistics. One of the most widely used is the Students Attitudes Toward Statistics (SATS) scale developed by Schau et al. (1995), which assesses students' affective, cognitive, value, and difficulty components of attitudes toward statistics. Other commonly used measures include the Statistical Anxiety Scale (SAS) by Vigil-Colet et al. (2008), which focuses specifically on measuring anxiety levels related to statistics, and the Attitudes Toward Statistics (ATS) scale by Wise (1985), which captures general attitudes. The Statistical Anxiety Rating Scale (STARS) by Cruise et al. (1985) is another instrument designed to measure the anxiety dimension of statistics attitudes. These multi-item scales have demonstrated reliability and validity in numerous studies across different student populations and educational contexts, providing researchers with robust tools to quantify and analyze students' attitudinal dispositions toward the field of statistics.

Researchers have consistently found moderate to strong correlations between these attitudes and academic performance, emphasizing the importance of students' perceptions and dispositions toward statistics in predicting their course outcomes (Emmioğlu & Capa-Aydin, 2012). While attitudes have been studied extensively in traditional face-to-face statistics courses (Gundlach et al., 2015), recent research has begun to investigate these factors in online and blended learning environments, revealing differences in how attitudes evolve and influence academic success (Zimmerman & Austin, 2018).

Statistics anxiety. Over the last several decades, researchers have conducted extensive investigations into the phenomenon of statistics anxiety, resulting in a wealth of knowledge on the subject. The scholarly literature offers numerous definitions of statistics anxiety. One perspective, presented by Onwuegbuzie et al. (1997), characterizes statistics anxiety as a "state-anxiety reaction to

any situation in which a student is confronted with statistics in any form and at any time" (p. 28). In contrast, Cruise et al. (1985) defined it as "the feelings of anxiety encountered when taking a statistics course or engaging in statistical analyses, encompassing the processes of gathering, processing, and interpreting data" (p. 92).

Statistics anxiety is one of facet of attitudes towards statistics (Chiesi & Primi, 2009; Marmolejo-Ramos et al., 2022). Over the years, researchers have extensively investigated the role of attitudes and anxiety within the realm of statistics education (Gundlach et al., 2015; Ramirez et al., 2012; Kadosh et al., 2023). Their studies have shed light on how these factors may influence students' performance in statistics courses, resulting in an array of key insights (Gundlach et al., 2015; Macher et al., 2012; Malik, 2015; Onwuegbuzie, 2004; Williams, 2013, 2015; Zimmerman & Austin, 2018).

The impact of statistics anxiety on students' academic performance is well-documented (Macher et al., 2012; Malik, 2015; Zare et al., 2011). High levels of statistics anxiety have consistently shown a negative correlation with academic achievement (Macher et al., 2012). When students experience heightened statistics anxiety, their performance in statistics courses tends to decline. This negative association has been observed in various educational settings, from introductory statistics courses to more advanced research methods courses (Malik, 2015). Students with elevated statistics anxiety often struggle to concentrate on course material, ineffectively engage in learning activities, and perform poorly on assessments. Furthermore, statistics anxiety has been identified as a significant contributor to procrastination behaviors among students enrolled in statistics courses (Zare et al., 2011), further exacerbating its adverse impact on academic performance. Exposure to statistical content, problem-solving, instructional scenarios, and evaluation processes can trigger heightened statistics anxiety, particularly among students who do not have a strong mathematical background, including those enrolled in psychology programs (Lesser & Reyes, 2015). This anxiety may impede a student's ability to effectively engage with course material and learn (Hanoch & Vitouch, 2004). This body of research underscores the need for interventions and support mechanisms to help students manage and reduce statistics anxiety, ultimately enhancing their performance in statistics education.

While attitudes and anxiety in the general student population have received substantial attention, it is crucial to investigate how these factors may uniquely affect students with ADHD in the context of statistics courses. Students with ADHD encounter distinct academic challenges stemming from their difficulties with attention and focus. Despite their potential for interaction, research specifically exploring attitudes and anxiety related to statistics education among students with ADHD is currently limited.

Therefore, this study is aimed at delving into the underlying mechanisms connecting ADHD to academic achievement in the context of a statistics course, particularly among undergraduate psychology students. This research investigated the potential mediating roles of self-efficacy, attitudes toward statistics, and statistics anxiety in the relationship between ADHD and academic performance. By shedding light on these interactions, this study contributes to a deeper understanding of how students with ADHD navigate the challenges of statistics education and offers insights into potential interventions to support their academic success.

In sum, we hypothesized that:

(1) Students with ADHD will present poorer academic achievements as compared to their peers.
(2) Self-efficacy, followed by attitudes towards statistics and statistics anxiety, will mediate the link between ADHD and academic achievement, as presented in Figure 1.

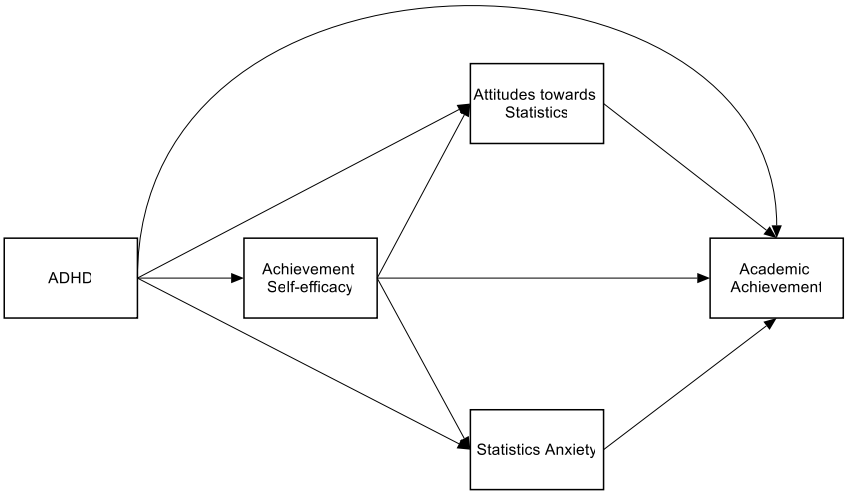


Figure 1. Hypothesized model

3. METHODS

3.1. PARTICIPANS

The participants of this study were first-year undergraduate psychology students from The Academic College of Tel Aviv-Yaffo. The final sample consisted of 208 (N = 208) participants; 34 men and 173 women (one unknown. Their ages ranged from 19 to 33 years (M = 23.73, SD = 1.73). Participants completed a questionnaire using the online platform Qualtrics. All participants were informed of the research background and gave their consent before participating.

3.2. INSTRUMENTATION

Demographic information. Demographic information was collected with questions designed for the current study. Participants were asked to report the following: (a) age, (b) gender, (c) socioeconomic status on a 3-point scale (below, about or above average), (d) math exam level in the high school finals (in Israel, final exam levels are indicated by a number of "units" ranging between 1 and 5, with higher numbers indicating higher levels), (e) math final exams (at the 3, 4, or 5 unit level), and (f) current work status (employed or not). In addition, we asked the participants for some basic information regarding their learning behaviors, including diagnosis of ADHD (participants were not asked about use of medication) and number of hours they devote to homework in statistic per week.

Students' academic achievement. Students' academic achievement is an important indicator of academic success at the university level (Ahmad & Bruinsma, 2006). We used grades as a measure of students' success because these scores were designed to assess the proficiency of all learning objectives. Students' grades were obtained from their college records (with permission).

Self-Efficacy Scale for Academic Performance. This tool was developed by Zimmerman et al. (1992) and is a self-report measure. We used the short Hebrew version, as demonstrated by Niflay (2003). The original scale includes three parts: (a) self-efficacy for learning, (b) self-efficacy for academic achievement, and (c) self-efficacy of emotional regulation in learning. We used only one subscale from the original scale for the current study: self-efficacy for academic achievement. Items are rated from 1 (very strongly disagree) to 7 (very strongly agree), with higher scores indicating higher self-efficacy. The subscale had seven items indicating participants' perceived ability to reach achievements while referring to learning that will contribute to success (i.e., "To be able to concentrate on lessons"; "To be able to achieve good grades"). Niflay (2003) originally measured this competence in three subjects: mathematics, English and history. In this study, we measured competence in the

context of statistics. Cronbach's alpha coefficients that were reported in Niflay (2003) ranged from .85–.88. In this study, Cronbach's alpha coefficient was also high (α = .84).

The Statistical Anxiety Rating Scale (STARS). STARS is a multi-dimensional measurement of statistics anxiety that is the most common tool for measuring statistics anxiety in academia thanks to its high levels of validity and reliability, developed by Cruise et al. (1985), and translated into several languages. A relatively recent review found that out of 50 quantitative studies on statistics anxiety examined, 39 (78%) used STARS (Chew & Dillon, 2014). The original tool, which consists of 51 items, used a 5-point Likert scale. Cruise et al. (1985) identified six distinct but interlinked factors which together constitute the phenomenon of statistics anxiety: worth of statistics, interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers.

Worth of statistics refers to students' perceptions of the usefulness of statistics either in their personal, academic, or future professional lives. Sample items include "I feel statistics is a waste" and "I'm never going to use statistics, so why should I have to take it?" and are scored along the continuum of 1 (strongly disagree) to 5 (strongly agree).

Interpretation anxiety, referring to how much anxiety students feel when faced with having to interpret statistical data or make a decision about an analysis outcome, is scored from 1 (no anxiety) to 5 (high anxiety). Sample items reflecting this type of anxiety include "Making an objective decision based on empirical data" and "Figuring out whether to reject or retain the null hypothesis."

Test and class anxiety are measured on the same scale, with items such as "Doing the homework for a statistics course" and "Finding that another student in class got a different answer than you did to a statistical problem."

Computation self-concept is intended to represent students' anxiety concerning working on math problems as well as their self-perceptions of mathematical ability (rather than actual mathematical ability). Sample items from this subscale, measured on a 5-point Likert scale from 1-strongly disagree to 5-strongly agree, include "I haven't had math for a long time. I know I'll have problems getting through statistics" and "I could enjoy statistics if it weren't so mathematical."

The final two subscales, *fear of asking for help* and *fear of statistics teachers*, are also measured on a 5-point Likert scale with 1 indicating no anxiety and 5 indicating high anxiety. These subscales are designed to assess students' anxiety over asking for help in understanding statistics material and students' perceptions of statistics teachers. Sample items include "Asking one of your professors for help in understanding a printout" and "Most statistics teachers are not human." Higher scores on each of the subscales indicate higher anxiety levels for that area. Cruise et al. (1985) reported that factor analysis was used to establish construct validity for the instrument, resulting in loadings for the 51 retained items of .50 or greater for the six factors. The authors also reported test-retest reliability for the six factors ranging from .67 to .80, and internal consistency reliabilities ranging from .68 to .94. These six factors may be combined into two overarching factors of *Attitudes* (worth of statistics, computational self-concept) and *Anxiety* (interpretation anxiety, test and class anxiety, fear of asking for help, fear of statistics teachers). In this study, we used the two-factor adaptation of the scale.

The Hebrew version of the Statistics Anxiety Rating Scale (H-STARS) is a shortened version of Cruise et al.'s (1985) original STARS scale. It was adapted to the population of Israeli students and found valid and reliable. The 35-item Hebrew version of STARS is also relating to six distinct subscales. Steinberger (2020) reported internal consistency reliability values that ranged from 0.80 to 0.94 and were consistent with those reported by Cruise et al. (1985). Following the authors' recommendation, the calculation of the overall score was conducted by averaging all the questionnaire items so that the higher the score, the higher the level of anxiety. No items were reverse coded.

In this study, only 30 items from the Hebrew version were used. This is because students in a basic statistics course are not familiar with the SPSS (Statistical Package for Social Sciences) and do not know how to rFinalltead data output. The eliminated items are: 8. "Interpreting the meaning of the results I obtained in my research assignment," 9. "Encoding statistical data into the computer," 12. "asking one of your lectures for help in understand an SPSS output," 13. "seeing a student poring over the SPSS output related to his research," 16. "asking a fellow student for help in understanding an SPSS output." In addition, for item number 29 ("I don't understand why people studying education need statistics"), we made an adjustment from learning education to learning psychology. We used two

subscales that derive from this questionnaire, Attitudes and Anxiety, as explained in further detail in the results. Internal consistencies of these subscales were .94 for Attitudes and .91 for Anxiety.

4. RESULTS

Two hundred and eight psychology undergraduate students participated in this study. Of them, 75 stated that they had an ADHD diagnosis. Sample demographics and a comparison between the study groups are presented in Table 1, where numeric data are presented as *M(SD)* and categorical data are presented as *N(%)*. We found that students with ADHD were significantly older than their peers with no diagnosis of ADHD. We also found that students with ADHD tended to take lower-level math exams for their high school finals. However, math exam level was not considered as a possible covariate because we believe that it is a different manifestation of our outcome variable.

Table 1. Sample demographics and group comparison

	ADHD (n = 75)	Non-ADHD (n = 133)	Test statistic
Gender (woman)	61 (83%)	112 (85%)	$\chi^2(1) = 0.43$
Math exam level			
3 units	42 (56%)	55 (41%)	$\chi^2(2) = 6.1$*
4 units	28 (37%	56 (42%)	
5 units	5 (7%)	22 (17%)	
Socio-economic status			
Below average	3 (4%)	5 (4%)	$\chi^2(2) = 1.4$
About average	43 (57%)	87 (65%)	
Above average	28 (39%)	41 (31%)	
Employed (yes)	64 (85%)	113 (85%)	$\chi^2(1)= 0.0$
Age	24.2 (1.9%)	23.5 (1.6%)	$F(1, 206) = 8.1$**
Hours per week spent doing statistics homework	2.2 (1.0%)	2.1 (1.3%)	$F(1, 206) = 0.14$

* $p < .05$ ** $p < .01$

We used the H-STARS questionnaire to evaluate statistics anxiety and attitudes. However, five items (Items 8, 9, 12, 13, 16) that related to using statistical software and interpreting its output were eliminated, as the students who took part in this study had not yet learned to use it. Because of this change, we conducted a two-level confirmatory factor analysis to ascertain the structure of the remaining questions, the first level being Attitudes and Anxiety, and the second level comprised the six subscales of the original questionnaire. Indices showed that the model was not satisfactory ($\chi^2(371) = 877.2$, $p < .01$, NFI =.79, TLI = .85, CFI = .86, RMSEA = 0.083). Following that, we conducted exploratory factor analysis using principal axes factoring with oblimin rotation. Results showed that four items (Items 23, 24, 25, 28) that loaded on the Worth of Statistics factor of the original questionnaire loaded on the Computational Self Concept factor in our analysis. However, both are subscales that belong to the Attitudes factor of the questionnaire, so it had no effect on constructing the Attitudes and Anxiety scales. Additionally, Item 32 of the Attitudes scale and Items 3, 4, and 15 of the Anxiety scale did not load on any factor and therefore were not used in the scale construction. Finally, the resulting scales showed high internal consistency (α = .94 and .91 for Attitudes and Anxiety, respectively). Repeating all subsequent analyses using scales including all items yielded equivalent results.

The correlations (Pearson or Spearman as appropriate) between the demographic characteristics and the main study variables are presented in Table 2, group comparisons are shown in Table 3 and correlations among the study variables are presented in Table 4. Age and gender were significantly related to the outcome variable yet including them in the model as covariates did not affect the results. Group differences were found in self-efficacy, as students who reported having an ADHD diagnosis were lower in self-efficacy than their peers. No other group differences were found. Specifically, no differences were found in their final grade. Thus, Hypothesis 1 was not supported. The final grade was related to the Attitudes subscale only.

Table 2. Correlations between the sociodemographic variables and the main study outcomes

	Achievement SE	STARS Attitudes	STARS Anxiety	Grade
Gender (woman)	-0.01	0.17*	0.34**	-0.12
Math exam level[a]	0.06	-0.24**	-0.08	0.23**
Socioeconomic status[a]	-0.04	-0.05	0.03	0.16*
Employed (yes)	0.01	0.01	0.03	-0.12
Age	-0.10	-0.15	-0.26**	0.23**
Hours per week spent doing statistics homework	-0.10	0.25**	0.21**	-0.06
M(*SD*)	5.1 (0.9)	2.2 (0.9)	3.3 (0.9)	81.4 (11.1)

Note: STARS = Statistics and Anxiety Rating Scale, SE = Self-efficacy, [a] Spearman correlation coefficient, * $p < .05$, ** $p < .01$

Table 3. Group differences in the study variables

	ADHD ($n = 75$)	Non-ADHD ($n = 133$)	$F(1, 206)$	Cohen's *D*
SE	4.8 (0.9)	5.3 (0.8)	13.9**	0.54
STARS attitudes	2.3 (0.9)	2.1 (0.8)	0.9	0.14
STARS anxiety	3.4 (0.8)	3.3(0.8)	0.6	0.14
Grade	82.5 (9.7)	80.8 (11.9)	1.2	0.16

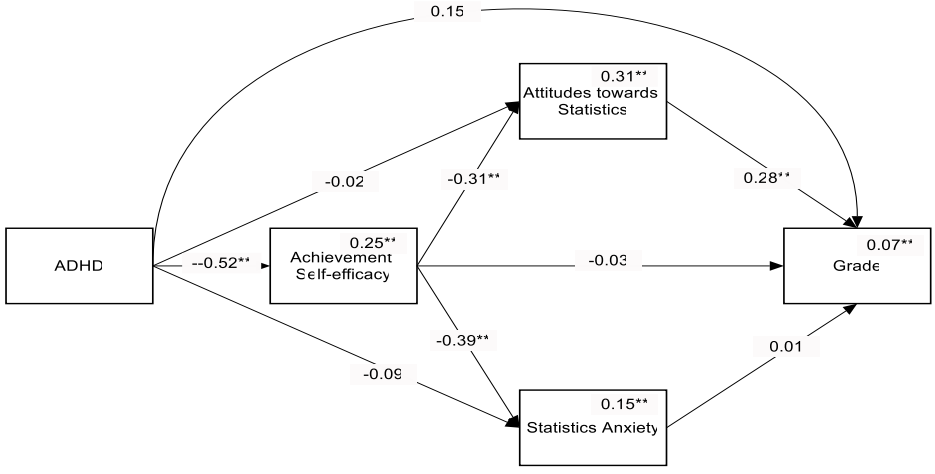
Note. Values are *M*(*SD*). STARS = Statistics and Anxiety Rating Scale, SE = Self-efficacy, ** $p < .01$

Table 4. Correlation coefficients among the study variables

	STARS Attitudes	STARS Anxiety	Grade
SE	-.31**	-.38**	.05
STARS Attitudes		.56**	-.26**
STARS Anxiety			-.13
Grade			

Note. STARS = Statistics and Anxiety Rating Scale, SE = Self-efficacy, ** $p < .01$

We tested our mediation model using Process Model 81. The final model is described in Figure 2. Results show a significant indirect effect of ADHD on the final course grade through self-efficacy and Attitudes towards statistics (β = -0.045, $p < .05$, 95% CI = [-0.1, -0.01]). No significant indirect path was found through Anxiety. Thus, Hypothesis 2 was partially supported.



Note. The numbers above the direct links are standardized regression coefficients. Numbers inserted above variable names are multiple squared correlations. * $p < .05$, ** $p < .01$

Figure 2. Mediation model

5. DISCUSSION

This study tested the possible underlying mechanism linking ADHD and academic achievements. Specifically, we were interested in the role of self-efficacy and statistics anxiety as mediators of this link. Our findings show that though students with ADHD eventually have the same academic achievements as their non-ADHD peers, the underlying mechanism leading to these achievements hides crucial psychological differences. An indirect effect shows that students with ADHD have less confidence in their ability to complete their academic tasks, leading to negative attitudes towards statistics and, consequently, lower grades.

Past research has shown that having ADHD may impair academic achievements (e.g., DuPaul et al., 2021), as well as their self-efficacy (Christiensen et al., 2011). High self-efficacy, in turn, was found to correlate with better academic accomplishments (Finnely & Schraw, 2003). Doménech-Betoret et al. (2017) found that motivational factors may account for the link between self-efficacy and test performance. The unique contribution of our study to this body of knowledge is first and foremost in bringing these factors together into a single model. This model addresses the overall mechanism that places ADHD together with known risk and protective factors and may be used as a basis for interventions and study programs that may aid in bridging the gap between students with ADHD and their peers. Secondly, we tackled the issue of what motivational factors can be the link between self-efficacy and performance in the specific setting of statistics courses. We showed what role the attitudes towards statistics and the statistics anxiety have in affecting academic performance. While course lecturers cannot treat ADHD directly—that remains solely in the hands of the students and their medical professionals—these findings suggest that course lecturers may be capable of positively impacting these students as the factors mediating their performance are, to some extent, manageable by instructors. We found little research that combined the study of ADHD with attitudes towards statistics and academic performance, specifically in the setting of an academic course in statistics.

The study by Lipka and Hess (2016) examined the effectiveness of a support course in improving attitudes toward statistics among post-secondary students with learning disabilities (LD) and/or attention deficit hyperactivity disorder (ADHD). The participants were 22 third-year students training to be teachers, all diagnosed with LD and/or ADHD. They were enrolled in an online statistics course and attended a weekly support course designed with evidence-based pedagogical methods. The results showed significant improvements in students' affective experience of learning statistics, their self-assessment of cognitive competence, and their perceived value of statistics after the support course. However, their perception of the difficulty of statistics did not change significantly. This study highlighted the importance of addressing attitudinal factors for at-risk student groups and providing targeted instructional support to foster more positive attitudes toward challenging subjects like statistics.

Such an intervention was suggested by Kadosh et al. (2023) in their study, the researchers sought to evaluate the impact of a teaching intervention in an undergraduate psychology statistics course. Several key findings underscore the intricate interplay among these variables. The intervention aimed to enhance students' statistics-related academic self-efficacy, alleviate statistics test anxiety, and ultimately enhance their course grades. The results revealed a noteworthy decrease in test anxiety within the intervention group by the course's conclusion. Moreover, compared to the control group, the intervention group exhibited significantly higher levels of academic self-efficacy and achieved superior final course grades. These findings underscore the pivotal role of these interconnected factors in shaping students' performance and learning experiences in statistics.

The above finding poses a challenging question, as no differences were found between the two groups in the final course grade. Previous research investigating the academic performance of students with ADHD has yielded mixed findings, with some studies reporting lower grades compared to their non-ADHD peers, while others have found no significant differences (Gray et al., 2016). These discrepancies highlight the need for further investigation into the underlying factors that may mediate or moderate the relationship between ADHD and academic achievement in statistics courses.

It may be speculated that some compensating mechanism helps students with ADHD overcome their initial setback. This compensation may be attributed to external sources such as Ritalin usage,

special exam conditions, etc., which we did not address or collect data about in this study. Our findings suggest that this compensation addresses the endpoint, yet it does not remedy the internal aspects of having ADHD—lower self-efficacy. A recent review study by Arnold et al. (2020) showed that children with ADHD can benefit from certain medications.

Further research is required to pinpoint the attenuating variables that may be hidden in this model and elevate the achievements of students with ADHD to those of their peers. It may also be that some students who were included in the control group were unaware of having ADHD as they were never officially tested and diagnosed. In addition, as the factors linking ADHD to performance are revealed, more effort should be invested in creating tailor-made programs aimed at enhancing the students' self-confidence, presenting the value of statistics to them and improving their overall attitudes towards the course material and the general topic of statistics.

Interestingly, no direct paths were found between ADHD and attitudes towards statistics or statistics anxiety. This may further highlight the important role of self-efficacy as a key factor in shaping the attitudes and anxiety. It seems that the attitudes and anxiety are derived from self-efficacy and that self-efficacy is not necessarily a stand-alone factor characterizing students with ADHD.

It should be noted that a finding that applies to students both with and without ADHD diagnosis and that deserves attention is that attitudes towards statistics play a role in this mechanism, while anxiety does not. Furthermore, additional analysis done to address this question showed that Anxiety scores were significantly higher than Attitude scores ($F(1, 197) = 370.2$, $p < .001$). This finding indicates that although the students feel anxiety more than negative attitude, negative attitude is the factor that is related to their achievements. It may indicate the need to emphasize the importance of statistics in research as well as in daily life to the students. This can be done by incorporating current, real-life examples of using statistics as well as examples related to the student's specific field of study. An example of such activity for high school students is presented by Huynh et al. (2014).

6. CONCLUSIONS

Students with ADHD have lower self-efficacy as compared to their peers, which leads to negative attitudes towards statistics and, in turn, lower achievement. It is important to strengthen self-efficacy among students with ADHD. To that effect, teachers can include supervised tasks in class that supply students with academic accomplishments and proof of their ability to handle the course's requirements. Moreover, all students may benefit from having better attitudes towards statistics, and teachers should address this issue when compiling the course material.

In summary, our study contributes to the existing research in that it highlights possible issues to be addressed in order to assist students with ADHD, and thus possibly enhancing the inclusion of other populations facing academic challenges. It calls for strengthening the understanding of the how and the why of learning statistics beyond the textbook formulae.

This study is not without limitations. It was conducted within a particular class of students. ADHD diagnoses were not verified and classification relied on self-report. Furthermore, no information was obtained regarding the use of medication among students with ADHD. Additionally, the outcome measure was obtained from the course's final exam and may have been affected by the students' high stress levels. Finally, the cross-sectional nature of our sample prevented us from inferring causality.

We see several possibilities for future research. Future research may include more detailed documentation regarding both the diagnosis and the handling of ADHD, specifically the use of medication. Interventions for improving self-efficacy should be tested, as should the effect of introducing examples that correspond to the students' everyday life or to their discipline of interest. Studies should include other populations in order to determine generalizability. Different outcome measures and means of testing statistics knowledge should also be assessed.

ACKNOWLEDGEMENTS

We wish to thank Shira Shiloah for her help in obtaining the data.

REFERENCES

Almasi, N. G. (2016). The comparison of self-efficacy dimensions in ADHD and normal students. *Open Journal of Medical Psychology*, *5*(04), 88–91. https://doi.org/10.4236/ojmp.2016.54010

Arnold, L. E., Hodgkins, P., Kahle, J., Madhoo, M., & Kewley, G. (2020). Long-term outcomes of ADHD: Academic achievement and performance. *Journal of Attention Disorders*, *24*(1), 73–85. https://doi.org/10.1177/1087054714566076

Bandalos, D. L., Yates, K., & Thorndike-Christ, T. (1995). Effects of math self-concept, perceived self-efficacy, and attributions for failure and success on test anxiety. *Journal of Educational Psychology*, *87*(4), 611–623. https://doi.org/10.1037/0022-0663.87.4.611

Bandura, A. (1997). *Self-efficacy: The exercise of control. W. H. Freeman.*

Barkley, R. A., Murphy, K. R., & Fischer, M. (2008). *ADHD in adults: What the science says*. Guilford Press.

Bartoli, F., Callovini, T., Cavaleri, D., Cioni, R. M., Bachi, B., Calabrese, A., Moretti, F., Canestro, A., Morreale, M., Nasti, C., Palpella, D., Piacenti, S., Nacinovich, R., Riboldi, I., Crocamo, C., & Carrà, G. (2023). Clinical correlates of comorbid attention deficit hyperactivity disorder in adults suffering from bipolar disorder: A meta-analysis. *Australian & New Zealand Journal of Psychiatry*, *57*(1), 34–48. https://doi.org/10.1177/00048674221106669

Benson, J., Bandalos, D., & Hutchinson, S. (1994). Modeling test anxiety among men and women. *Anxiety, Stress, & Coping*, *7*(2), 131–148. https://doi.org/10.1080/10615809408249340

Chew, P. K. H., & Dillon, D. B. (2014). Statistics anxiety update: Refining the construct and recommendations for a new research agenda. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science*, *9*(2), 196–208. https://doi.org/10.1177/1745691613518077

Chiesi, F., & Primi, C. (2009). Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes toward Statistics *(*SATS*). Learning and Individual Differences*, *19*(2), 309–313. https://doi.org/10.1016/j.lindif.2008.10.008

Chiesi, F., Primi, C., & Carmona, J. (2011). Measuring statistics anxiety: Cross-country validity of the Statistical Anxiety Scale (SAS). *Journal of Psychoeducational Assessment*, *29*(6), 559–569. https://doi.org/10.1177/0734282911404985

Cheng, P.-Y., & Chiou, W.-B. (2010). Achievement, attributions, self-efficacy, and goal setting by accounting undergraduates. *Psychological Reports*, *106*(1), 54–64. https://doi.org/10.2466/PR0.106.1.54-64

Christensen, D., Barnes, J., & Rees, D. (2011). Improving the writing skills of accounting students: An experiment. *Journal of College Teaching & Learning (TLC)*, *1*(1). https://doi.org/10.19030/tlc.v1i1.1902

Cruise, R. J., Cash, R. W., & Bolton, D. L. (1985). Development and validation of an instrument to measure statistics anxiety. *Proceedings of the Joint Statistical Meetings: Section on Statistical Education* (pp. 92–97*)*. American Statistical Association.

Doménech-Betoret, F., Abellán-Roselló, L., & Gómez-Artiga, A. (2017). Self-efficacy, satisfaction, and academic achievement: The mediator role of students' expectancy-value beliefs. *Frontiers in Psychology*, *8*, Article 1193. https://doi.org/10.3389/fpsyg.2017.01193

DuPaul, G. J., Gormley, M. J., Anastopoulos, A. D., Weyandt, L. L., Labban, J., Sass, A. J., Busch, C. Z., Franklin, M. K., & Postler, K. B. (2021). Academic trajectories of college students with and without ADHD: Predictors of four-year outcomes. *Journal of Clinical Child & Adolescent Psychology*, *50*(6), 828–843. https://doi.org/10.1080/15374416.2020.1867990

Emmioğlu, E., & Capa-Aydin, Y. (2012). Attitudes and achievement in statistics: A meta-analysis study. *Statistics Education Research Journal*, *11*(2), 95–102. https://doi.org/10.52041/serj.v11i2.332

Finney, S. J., & Schraw, G. (2003). Self-efficacy beliefs in college statistics courses. *Contemporary Educational Psychology*, *28*(2), 161–186. https://doi.org/10.1016/S0361-476X(02)00015-2

Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Towards an assessment framework. *Journal of Statistics Education*, *14*(3), Article 2. https://doi.org/10.1080/10691898.1994.11910471

Gormley, M. J., DuPaul, G. J., Weyandt, L. L., & Anastopoulos, A. D. (2019). First-year GPA and academic service use among college students with and without ADHD. *Journal of Attention Disorders*, *23*(14), 1766–1779. https://doi.org/10.1177/1087054715623046

Gray, S. A., Fettes, P., Woltering, S., Mawjee, K., & Tannock, R. (2016). Symptom manifestation and impairments in college students with ADHD. *Journal of Learning Disabilities*, *49*(6), 616–630. https://doi.org/10.1177/0022219415576523

Gundlach, E., Richards, K. A. R., Nelson, D., & Levesque-Bristol, C. (2015). A comparison of student attitudes, statistical reasoning, performance, and perceptions for web-augmented traditional, fully online, and flipped sections of a statistical literacy class. *Journal of Statistics Education*, *23*(1), Article 3. https://doi.org/10.1080/10691898.2015.11889723

Hanoch, Y., & Vitouch, O. (2004). When less is more. *Theory & Psychology*, *14*(4), 427–452. https://doi.org/10.1177/0959354304044918

Honicke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review*, *17*, 63–84. https://doi.org/10.1016/j.edurev.2015.11.002

Huynh, M., Baglin, J., & Bedford, A. (2014). Improving the attitudes of high school students towards statistics: An island-based approach. In K. Makar & R. Gould (Eds.), *Sustainability in statistics education.* Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9), Flagstaff, Arizona. https://icots.info/9/proceedings/pdfs/ICOTS9_9G2_HUYNH.pdf

Kadosh, M., Hen, M., & Ferrari, J. R. (2023). Reducing statistics anxiety and academic procrastination among Israeli students: A pilot program. *Teaching Statistics*, *45*(3), 167–175. https://doi.org/10.1111/test.12356

Köseoğlu, Y. (2015). Self-efficacy and academic achievement: A case from Turkey. *Journal of Education and Practice*, *6*(29), 131–141.

Lai Mooi, T. (2006). Self-efficacy and student performance in an accounting course. *Journal of Financial Reporting and Accounting*, *4*(1), 129–146.

Lane, J., & Lane, A. (2001). Self-efficacy and academic performance. *Social Behavior and Personality: An International Journal*, *29*(7), 687–693. https://doi.org/10.2224/sbp.2001.29.7.687

Lesser, L. M., & Reyes, R. (2015). Student reactions to the integration of fun material in a high-anxiety subject: A case study in the teaching of college introductory statistics. *Transformative dialogues: Teaching and Learning Journal*, *8*(1), Article 5. https://journals.psu.edu/td/article/view/1171

Lipka, O., & Hess, I. (2016). Attitudes toward statistics studies among students with learning disabilities. *Numeracy*, *9*(2), Article 7.

Macher, D., Paechter, M., Papousek, I., & Ruggeri, K. (2012). Statistics anxiety, trait anxiety, learning behavior, and academic performance. *European Journal of Psychology of Education*, *27*(4), 483–498. https://doi.org/10.1007/s10212-011-0090-5

Malik, S. (2015). Undergraduates' statistics anxiety: A phenomenological study. *The Qualitative Report*, *20*(2), 120–133. https://doi.org/10.46743/2160-3715/2015.2101

Marmolejo-Ramos, F., Gabriel, F., Kariuki, P., Ruiz-Ruano, A. M., Marrone, R. L., Miles, A., Fewster-Young, N., Malgorzata Korolkiewicz, M. & Puga, J. L. (2022, November 25). *Investigating the relationship between statistics anxiety and attitudes towards statistics in three countries.* https://doi.org/10.35542/osf.io/rg4hd

Niflay E. (2003). *Perception of self-worth, intrinsic/extrinsic motivation and achievement goal orientation in the educational context among high school students with learning disabilities and those without learning disabilities.* [Doctoral thesis, Tel Aviv University].

Newark, P. E., Elsässer, M., & Stieglitz, R.-D. (2016). Self-esteem, self-efficacy, and resources in adults with ADHD. *Journal of Attention Disorders*, *20*(3), 279–290. https://doi.org/10.1177/1087054712459561

Onwuegbuzie, A. J., Daros, D. A., & Ryan, J. (1997). The components of statistics anxiety: A phenomenological study. *Focus on Learning Problems in Mathematics*, *19*(4), 11–35.

Onwuegbuzie, A. J. (2004). Academic procrastination and statistics anxiety. *Assessment & Evaluation in Higher Education*, *29*(1), 3–19. https://doi.org/10.1080/0260293042000160384

Perepiczka, M., Chandler, N., & Becerra, M. (2011). Relationship between graduate students' statistics self-efficacy, statistics anxiety, attitude toward statistics, and social support. *The Professional Counselor*, *1*(2), 99–108. https://doi.org/10.15241/mpa.1.2.99

Posner, J., Polanczyk, G. V., & Sonuga-Barke, E. (2020). Attention-deficit hyperactivity disorder. *The Lancet, 395*(10222), 450–462. https://doi.org/10.1016/S0140-6736(19)33004-1

Prevatt, F., & Young, J. L. (2014). Recognizing and treating attention-deficit/hyperactivity disorder in college students. *Journal of College Student Psychotherapy*, *28*(3), 182–200. https://doi.org/10.1080/87568225.2014.914825

Ramirez, C., Schau, C., & Emmioğlu, E. (2012). The importance of attitudes in statistics education. *Statistics Education Research Journal*, *11*(2), 57–71. https://doi.org/10.52041/serj.v11i2.329

Riboldi, I., Crocamo, C., Callovini, T., Capogrosso, C. A., Piacenti, S., Calabrese, A., Lucini Paioni, S., Moretti, F., Bartoli, F., & Carrà, G. (2022). Testing the impact of depressive and anxiety features on the association between attention-deficit/hyperactivity disorder symptoms and academic performance among university students: A mediation analysis. *Brain Sciences*, *12*(9), Article 1155. https://doi.org/10.3390/brainsci12091155

Schau, C., Millar, M., & Petocz, P. (2012). Research on attitudes toward statistics. *Statistics Education Research Journal*, *11*(2), 2–5. https://doi.org/10.52041/serj.v11i2.324

Schau, C., Stevens, J., Dauphinee, T. L., & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes Toward Statistics. *Educational and Psychological Measurement, 55*(5), 868–875

Ubaka, C. M., Sansgiry, S. S., & Ukwe, C. V. (2015). Cognitive determinants of academic performance in Nigerian pharmacy schools. *American Journal of Pharmaceutical Education*, *79*(7), Article 101. https://doi.org/10.5688/ajpe797101

Vigil-Colet, A., Lorenzo-Seva, U., & Condon, L. (2008). Development and validation of the statistical anxiety scale. *Psicothema*, *20*(1), 174–180.

Weyandt, L. L., & DuPaul, G. J. (2013). *College students with ADHD: Current issues and future directions*. Springer. https://doi.org/10.1007/978-1-4614-5345-1

Williams, A. S. (2013). Worry, intolerance of uncertainty, and statistics anxiety. *Statistics Education Research Journal*, *12*(1), 48–59. https://doi.org/10.52041/serj.v12i1.321

Williams, A. S. (2015). Statistics anxiety and worry: The roles of worry beliefs, negative problem orientation, and cognitive avoidance. *Statistics Education Research Journal*, *14*(2), 53–75. https://doi.org/10.52041/serj.v14i2.261

Wise, S. L. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement, 45*(2), 401–405.

Zare, H., Rastegar, A., & Hosseini, S. M. D. (2011). The relation among achievement goals and academic achievement in statistics: The mediating role of statistics anxiety and statistics self-efficacy. *Procedia: Social and Behavioral Sciences*, *30*, 1166–1172. https://doi.org/10.1016/j.sbspro.2011.10.227

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, *29*(3), 663–676. https://doi.org/10.3102/00028312029003663

Zimmerman, W. A., & Austin, S. R. (2018). Using attitudes and anxieties to predict end-of-course outcomes in online and face-to-face introductory statistics courses. *Statistics Education Research Journal*, *17*(2), 68–81. https://doi.org/10.52041/serj.v17i2.159

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