ADHD and Cognitive Self-Regulated Learning Strategies: The Role of Executive Functions

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PSB3E-BT15: Bachelor Thesis

Group number: 10

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April 28, 2023

Abstract

Attention Deficit Hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by behavioural and cognitive difficulties. Executive functions (EF) are a set of cognitive abilities research has extensively linked to ADHD, with EF levels being significantly lower in people with ADHD. Self-Regulated Learning (SRL) refers to the self-regulated pursuit of academic achievements, and is another factor associated with ADHD, with lower levels of SRL use being a prominent characteristic in ADHD populations, and is closely related to EF due to overlapping cognitive processes. The present study utilised the dimensional conceptualisation of ADHD to investigate the relation between ADHD and SRL. The influence EF has on this relationship was investigated. Our secondary analysis investigated the relation between ADHD symptom domains (inattentive, hyperactive/impulsive) and SRL. A sample of students from the University of Groningen (N=160) were recruited to participate in this study. Self-report measures of ADHD, EF, and SRL were utilised. Results found a negative relation between ADHD and SRL, with EF acting as a significant mediating factor in this relation. Secondary analysis identified inattentive type symptoms as significantly negatively related to SRL but failed to find a significant relation between hyperactive/impulsive symptoms and SRL. Strengths, Limitations, and directions for future research are discussed.

Keywords: ADHD, Executive Functions, Self-Regulated Learning, Dimensional Approach.

ADHD and Cognitive Self-Regulated Learning Strategies: The Role of Executive Functions

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterised by behavioural deficits in the domains of hyperactivity, impulsivity, and inattention (American Psychiatric Association, 2013). The onset of ADHD symptoms occurs in early childhood, and recent evidence suggests that this disorder persists into adulthood, with an estimated prevalence of 2.18% in adulthood (Asherson, 2016; Dobrosavljevic, 2020; Rocco, 2022). ADHD is best conceptualised as a heterogenous disorder, being highly comorbid with other disorders such as anxiety, depression, and bipolar disorder (Bain, 2019; Schiweck, 2021). ADHD is further categorized into three subtypes, namely: Inattentive type, hyperactive/impulsive type, and combined type, each reflecting their respective patterns of symptoms. For example, difficulties maintaining attention and organising tasks are symptoms reflective of inattentive type ADHD, whereas fidgeting and excessive speech are hyperactive/impulsive type symptoms, and the combined subtype reflects a myriad of both symptom types. Inattentive type ADHD is shown to be more reflective of cognitive difficulties than hyperactive/impulsive type (Molavi, 2020; Vahid, 2012). Furthermore, research suggests that inattentive type ADHD is highly prevalent in adult ADHD populations, suggesting that the cognitive difficulties capsulated by the inattentive symptom domain may play a central role in the persistence of ADHD (Gibbins, 2012; Pazvantoğlu, 2012; Wilens, 2009; Vitola, 2017).

Given the nature of the behavioural symptoms of ADHD and the effects of comorbid disorders, it's no surprise that the quality of life in people diagnosed with ADHD is often significantly compromised (Krauss, 2022; Sjöwall, 2022). For example, the lack of organisational and planning skills in ADHD may lead to difficulties in organising doctors' appointments, social gatherings, bill payments, etc. Academic performance is one area of

daily life where impairments as a result of ADHD are particularly salient, with students that have ADHD often experiencing difficulties in their academic endeavours, such as having lower achievement levels, extracting lower GPAs than their peers, and being less likely to complete their studies successfully (Arnold, 2020; DuPaul, 2021; Tan, 2022). Furthermore, research has provided evidence that inattentive type ADHD is more predictive of academic difficulties than hyperactive/impulsive type, a logical connection considering the correlates between inattentive type ADHD and cognitive symptoms (Norwalk, 2009; Wolf, 2009). Conducting specific research into the underlying causes of academic difficulties in ADHD populations is vital in order to improve interventions and gain a greater understanding of the disorder.

Executive Functions

Barkley (1977) proposed a model of ADHD which suggests that executive functions, specifically response inhibition, are the primary causes of the neuropsychological deficits found in ADHD, and may be one such factor contributing to the academic difficulties observed in people with ADHD. Executive functioning (EF) is an overarching term for higher order cognitive processes involved in regulating adaptive behaviours in the pursuit of specific goal states and includes aspects such as response inhibition, set shifting, and strategic planning/monitoring (Spinella, 2005). Research seems to complement Barkley's hypothesis, with various studies demonstrating that significant EF impairments are present in ADHD populations (Boonstra, 2006; Doyle, 2006; Salomone, 2020). However, this conclusion is not without its drawbacks, as not all instances of ADHD are accompanied by EF impairments (Doyle, 2006), and the comorbidity and variability of ADHD make it extremely difficult to attribute all symptomology to a single underlying cause (Kofler, 2019), so it is more likely that response inhibition is indeed an important causal aspect, but certainly not the only one. Given the cognitive nature of EF, it's unsurprising that it is related to several aspects of

academic performance, particularly in the area of mathematics, with low EF levels being a potential risk factor for academic disturbances (Tamm, 2021; Zelazo, 2020). Another potential risk factor for academic disturbances is the self-regulated learning (SRL) strategies students employ (Pintrich, 1995). SRL refers to the cognitive and motivational strategies one undertakes to achieve academic goals. Given the cognitive nature of SRL, it is unsurprising that this factor is related to EF levels (Garner, 2009).

Self-regulated Learning

Self-regulated learning (SRL) refers to the goal oriented, self-directed behaviours one employs to achieve an end goal state, a vital aspect contributing to successful academic endeavours (Pintrich, 1995). SRL includes three areas of engagement, namely; motivational aspects, cognitive, and metacognitive aspects. For the purpose of this paper, we will group cognitive and metacognitive areas under the same umbrella term of cognitive aspects, which includes aspects such as rehearsal, elaboration, and organisation. Research suggests that SRL correlates positively with academic achievement, and students can be distinguished by their SRL strategies (Dent, 2016; Vanderstoep, 1997). At face value, SRL appears to have a similar operational definition as general EF (i.e. higher order processes involved in goal achievement), however, research suggests that these aspects are fundamentally different and are better conceptualised as differing aspects with areas of significant convergence and divergence, with certain areas of EF (impulse control, planning, and motivational drive) being strong predictors of cognitive/metacognitive strategy use (Garner, 2009). Areas of divergence between EF and SRL found by Garner (2009) included the attributional and affective components of SRL.

Research examining the relation between SRL and ADHD is scarce, with the limited research suggesting a possible negative correlation between these factors (Reaser, 2007; Shelton, 2019). Interestingly, Shelton (2019) found differences between the two symptom

domains of ADHD (inattentive and hyperactive/impulsive) on SRL. Inattentive type ADHD had a moderate negative correlation with SRL, as is consistent with previous findings. However, it was found that hyperactive/impulsive symptoms had a low positive correlation with SRL, even when controlling for confounding variables. Shelton suggests that this finding may point to the possibility that hyperactive/impulsive symptoms of ADHD act as some sort of protective factor for SRL deficits in ADHD. These findings are promising, but further replication is needed.

The Present Study

The present study aims to investigate the relation between ADHD levels and the use of cognitive SRL strategies, and how EF levels may interact with this relation. Self-report measures will be utilised to quantify our variables, and correlational analysis will be used to explore the aforementioned associations. This study will also be operationalising the dimensional approach to ADHD. Our understanding of ADHD has been improving throughout the years, and research suggests that this disorder is better understood in a dimensional manner, i.e. on a spectrum (McLennan, 2016). In clinical practice, the dimensional approach has the advantage of assisting practitioners in the accurate diagnosis of ADHD in the presence of complex comorbid interactions, particularly in adult ADHD (Katzman, 2017). In research, the dimensional approach allows the inclusion of participants who may have been below the categorical threshold of an ADHD diagnosis, thus greatly increasing the generalisability of results. This gives us the advantage in our study to examine ADHD symptomology at differing severity levels, without the necessity of an actual ADHD diagnosis. This perspective is in contrast to the current DSM diagnostic criteria for ADHD, which adopts the categorical approach (American Psychiatric Association, 2013). Thus, expanding the literature using this approach will add validity to the approach.

The primary aim of the present study is twofold. (1) We aim to investigate the degree of association between ADHD and the cognitive measures of SRL. Based on the observed interactions between these variables, a negative correlation is expected (Reaser, 2007). We chose to focus on the cognitive aspects of SRL due to the prominence of cognitive dysfunction in academic achievement among the ADHD population, and the centrality of cognitive dysfunction in general in adult ADHD populations (e.g. Vitola, 2017). (2) We aim to examine the role EF levels play in any observed interaction between ADHD and the cognitive aspects of SRL. Due to the higher order cognitive nature of EF, and the prominence of EF deficits in the ADHD population, we expect EF to play a significant role in this interaction.

As a secondary objective, we aim to replicate the results obtained by Shelton (2019) relating to the interaction between the ADHD symptom domains and SRL. Shelton utilised a factor analysed version of the MSLQ which included both cognitive and motivational aspects capsulated by three scales, namely; Expectancy, Value, and Self-Regulation. Shelton presented their results in the context of SRL as a whole, as correlations between symptom domains and each of the three scales were statistically significant and consistent. Thus, we examined participants' total scores on the MSLQ (both cognitive and motivational aspects), assessing SRL as a whole, in order to obtain more comparable results. As we cannot distinguish between diagnoses of ADHD subtypes in our study, we will focus on the degree of symptomology related to aspects reflective of their respective diagnostic subtypes. Based on Shelton's (2019) findings, we expect to see a negative correlation between inattentive symptoms and SRL, with a small positive correlation between Hyperactive/impulsive symptoms of ADHD and SRL.

Methods

Participants

Data for this study was obtained from a sample of first year psychology students from the University of Groningen. Data was collected by utilising two surveys which were administered at two separate times. Only participants who completed both surveys were included in the analysis. In the first part of the study, 303 people participated. Of this group, 257 people also participated in the second part of the study. Altogether, 58 of the participants that participated in both surveys were removed from the analysis due to incomplete questions or they were younger than the exclusion age of 18. The final sample consisted of 160 participants with ages ranging from 18 to 35 years old *(M = 19.73, SD = 2.07)*. Of these participants, 128 identified as female, 32 identified as male.

Participants for this study were recruited through SONA, an online research platform where students can participate in scientific research in exchange for credits, as part of the practical introduction to research methods course. Students participating in this course were invited to participate in scientific studies conducted by the university, or complete essay assignments as an alternative assessment method if they chose not to partake in scientific studies. To participate in this study, participants had to be at least 18 years of age, and enrolled in the course 'Introduction to Psychology', as their grades obtained on this course were used for further research, and the questions MSLQ survey referred specifically to this course. Before participating, all participants were informed of their rights, confidentiality of their data, and were given an outline of the study. They were then asked for their informed consent, based on this information. Before recruitment took place, the study was approved by the Ethics Committee of the Psychology Department of the University of Groningen (PSY-2021-S-0054).

Research design and procedure

The present study implemented a correlational design, and investigates the relation between levels of ADHD symptoms, executive functioning and cognitive self-regulated learning strategies through the use of quantitative analysis methods. As such, we made no predictions about the causality of these associations. A correlational analysis was chosen in order to reflect on the dimensional nature of the studied variables. This approach allowed us to quantify severity of ADHD symptoms, and include participants who would not have met the diagnostic criteria for ADHD, thus increasing relevance to the wider ADHD population than in a clinical study.

Data was collected through the online questionnaire platform Qualtrics, which participants were redirected to after signing up for the study through SONA, using their university login information.

Participants were redirected to Qualtrics, where they completed multiple surveys measuring their executive functioning and asking them about the learning strategies they typically employ while studying. Jointly, the two surveys consisted of the CAARS, EFI, and MSLQ self-report questionnaires (see Measures). The total time needed to complete the study is estimated to be around 60 minutes for the first part and 40 minutes for the second part, for which participants are compensated with SONA credits. The study was available on SONA from January 25 until February 14 2023. Participants were free to sign up for and complete the study at any time within this period.

Measures

CAARS

The Conners' Adult ADHD Rating Scales (CAARS) is used to measure the ADHD-symptoms. The CAARS is a self-rating scale intended for adults aged 18 and up who present with ADHD-symptoms (Conners et al., 1998). It makes use of a four-point Likert scale (0 =

never; 1 = occasional; 2 = often; 3 = very often). The CAARS consists of two types of forms, a self-report rating and an observer rating. For this study the long version of the self-report CAARS (CAARS-S:L) was used. This list consists of 66 items which represent nine different subscales. The long form of the CAARS will take most adults approximately less than 30 minutes. If participants finish the questionnaire within 10 minutes, a haphazard response can be expected.

Four of these subscales test for the behavioural symptoms of ADHD: 1. Inattention/Memory Problems (12-item); 2. Hyperactivity/Restlessness (12-item); 3. Impulsivity/Emotional Lability (12-item); 4. self-concept problems (6-item). For the subscale Inattention/Memory Problems examples of questions are: “I don’t plan ahead.” and “I can’t get things done unless there’s an absolute deadline.”. Examples of questions for the subscale Hyperactivity/Restlessness are: “I like to be doing active things.” and “I can’t sit still for very long.”. Examples of questions from the subscale Impulsivity/Emotional Lability are: “I blurt out things” and “My moods are unpredictable.”. For the subscale problems with Self-Concept example questions are: “I get down on myself.” and “I wish I had greater confidence in my abilities”. The remaining three scales measure ADHD-symptomatology in keeping with the guidelines of the Diagnostic and Statistical Manual of Mental Disorders (APA, 1994): DSM-IV Inattention Symptoms subscale (9-item), DSM-IV Hyperactivity-Impulsivity symptoms subscale (9-item) and the DSM-IV ADHD-symptoms total scale. To report on the total degree of adult ADHD-symptomatology and to assess an individual’s overall risk of being diagnosed with ADHD (Mohamed et al., 2016), the questionnaire uses the ADHD index subscale (12-item). Example questions of the DSM-IV Inattentive Symptoms list are: “I lose things necessary for tasks or activities.” and “I don’t like homework or job activities where I have to think a lot.”. Example questions from the DSM-IV Hyperactive-Impulsive Symptoms are: “I talk too much.” and “I am restless or overactive.”. For the ADHD Index the following

questions are examples of questions included: “I am always on the go, as if driven by a motor.” and “I can’t keep my mind on something unless it’s really interesting.”.

The total score of the CAARS varies between 0 and 198. For the analysis, the raw scores of the CAARS subscales first have to be converted into T-scores, a standard score with a mean of 50 and a standard deviation of 10 across all scales in every sample. Using T-scores help to compare subscale results. The correct gender and age category column will be used.

The CAARS manual dictates that a T-score of 65 or higher fall into the clinically significant range and therefore signals an above average representation of ADHD-symptomatology in an individual (Conners et al., 1998). When the T-score is below 60, it often indicates no ADHD-symptomology. A T-score above 80 can be a possible indicator of invalidity because of exaggeration or malingering of symptoms (Conners et al., 1998; Suhrm et al., 2011). Overall, the higher the T-score, the higher the presented ADHD-symptomatology.

This study has found an alpha of (.959). Other studies have found the alpha of the CAARS self-report measures to fall in between .66 and .90 (Conners et al., 1998). The CAARS questionnaire has shown to have a good internal consistency, acceptable test-retest reliability and holds a high sensitivity towards distinguishing between healthy control groups and individuals diagnosed with ADHD (Christiansen et al., 2012; Erhard et al., 1999). The Total Infrequency Index (CII) for the CAARS-S-L, created to detect possible feigning, has a Cronbach’s alpha of .86. A score of 20 or less occurred in 90.1% of the ADHD group (Suhr et al., 2011). The CII has a general modest sensitivity (30%) and a high specificity (95%) (Wallace & Walls, 2020).

MSLQ

The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, 1993) is a self-report scale used to assess academic motivation and the different learning strategies in

university students. This scale consists of two sections: Motivation scales and Learning Strategies scales, which cover 15 different subscales (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety, Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning and Help Seeking). They are assessed using a seven-point Likert response option format (from 1 = not at all true of me to 7 = very true of me).

The first section assesses motivation with 31 items and asks for goals-value beliefs, control beliefs and self-efficacy. The second section assesses learning strategies includes 31 items to assess different cognitive and metacognitive strategies. This part further includes 19 items to assess for resource management. Examples of questions from the Motivation scale are: “In a class like this, I prefer course material that really challenges me so I can learn new things.” and “Getting a good grade in this class is the most satisfying thing for me right now.”. Examples of questions from the Learning Strategies scales are: “When I study for this class, I practice saying that material to myself over and over.” and “When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.”. Overall, the entire questionnaire takes about 20-30 minutes for completion but it is possible to only administer individual subscales for assessment.

Scales for the MSLQ are constructed by taking the mean of the items making up that scale. The score will be computed by summing up the items and taking the average. The score of the “reversed” items have to be reversed. For example an individual scoring a 1 on an item now receives a 7. A higher score like 4, 5, 6, and 7 is better than a lower score like 1, 2, or 3. Exception is the Anxiety scale where a higher score is more worrying. If the scores on the MSLQ are above 3, the individual is doing well. If the score on the MSLQ is below 3, help may be needed from instructors or services at the institution.

Past research has reported the alpha of the MSLQ to fall in between .52 and .93 (Pintrich et al., 1993). This study has found an alpha of (.894). The MSLQ has so far demonstrated a good reliability of its subscales, as well as reasonably good predictive validity of performance (Pintrich et al., 1993). Given the sample characteristics, the MSLQ is an appropriate and well fit research tool (Davenport, 2003)

EFI

The Executive Function Index Scale (EFI; Spinella, 2005) is a self-assessment scale to measure executive functions used in daily life (Mohamed et al., 2021). It utilizes a five-point Likert scale response format (1 = not at all, to 5 = very much) for 27 items. Those items are representative of five subscales: motivational drive (motivation, energy levels), organization (multitasking, sequencing), impulse control (self-inhibition, propensity for risky behaviour), empathy (interest in the well-being of others, pro-social behaviour), and strategic planning (planning, thinking ahead, making use of strategies) (Spinella, 2005). Questions for this scale include, for example: “I save money on a regular basis” or “I think about the consequences of an action before I do it”.

The total score of the EFI is calculated using the sum of all items. Here, a lower score is indicative of poorer executive functioning. With an increase in score, the executive functioning improves as well (Spinella, 2005).

Different studies have reported the internal consistency to be acceptable (Gwenny et al., 2009; Spinella, 2005). Originally, the reported alpha for the EFI scale falls in between .70 to .82 (Spinella, 2005). In comparison, this study reports an alpha of (.75).

Data Analysis

After extracting the raw data from the Qualtrics software, results from the CAARS, EFI, and MSLQ were analysed. Descriptive statistics were obtained for our data. We conducted assumption checks on the data to assess the validity of our chosen statistical

methods, descriptions of which can be found in the appendix. We extracted six variables from our data based on their respective measures, namely; EFITot, ADHDTot, ADHDIna, ADHDHypImp, MSLQTot, and MSLQCog. In order to assess our first hypothesis we computed the correlation coefficient between ADHD levels and the cognitive measures of SRL. To assess our second hypothesis, we computed the partial regression coefficient between ADHD and Cognitive SRL, controlling for the influence of EF. In order to examine our secondary objective, we utilised the sub scores from the CAARS relating to two symptom domains of ADHD, namely an inattentive type and hyperactive/impulsive type. Partial correlations were calculated for each symptom domain on participants' total MSLQ scores, statistically controlling for their respective counterparts.

Results

Descriptive statistics for participants' scores on the CAARS, EFI, and MSLQ scales were calculated and can be found in Table 1. Assumption checks were conducted on our data, descriptions of which can be found in the appendix. Assumption checks revealed that the CAARS scores deviated slightly from normal, with moderate right skewness (Skewness=0.580). This skewness is further visualised in Figure 1. We decided not to alter the CAARS data as the skewness violation was relatively minor, and the distribution remains close to normal. Furthermore, the CAARS data distribution, as seen in Figure 1, is unimodal and has a broad distribution which is congruent with the dimensional approach to ADHD. Two potential outliers were identified, one in the CAARS data, and one in the MSLQCog data. We decided to leave these potential outliers in the data, as our sample size (N=160) is large enough to reduce the possibility that these outliers are heavily influential on our obtained results. Removing outliers is not in line with the dimensional approach to ADHD, further validating their inclusion.

Table 1

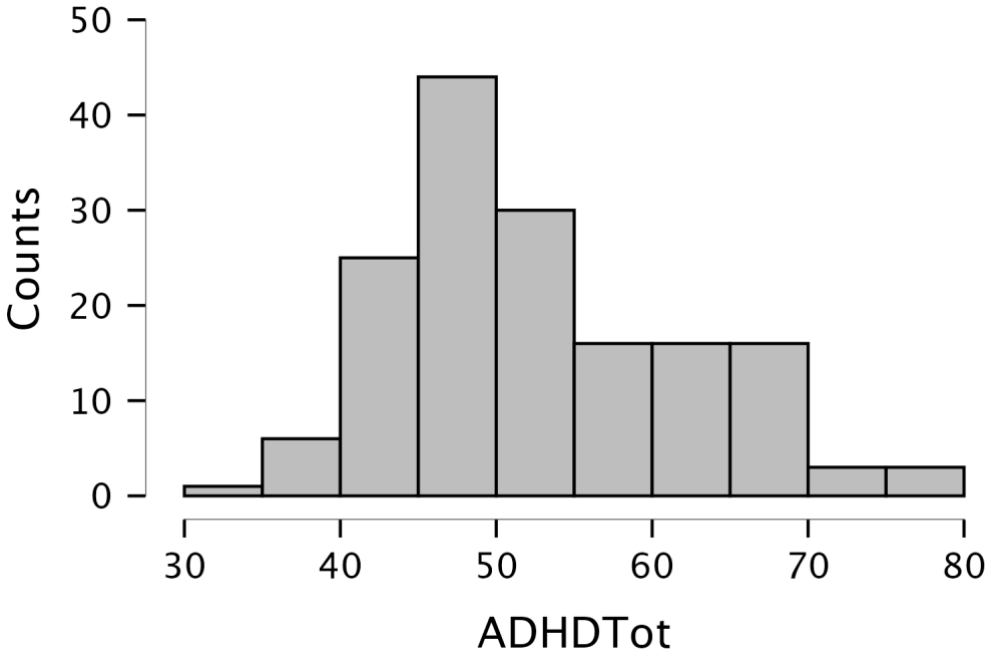
Descriptive Statistics for Scores on the EFI, MSLQ, and CAARS Scales.

	M (SD)	*Range*	*Min-Max*
ADHDTot	52.7(9.39)	45.88	33.75-79.62
ADHDIna	54.21(10.84)	49	34.63-83.65
ADHDHyp/Imp	50.67(8.66)	49.2	34.59-83.74
MSLQCog	4.5 (0.79)	4.16	2.45-6.62
MSLQTot	4.12(0.51)	2.59	2.86-5.46
EFITot	95.6(9.89)	49	72-121

Note. N=160; EFITot= Executive Functioning Index Scale; MSLQTot= Total score for Motivated Strategies for Learning Questionnaire; MSLQCog= Cognitive Measures of the Motivated Strategies for Learning Questionnaire; ADHDTot= Conners Adult ADHD Rating Scales; ADHDIna= Inattentive symptom scores on Conners Adult ADHD Rating Scales, ADHDHypImp= Hyperactive/impulsive symptom scores on Conners Adult ADHD Rating Scales.

Figure 1

Data distribution of ADHDTot Data.



Hypothesis 1: Relation between ADHD levels and cognitive measures of SRL

A correlation matrix examining the relation between ADHD levels and the cognitive measures of SRL can be found in Table 2. A weak negative correlation was found between ADHDTot levels and MSLQCog levels (p=.036). As the scores on the cognitive measures of SRL increase, ADHD severity scores decrease, an association which is visualised in Figure 2. These findings are in line with our hypothesis.

Table 2

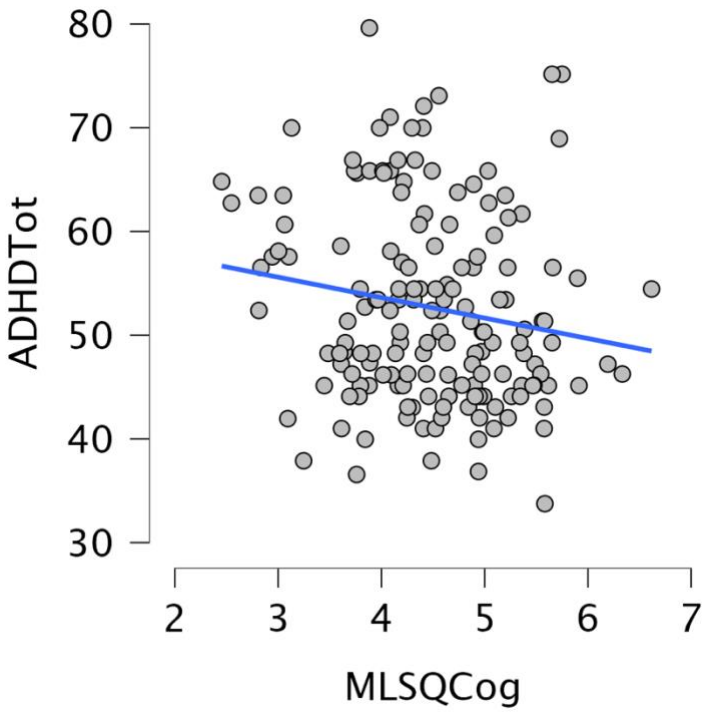
Correlation Matrix For EFI Total, Cognitive measures of SRL, and CAARS Total Scores.

Variable	1	2	3
1. EFITot	-		
2. MSLQCog	.385***	-	
3.ADHDTot	-.518***	-.166*	-

Note. ***P<.001, **P<.01, *P<.05

Figure 2.

Scatter Plot Distribution For ADHDTot and MSLQCog. r=-.166.



Hypothesis 2: The effect EFI has on the observed relation between ADHD and cognitive measures of SRL.

Partial correlations were conducted to assess the extent to which EFI influences the relationship between ADHD levels and the cognitive measures of SRL. The partial correlation on the relation between EFITot and MSLQCog, controlling for ADHDTot levels revealed a significant correlation (r=.354, p=<.001). Thus, EFI is significantly associated with the cognitive measures of SRL, independent of ADHD levels. Partial correlations revealed that when controlling for EFI, the strength of the relation between ADHDTot and MSLQCog is reduced to a point of non-significance (r=.042, p=.596). Thus, when EFI is held constant, the negative relation between ADHD and cognitive measures of SRL is reduced, implying that EFI is indeed a significant mediator in this relation. These results are in line with our hypothesis.

Secondary Question: Correlations between ADHD Subtype Scores and SRL.

Partial correlations were calculated to assess the relations between ADHD symptom domain scores and the total scores of SRL. Partial Correlations between ADHDIna on MSLQTot, controlling for ADHDHypImp, show a significant negative correlation (r=-.250, p=.001). the partial correlation between ADHDHypImp and MSLQTot, controlling for ADHDIna, fails to reveal a significant correlation (r=.057, p=.472) These correlations show that inattentive symptoms of ADHD have a moderate negative association with total scores of SRL, and hyperactive/impulsive symptoms of ADHD does not have a significant correlation with total SRL levels. These results are partly in line with our hypothesis as the negative correlation between MSLQTot and ADHDIna controlling for ADHDHypImp was expected, however, the hypothesised positive correlation between MSLQTot and ADHDHypImp controlling for ADHDIna was not found.

Summary of Results

Our analysis revealed an expected negative correlation between CAARS ADHD scores and MSLQCog levels, with higher scores on the CAARS being associated with lower scores on the MSLQCog. Our analysis also identified EFI as a significant mediator in the relationship between CAARS levels and the cognitive measures of SRL, as was in line with our expectations. When EFI was statistically controlled for, the negative correlation between ADHD and MSLQ became non-significant. Our secondary analysis identified a moderate negative correlation between inattentive type ADHD symptoms and the total scores of MSLQ, however, no significant correlation was found between hyperactive/impulsive type ADHD symptoms and total MSLQ scores, partly confirming our hypothesis.

Discussion

The present study aimed to examine the relation between ADHD symptoms and the cognitive aspects of SRL, whilst investigating the influence EF levels had on this relation. As a secondary objective, this study investigated the relations between ADHD symptom domains and total SRL scores, an aspect seldom addressed in previous research. Results were consistent with our first hypothesis, with higher severity of ADHD symptoms being associated with less efficient cognitive SRL strategy use. Our second hypothesis was also confirmed, with EF levels being identified as a significant contributing factor to the relation between ADHD and cognitive SRL strategies. ADHD symptom domains were observed to have differing degrees of relation to SRL strategies, partly confirming our secondary hypothesis, with the inattentive symptoms of ADHD being moderately negatively related to SRL efficacy, and the hyperactive/impulsive symptoms having no significant correlation with SRL efficacy.

Our first hypothesis aimed to examine the relation between ADHD and the cognitive aspects of SRL. Our findings suggest a negative relation between these two factors exists,

with people scoring high on measures of ADHD utilising less cognitive SRL strategies. This relation was expected based on past research (Shelton, 2019; Reaser, 2007). Thus, it could be possible that people with higher levels of ADHD symptoms have difficulties effectively utilising certain cognitive SRL strategies such as rehearsal, elaboration, and organisation. Cognitive difficulties are a prominent aspect in some people with ADHD (Salomone, 2020) and are thought to partly be the result of EF dysfunctions (Barkley, 1997). Garner (2009) identified certain aspects of EF, as measured by the EFI, to be significant predictors for cognitive SRL utilisation, with higher levels of EF dysfunction relating to lower utilisation of cognitive SRL strategies. Specifically, Garner (2009) identified the EF aspects of planning, impulse control, and motivational drive as significant predictors. Garner identified impulse control and motivational drive as more relevant when predicting SRL levels, as the maintenance and self-regulatory utilisation of these cognitive skills requires deliberation and motivation, particularly in boring/frustrating circumstances. Thus, it could be the case that the EF dysfunctions that are present with ADHD could be the same factors leading to lowered cognitive SRL use in our sample, either due to insufficient underlying cognitive abilities, or lacking the motivation to utilise these abilities.

Dysfunction in the EF aspect of planning could lead to significant difficulties in utilising specific cognitive SRL strategies. Planning is vital in the use of metacognitive self-regulation, which refers to the general awareness and use of cognition. Planning goals and analysing progress is vital in accessing relevant prior knowledge, which can lead to a more detailed comprehension of learning material (Pintrich, 1991). Planning may also be a vital aspect of the organisation SRL strategy. Organisation requires effortful planning of learning goals and outlining of learning material. Someone with dysfunction in planning, for example, may struggle in an academic context due to difficulties utilising effective reading strategies, identifying learning goals/outcomes, or engaging the material with prior knowledge. Thus

dysfunction in planning will lead to greater difficulties utilising metacognitive self-regulation and organisation strategies, which could be one possible factor that led to lowered cognitive SRL levels in our sample. Dysfunction in the EF aspect of impulse control may negatively impact goal directed behaviour in general, and certain cognitive aspects such as working memory and self-regulation (Barkley, 1997). Thus, someone with EF dysfunction may have difficulties with the self-regulation aspect of SRL due to the inability to control situationally inappropriate behaviour, as well as difficulties with the cognitive SRL aspect of rehearsal and elaboration due to the effects of working memory deficits. Garner (2009) also suggests that poor impulse control may result in poor emotional control, decision making, and task completion. As an example, a student with specific impulse control difficulties may have problems regulating cognitive activities such as rehearsing items to be learnt, maintaining sufficient attention on reading tasks, and undertaking class assignments till completion. Thus, lowered impulse control may also contribute to the lowered levels of cognitive SRL observed in our sample.

Our second hypothesis aimed to examine if EF did account for a substantial amount of the variation in the observed relation between ADHD and cognitive SRL strategies, evidence for which can add validity to the claims suggested concerning our first hypothesis. Evidence indeed suggested that EF levels explained a substantial amount of variation in the relation between ADHD and cognitive SRL, with this relation vanishing when EF was controlled for. In other words, when EF levels were "removed" from the equation, the relation between ADHD and cognitive SRL vanished. If an aspect of ADHD independent of EF (such as fidgeting or attention to details) contributed to the lowered use of cognitive SRL strategies, it would be unlikely that the relation would completely disappear when EF was controlled for, thus it is likely that the EF aspects of ADHD contributed to the lowered SRL in our sample. Impulse control, planning, and motivational drive were aspects of EF identified to be

significant predictors of cognitive SRL strategy (Garner, 2009). These factors may be significant mediators as they are related to both ADHD and cognitive SRL, thus may be a good starting point to examine the specific underpinnings of this relation. For example, response inhibition is a prominent aspect of interest in ADHD (Barkley, 1977), as well as being a correlational aspect between EF and SRL, pointing to this aspect as a fruitful avenue for more specific, detailed examination.

Our secondary analysis aimed to explore the two symptom domains of ADHD in relation to both the cognitive and motivational aspects of SRL combined. The findings were partially in line with the limited past research (Shelton, 2019). It was observed that inattentive symptoms were negatively related to SRL strategies, whereas hyperactive/impulsive symptoms had no significant relation to SRL strategies. These findings suggest that the cognitive aspects of ADHD that are captured by the inattentive symptom domain account for a more significant amount of variance than the hyperactive/impulsive domain, in relation to SRL strategy use. Shelton (2019) suggested that the positive correlation between the hyperactive/impulsive symptoms of ADHD and SRL may point to a protective factor of sorts, an aspect which was not found in our study. A possible reason for the discrepancy in findings between the present study and the study conducted by Shelton (2019) may lie in the measures used. Shelton's study utilised a factor analysed version of the MSLQ which included aspects of motivational and cognitive SRL strategies, whereas our study made use of the full version of the MSLQ in relation to our secondary hypothesis. Shelton's study measured ADHD levels using the BAARS-IV, whereas this study used the CAARS. These differing measures may have captured different aspects of the same constructs, which could have led to the observed differing results.

Strengths and Limitations

Our study had several distinct strengths. Firstly, our study had a large sample size (N=160) which has the benefit of greater statistical power. Secondly, Our study utilised validated and reliable measures to quantify our variables, which adds validity to any conclusions made. Finally, our study utilised the dimensional approach to ADHD, which has the advantage of including participants who do not meet the criteria for an ADHD diagnosis, which may increase generalisability to the wider population. The dimensional approach also has the advantage of having a lower influence of ADHD comorbid disorders than in clinical studies.

Several limitations were present in our study, Firstly, our study was correlational in nature, so causal conclusions about these results cannot be reached. Secondly, The present study utilised an online survey environment for the collection of data, thus, it was not feasible to have an experimentally controlled environment, which may have resulted in a large variety of test environments. Although the inaccuracy and validity of responses were measured through embedded checks within the surveys, it is still possible that environmental distractions may have skewed participants' responses, leading to inaccurate measures of participant characteristics. A controlled testing environment would be required to overcome this limitation. Thirdly, We utilised self-report surveys to construct our variables which have certain disadvantages such as the social desirability effect, which refers to a person's motivation to appear socially desirable (Bergen, 2020; Dodou, 2014). This effect, for example, may have led to an over report of EF levels due to participants' desire to appear socially desirable. A second bias present with self-report surveys is the "better than average" effect which refers to the general over estimation of one's abilities (Franz, 2023), which again could have led to an over report of EF levels. These biases in combination could skew our results, artificially inflating EF levels. Finally, Our sample was dominated by female

participants (80%) which may have led to skewed results due to the gender differences observed in ADHD (Geshron, 2022; Stibbe, 2020). Our sample also consisted of first year psychology students recruited from the University of Groningen, thus our generalisability to the wider student population is compromised.

Directions for Future Research

Firstly, Future research should examine the specific underlying EF mechanisms that lead to lowered SRL levels. For example, research could examine which aspect of EF is the strongest predictor of cognitive SRL use, identification of such a predictor could be beneficial in understanding what specific cognitive difficulties lead to lowered SRL use. Understanding these mechanisms could also allow for the opportunity to introduce EF training, which has shown promising results in reducing the negative effects of EF dysfunction in children and adolescents with ADHD (Juriadeh, 2016; Shepard, 2022). Secondly, our study primarily focused on the cognitive aspects of SRL, future research may look into the motivational aspects of SRL and examine how these aspects relate to ADHD and EF levels. For example, research could examine the role need for cognition (NFC) plays in the interaction between ADHD levels and SRL. NFC refers to an individual's motivation to allocate resources in order to complete a task, and one's enjoyment of undertaking cognitively complex tasks (Cacioppo, 1982). Thus, NFC is more a measure of one's willingness to use their available cognitive resources, rather than a measure of their absolute cognitive abilities. Garners' (2009) research alludes to motivation as a significant predictor of cognitive SRL strategy use, research could be conducted to provide more evidence for this idea. Finally, future research could aim to further replicate the results found by Shelton (2019) relating to ADHD symptom domains and SRL strategy use, as identifying and understanding the hypothesised protective factor provided by hyperactive/impulsive ADHD symptoms could greatly change our perception of SRL difficulties in the ADHD population. However, our study did not find such

an effect, so differing methodologies and measures may be required to explore this aspect. For example, a mediation analysis on a more diverse, gender balanced sample may yield differing results.

Conclusions

In conclusion, our results suggest that ADHD is significantly negatively correlated with the utilisation of cognitive SRL strategies, with higher levels of ADHD symptomology being associated with less cognitive SRL utilisation. EF was identified as a significant mediating factor in the relation between ADHD and cognitive SRL. Our secondary analysis suggests that the inattentive symptoms of ADHD are significantly related to overall SRL strategy use, with higher levels of inattentive type ADHD symptoms being associated with lower SRL strategy use. Hyperactive/Impulsive type symptoms were found to be insignificant in the relation to SRL, suggesting that the cognitive symptoms reflective of inattentive type ADHD may play a more significant role in predicting SRL levels.

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Appendix

Normality of Data Assumptions

Figure A1

QQ Plot For EFITot Data.

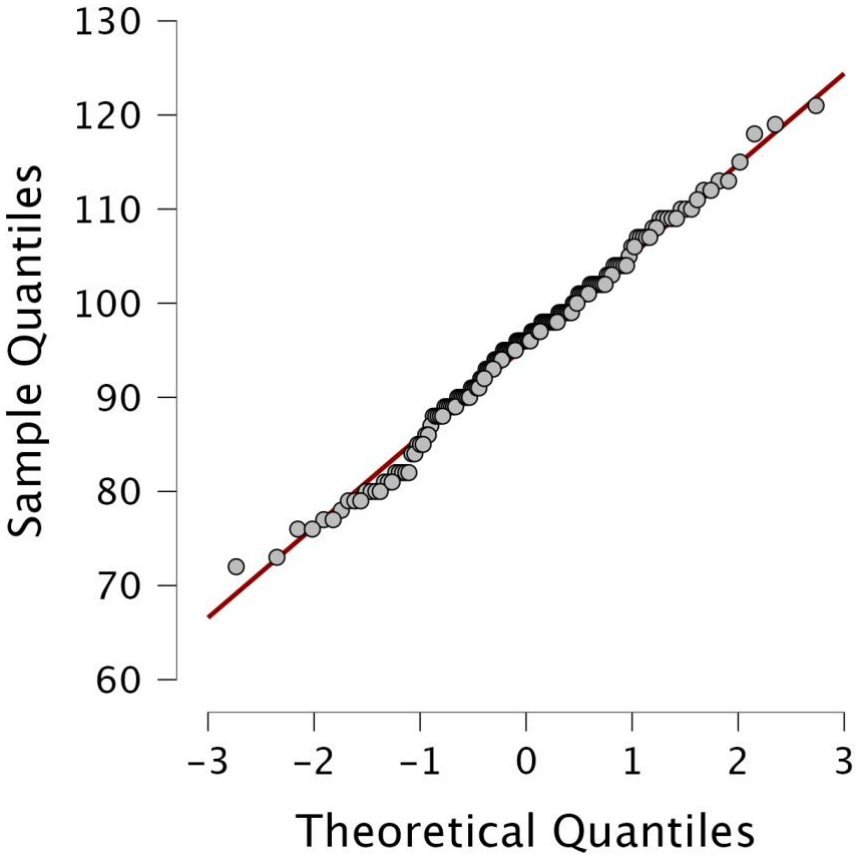
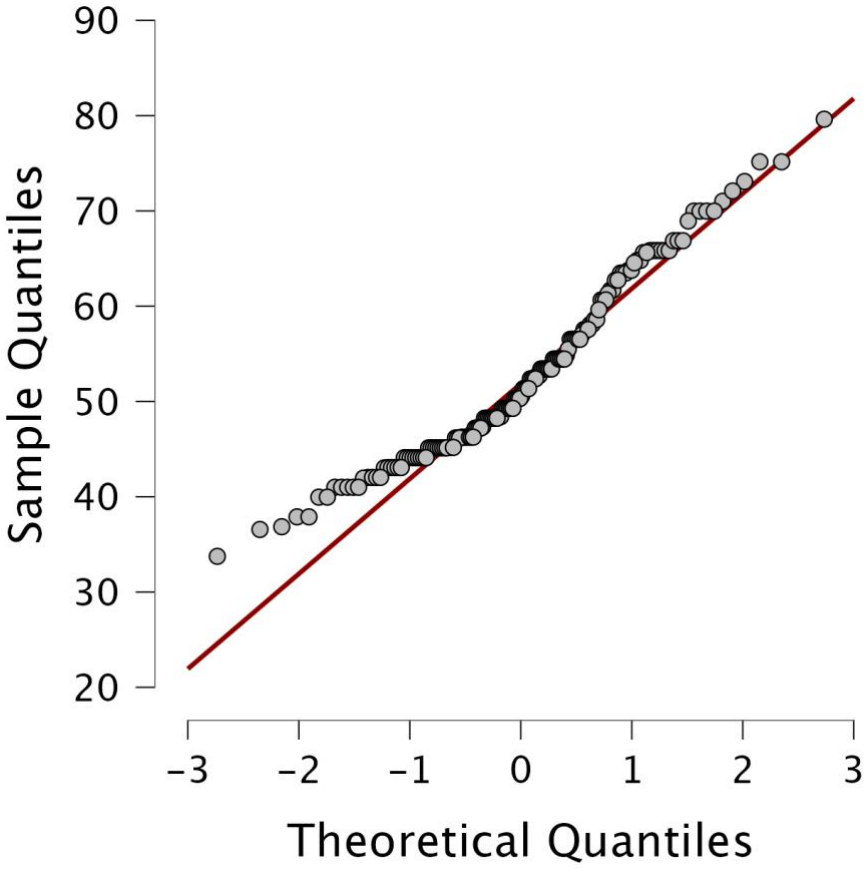


Figure A2

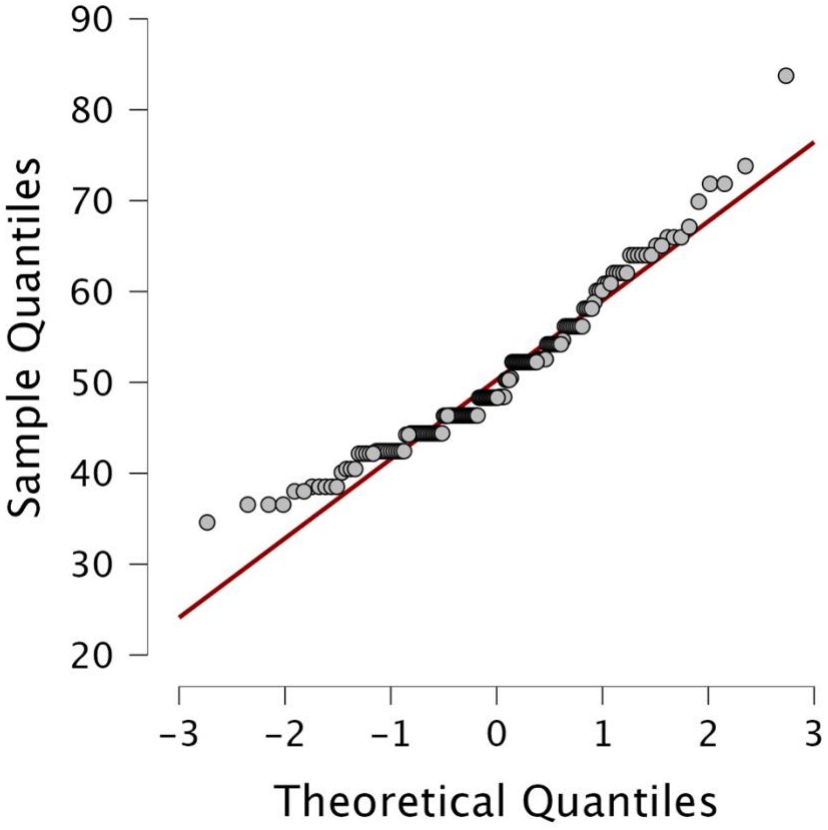
QQ Plot for ADHDTot



Note. Slight deviation from normal, with skewness=0.580

Figure A3

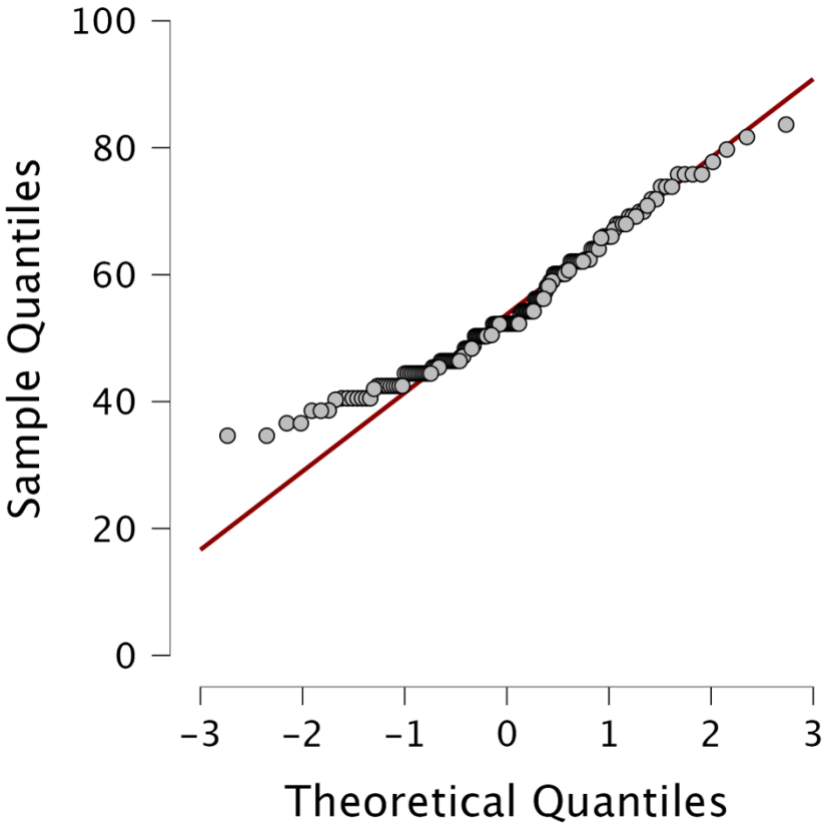
QQ Plot for ADHDHypImp



Note. Slight deviation from normal with skewness= .541

Figure A4

QQ Plot for ADHDIna



Note. Deviation from normal with skewness= .801

Figure A5

QQ Plot for MSLQCog.

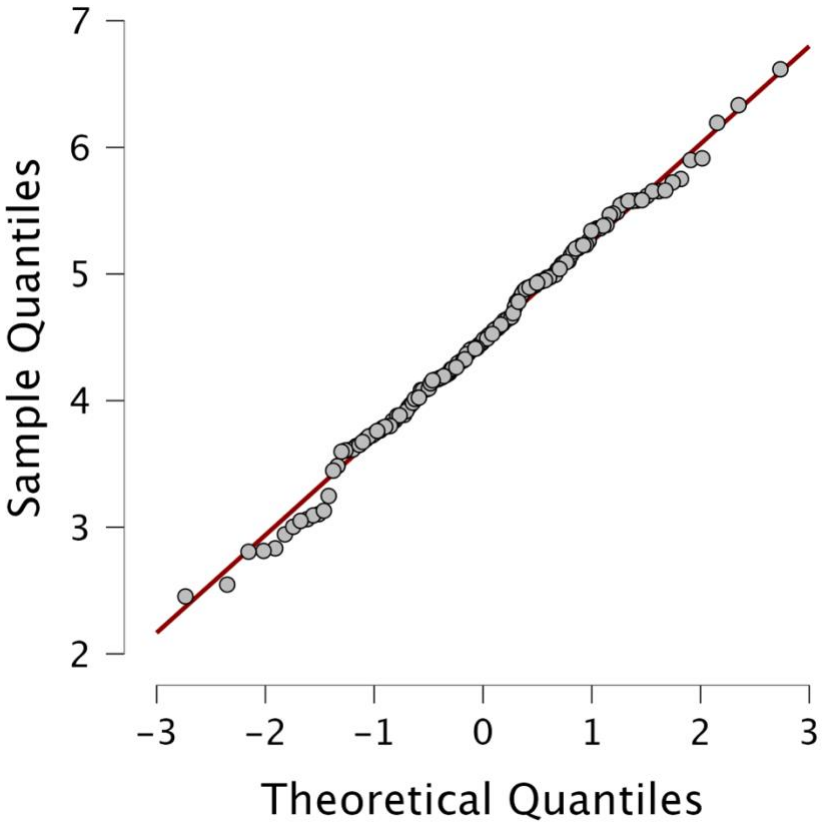


Figure A6

QQ Plot for MSLQTot

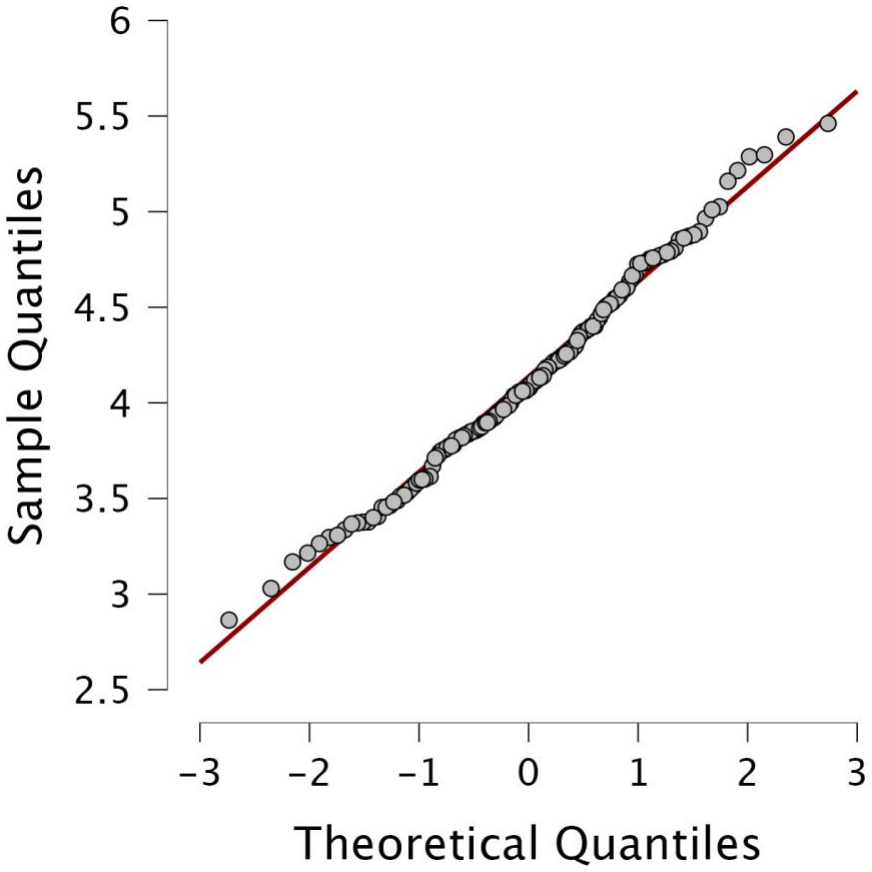


Figure A7

Boxplot for EFITot

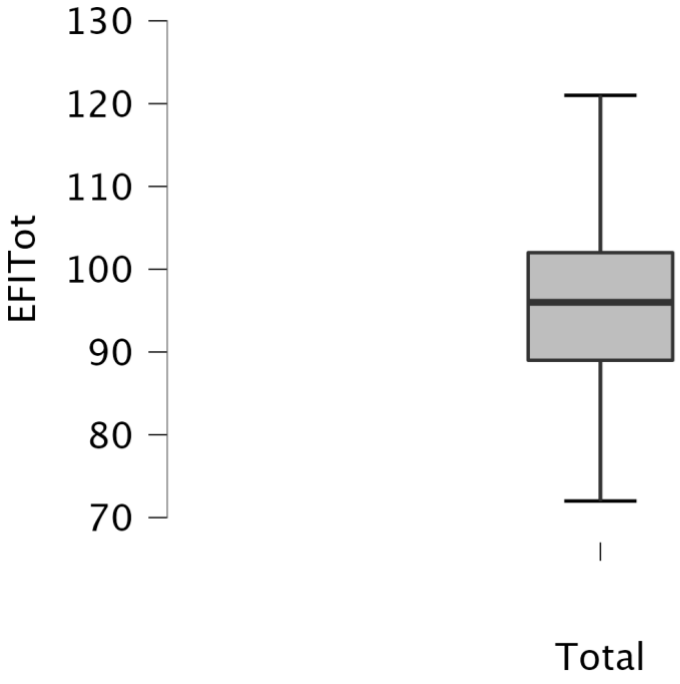
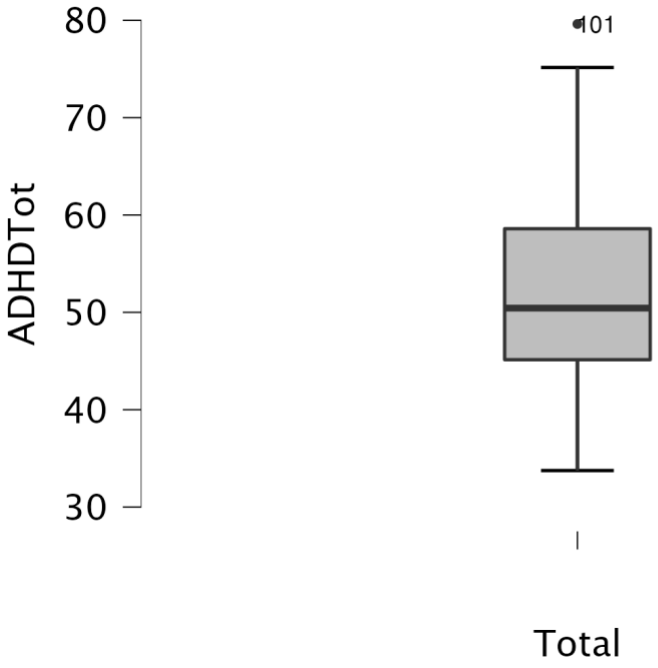


Figure A8

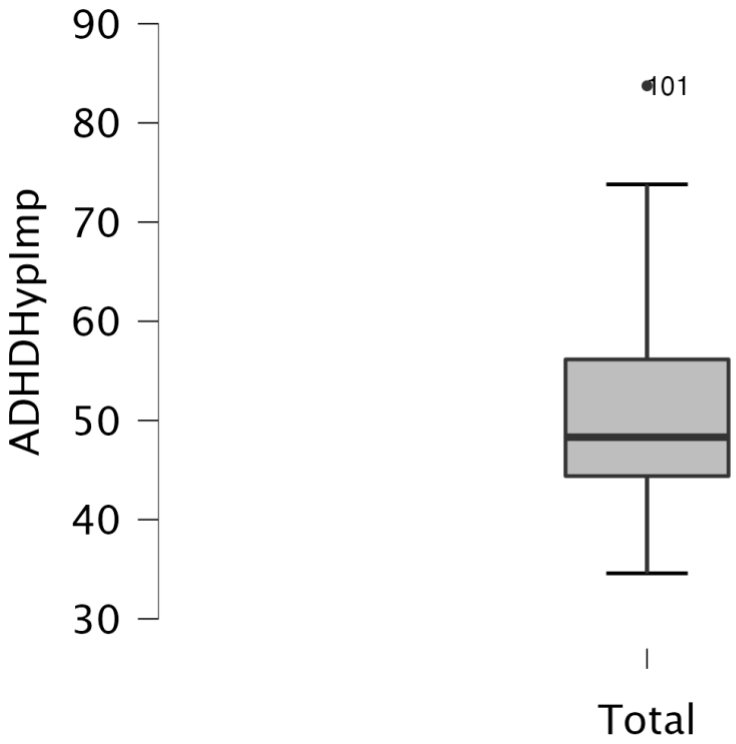
Boxplot for ADHDTot



Note. Potential Outliers are Marked.

Figure A9

Boxplot for ADHDHypImp



Note. Potential Outliers are Marked.

Figure A10

Boxplot for ADHDIna

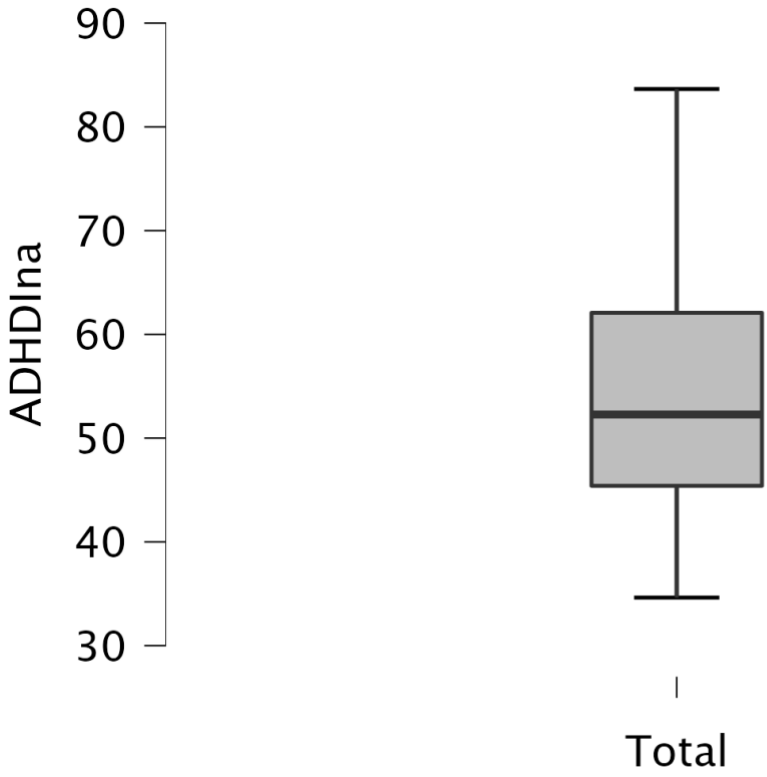
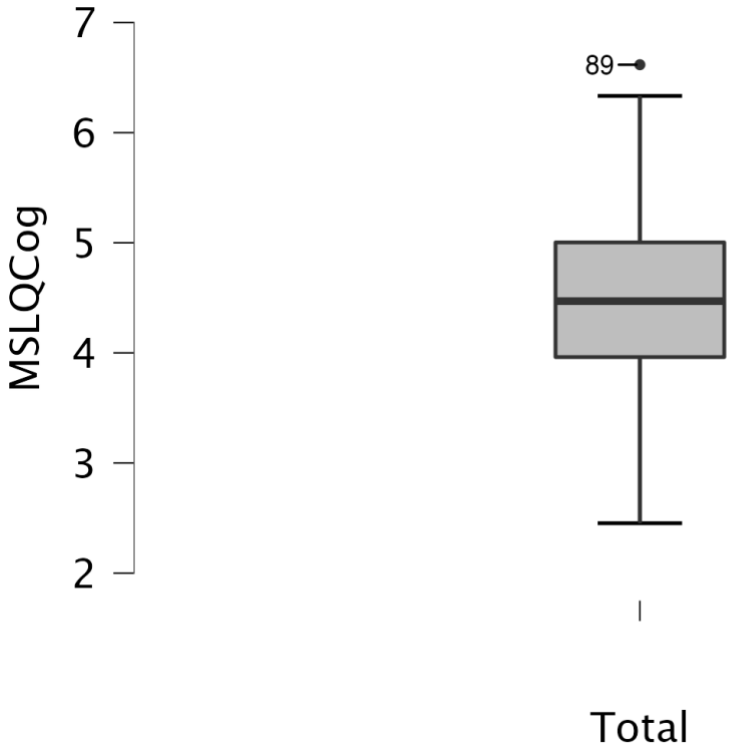


Figure A11

Boxplot for MSLQCog



Note. Potential Outliers are Marked

Figure A12

Boxplot for MSLQTot