The Impact of ADHD Symptoms and Executive Functioning on Cognitive Self-Regulated Learning Strategies in University Students

Vanja Tanasic

S4316258

Department of Psychology, University of Groningen

PSB3E-BT15: Bachelor Thesis

Group number: 10

Supervisor: Dr. Yvonne Groen

Second evaluator: Dr. Norbert Börger

In collaboration with: Joana Thomfohrde, Naomi van den Hoek, Astrid Prins, Lindsay Husada, and Fearghal Lee

April 28, 2023

Abstract

Introduction. The relationships between levels of ADHD symptoms, executive functioning (EF) and cognitive strategies of Self-regulated learning (SRL) were investigated in university students. For this group in particular, self-regulated learning is likely a particularly relevant concept, as higher education typically entails a strong degree of reliance on self-regulation. ADHD is known to be associated with executive dysfunction, and EF to be correlated with SRL; therefore, an exploration of these variables in the context of higher education is presented. The relation between ADHD symptom domains and SRL cognitive strategies were analysed to assess whether hyperactive/impulsive ADHD symptoms act as a protective factor for SRL cognitive strategies. *Methods*. Partial correlation analyses were conducted to investigate the effects of ADHD symptoms and EF, as well as ADHD symptom domains (inattentive and hyperactive/impulsive) on SRL cognitive strategies. A non-clinical sample of 160 psychology students from the University of Groningen was assessed. Relevant concepts were measured using the CAARS, MSLQ and EFI. *Results.* ADHD symptom level was negatively correlated with EF. ADHD symptom level was negatively correlated with cognitive SRL strategies, but not so when EF was controlled for. ADHD's hyperactive/impulsive symptoms were not correlated with SRL, while inattentive ADHD symptoms were significantly correlated with SRL. *Discussion*. EF for a large part explained the relationship between ADHD and SRL, and ADHD hyp/imp did not act as a protective factor for SRL. The proposed overlap between EF and SRL concepts, effects of sample characteristics and choice of measurement scales are discussed.

The Impact of ADHD Symptoms and Executive Functioning on Cognitive Self-Regulated Learning Strategies in University Students

Self-regulated learning (SRL) is part of a broader framework of self-regulation and includes the ways in which students regulate their behaviour and thinking in an attempt to achieve their academic goals, but also the way they plan, adapt, and manage their resources (Shelton et al., 2019). SRL is increasingly being understood as an important factor to consider when assessing students' grasp and mastery of material in academic contexts (Pintrich, 1995). Further, the view of self-regulated learning as more of a skill that can be taught, practised, and developed, rather than a quality a student either inherently possesses or lacks, provides a more optimistic view of education and the development of the individual through academia. Because of the value now identified in SRL, it is important to assess not only how to implement these strategies further in university-level education, but also which obstacles might be in the way of doing so, or which factors hinder the effectiveness of using SRL among university students. The present study hypothesised that one such hindering factor could be the self-reported level of Attention-deficit/hyperactivity disorder (ADHD) symptoms that students experience.

Attention-deficit/hyperactivity disorder (ADHD) is defined by the American Psychological Association as "a behavioural condition that makes focusing on everyday requests and routines challenging" (American Psychological Association). ADHD is generally considered a neuropsychologically heterogeneous disorder, due to the variability in experienced symptomatology of ADHD. Symptoms usually fall within one of two broader domains: hyperactive/impulsive and inattentive. In clinical practice, it is usually specified whether the symptoms experienced by the individual belong predominantly to the inattentive domain (ADHD-I), the hyperactive/impulsive domain (ADHD-H), or whether a combined presentation is observed (ADHD-C).

Certain effects of experiencing ADHD symptoms seem particularly relevant when considering SRL, namely that ADHD has been found to be connected to deficits in behavioural inhibition, which are themselves associated with difficulties with self-regulation, among other things (Boonstra et al., 2005). As self-regulation is an essential component of SRL, it seems plausible that a connection may exist between the level of reported ADHD symptoms and successful use of SRL cognitive strategies.

Self-regulated learning entails a student exercising active, goal-directed self-control over their behaviour, motivation, and cognition in order to complete academic tasks (Pintrich, 1995). Bearing this in mind, it again seems plausible to consider that students who experience a higher level of ADHD symptoms might also experience more difficulty effectively implementing SRL strategies when studying. This might be especially relevant for students who exhibit symptoms more closely related to a particular symptom cluster of ADHD (either impulsive/hyperactive, or inattentive).

The inattentive subtype of ADHD differs importantly from ADHD's other presentations in terms of severity of symptoms, age and gender distribution, sustained attention, anxiety and cognitive function (Grizenko et al., 2010; Wu et al., 2022). According to Grizenko et al. (2010), although both patients with the combined and inattentive subtypes experience problems with inattention, "the type of inattention suffered by both may be different". Additionally, of these three presentations of ADHD "it is estimated that ADHD-I is the most prevalent in population-based studies" (Grizenko et al., 2010). Wu et al. (2022) even found that although patients with ADHD-I have fewer behavioural symptoms, they also show more profound impairment in cognitive function than patients with ADHD-C and healthy controls. Additionally, Shelton et al. (2019) introduced the notion that hyperactive/impulsive ADHD symptoms may lessen the negative effects of inattentive ADHD symptoms on self-regulated learning. This makes it all the more relevant to inspect

whether a difference can be observed in the use of SRL cognitive strategies between students with more inattention-oriented ADHD symptoms, as compared to students with hyperactivity/impulsivity-related symptoms .Therefore, in an attempt to replicate the findings of Shelton et al. (2019), we hypothesize that ADHD's hyperactive/impulsive symptoms may lessen the effect of inattentive symptoms on SRL scores, acting as a protective factor.

Executive functioning (EF) is widely understood to encompass a range of higher-order cognitive abilities relevant for "strategic planning, cognitive flexibility, self-regulation, and goal-directed behaviour" (Weyandt, 2005). Furthermore, it has been found in a number of studies of EF in individuals with ADHD that children, adolescents, and young adults with ADHD exhibit poorer performance on EF tasks compared to peers who were unaffected by ADHD (Weyandt, 2005, Boonstra et al., 2005). Despite the broad definition of EF, it is still surely a variable of indisputable relevance for the consideration of the effectiveness of SRL strategies. Particularly because of the emphasis on the involvement of executive functioning in self-regulation, behavioural inhibition, planning and goal-oriented activity, it seems plausible that a deficit in executive functioning may (partly) thwart the benefits of implementing SRL strategies when studying (Garner, 2009). Thus, we hypothesise that a higher level of reported ADHD symptoms, and a lower score on the Executive Functioning Index (EFI), is positively correlated to self-reported less effective SRL cognitive learning strategies among university students. In other words, we expect to see a negative correlation between ADHD symptoms and SRL, and a positive correlation between EF and SRL. At present no predictions about the causality of these relationships are made.

In the present study, the correlation between the level of experienced ADHD symptoms and executive functioning, and the connection of SRL with these factors, were assessed through the analysis of a sample of 160 students of the University of Groningen. Data relating to ADHD symptomatology, executive functioning, and self-reported SRL

strategies employed by the students were gathered through an online questionnaire study and subjected to statistical analysis of correlation. Furthermore, we explored whether a notable difference could be observed among the two symptom domains of ADHD (inattentive and hyperactive/impulsive) in their relation to the two other aforementioned variables. It is also worth noting that in this study ADHD symptoms will be considered according to a dimensional approach, rather than a categorical one. To summarize, our hypotheses are:

Hypothesis I: A negative association will be observed between the level of reported ADHD symptoms and Self-Regulated Learning strategies.

Hypothesis II: Executive functioning is negatively correlated with ADHD symptom level and positively correlated with SRL.

Hypothesis III: ADHD's Hyperactive/Impulsive symptoms act as a protective factor when assessing the effect of Inattentive ADHD symptoms on cognitive SRL strategies.

Method

Participants

The participants of this study were first year Psychology students of the University of Groningen. The study consisted of two surveys which were administered at two different times. Only participants who completed both questionnaires at both times 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 exclusion criteria (i.e., because they did not complete the entire questionnaire or because they were younger than 18 years). Additionally, 39 more participants were removed after checking for reliability of responding and by implementing the inconsistency and infrequency index of the CAARS. The final sample consisted of 160 participants with ages ranging from 18 to 35 years old *(M*

= 19.73, SD = 2.074). Of these participants, 128 identified as female and 32 identified as male.

All the 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 a course. To participate in this study, the students had to be at least 18 years old, as the CAARS only has norm scores for individuals 18 or older. They also must have participated in the "Introduction to Psychology" course and have sufficient command of the English language. 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 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 had a correlational design, and investigated connections 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. In particular, a correlational analysis was chosen in order to reflect on the dimensional nature of the studied variables. This approach allowed us to analyse the differences in the strength of association between ADHD, EF and different cognitive SRL strategies in a more nuanced way and is further relevant because of our use of a non-clinical sample.

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 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. Participants were compensated with SONA credits for their participation. 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) was used to measure the level of participants' 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-symptomatology. A T-score above 80 can be a possible indicator of invalidity because of exaggeration or malingering of symptoms (Conners et al., 1998; Suhr et al., 2011). Overall, the higher the T-score, the higher the presented ADHD-symptomatology.

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; Erhardt et al., 1999). This study has found a Cronbach's alpha of .959. Other studies have found the Cronbach's alpha of the CAARS self-report measures to fall in between .66 and .90 (Conners et al., 1998). 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%) (Harp et al., 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 is computed by summing up the items and calculating their average. The score of the “reversed” items have to be reversed. For example, in reversed scoring, an individual scoring a 1 on an item now receives a 7. The average score for a class, as well as the breakdown of the bottom 25%, middle 50% and top 25% are provided in each scale. When scoring in the middle 50%, the score is similar to most students. A higher score like 4, 5, 6, and 7 is better than a lower score like 1, 2, or 3. The exception is the Anxiety scale where a higher score is more worrying. If the scores are above 3, the individual is doing well. If the score is below 3, help may be needed from instructors or services at the institution.

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). Past research has reported the Cronbach’s alpha of the MSLQ to fall in between .52 and .93 (Pintrich et al., 1993). This study has found a Cronbach’s alpha of .894. 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

behavior), empathy (interest in the well-being of others, prosocial behavior), 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 of the EFI to be acceptable (Spinella, 2005; Janssen et al., 2009). Originally, the reported Cronbach’s alpha for the EFI scale falls in between .70 to .82 (Spinella, 2005). In comparison, this study reports a Crinbach’s alpha of .750.

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. Assumption checks were conducted to assess the validity of the statistical analysis, descriptions of which can be found in the appendix. Three variables were extracted from our data based on their respective measures, namely, EF levels, ADHD levels, and SRL strategies. Given the strong correlation between EFI and CAARS, the assumption of multicollinearity is likely to be violated for the regression model. Therefore, instead of conducting a regression analysis using EFI and CAARS scores as predictors, as was originally intended, partial correlations with cognitive SRL strategies were computed instead. In order to assess our first and second hypothesis we conducted a partial correlation analysis for ADHD and EF levels, and cognitive measures of SRL. The correlational values of these two analyses are then compared to deduce the influence the inclusion of EF has on the relation between ADHD and SRL. In order to examine our secondary objective (hypothesis III), we created two ADHD scores

based on subtype symptomatology (i.e., Inattentive and hyperactive/impulsive) and conducted partial correlation analyses on cognitive strategies of SRL.

Results

According to hypothesis I we expected a negative association between the level of reported ADHD symptoms and SRL cognitive strategies. This was supported by the values obtained in the correlation analysis (see Table 1).

Table 1

Summary of correlations between MSLQ cognitive strategies, ADHD symptom level and executive functioning level

Pearson correlations			
	1	2	3
1. MSLQ_CMS	-		
2. CAARS score	-.166*	-	
3. EFI score	.385**	-.518**	-

Note. *p<0.05, **p<0.01
MSLQ CMS - The Motivated Strategies for Learning Questionnaire Cognitive and Metacognitive Strategies; CAARS - Conners' Adult ADHD Rating Scales; EFI - Executive Functioning Index.

In support of our second hypothesis, scores on the EFI were indeed (moderately to strongly) negatively correlated with scores obtained on the CAARS and this correlation was significant (Table 1). Additionally, a (moderately) positive correlation was found between executive functioning and cognitive SRL strategies, and this relationship was also significant.

The partial correlation showing the predictive value of EFI scores for cognitive SRL strategies was $r(157)=.354$, $p<.001$, while the partial correlation for ADHD symptoms and cognitive SRL strategies was $r(157)=.042$, $p=.596$. Overall, our analysis found that scores on

the EFI were a better predictor of cognitive SRL strategies than scores on the CAARS were, both in terms of the strength and significance of the association.

Similarly, partial correlations were also computed to test our third hypothesis, predicting that ADHD's hyperactive/impulsive symptoms would act as a protective factor in the association between ADHD's inattentive symptoms and cognitive SRL strategies. The results of this analysis show a significant mildly negative correlation ($r = -.163$, $p < .05$) between ADHD's inattentive symptoms and cognitive SRL strategies; and a non-significant weakly positive correlation ($r = .024$, $p > .05$) between ADHD's hyperactive/impulsive symptoms and cognitive SRL strategies. These partial correlations show that inattentive symptoms contribute more to the observed variance in SRL cognitive strategy use than do hyperactive/impulsive symptoms. Overall, we found no support for our hypothesis that ADHD's hyperactive/impulsive symptoms will mitigate the effect of inattentive ADHD symptoms on cognitive SRL strategies, due to the statistically insignificant effect of hyperactive/impulsive symptoms on cognitive SRL strategy use.

Discussion

The aim of the present study was to investigate the relationships between ADHD symptoms, executive functioning, and cognitive self-regulated learning strategies, as well as the possible protective effects of hyperactive/impulsive ADHD symptoms on self-regulated learning. The finding that executive functioning and level of ADHD symptoms are negatively correlated is largely in line with the results of previous research and comes as no surprise, as executive dysfunction was found to be associated with ADHD in a number of studies (Weyandt, 2005; Boonstra et al., 2005). On the other hand, it has also been suggested that executive functioning should be thought of as more multifaceted, and that ADHD is only associated with certain types of deficits in executive functioning, including regulation for

attentional resources, planning and organizational tasks, working memory, and behavioural inhibition; at least among children and adolescents (Weyandt, 2005).

Our study found that the association between ADHD symptom level and SRL cognitive strategy use is strongly influenced by the reported level of executive functioning. This was apparent by the results of our analysis, which indicate that the relationship between ADHD symptoms and SRL cognitive strategies, controlling for EF, was weakly positive, but statistically insignificant. Contrastingly, when executive functioning was not controlled for, a significant negative correlation was observed, indicating that individuals with higher levels of ADHD symptoms have more difficulties successfully implementing cognitive SRL strategies than those with lower levels of ADHD symptoms. These results provide support for our hypothesis and suggest executive functioning significantly impacts the relationship between ADHD symptoms and SRL, making it an important variable to take into account when interpreting the effects of ADHD symptoms on SRL cognitive strategy use.

The positive association between executive functioning and SRL cognitive strategies is in line with our hypothesis. Further, this finding corroborates previous studies (Follmer and Sperling, 2016; Rutherford et al., 2018), although different suggestions have been made as to why the association was observed. Follmer and Sperling (2016) primarily investigated the metacognition aspect of executive functioning and how it mediated the relationship between EF and SRL, while Rutherford et al. (2018) mostly examined inhibition and shifting elements of EF as an explanatory factor in school academic achievement and in SRL (albeit in children, limiting the generalizability of their results to a university student population). Thus, it seems plausible that certain components of executive functioning may be more predictive of academic outcomes and use of SRL strategies than others, although in general a relationship between EF and SRL appears to be well established in the literature and is reaffirmed in our study. Garner (2009) provides another perspective on the relationship

between EF and SRL, suggesting the two are more overlapping concepts and thus a dysfunction of EF would manifest itself as less effective SRL strategy use in some form. For example, problems with impulse control, which are often seen in people with ADHD, would also make it more difficult to regulate effort and strategy use, both of which are key components of SRL. In fact, effort regulation with the purpose of achieving academic goals may correlate with executive impulse control capabilities. Garner's (2009) study also found the EFI scales relating to planning, organization, and impulse control to correlate with metacognitive strategy use and academic effort regulation (Garner, 2009).

Our finding that EF is more strongly associated with SRL strategy use than ADHD symptoms seems to complement the findings of previous studies. Biederman et al (2006) found that Deficits of EF were associated with lower academic achievement, irrespective of the individual's ADHD status; while Dorr & Armstrong (2019) found that Among individuals screening negative for ADHD, those with higher EFI scores experienced significantly less impairment than those with lower EFI scores. They suggest that individuals with lower EF may have difficulties with tasks such as planning, organizing and enacting plans with delayed rewards, as well as with plans with a short-term cost to the individual (Dorr & Armstrong, 2019). It thus appears that EF is a stronger predictor of SRL strategy use than level of reported ADHD symptoms.

Our findings indicate that ADHD's hyperactive/impulsive symptoms do not act as a protective factor for the relationship between ADHD's inattentive symptoms and cognitive SRL strategies. Indeed, the negative correlation between inattentive ADHD symptoms and SRL cognitive strategies is stronger when hyperactive/impulsive symptoms are not controlled for. This would suggest that the presence of hyperactive/impulsive symptoms contributes to, or strengthens, the negative association between inattentive symptoms and SRL, rather than weakens it. Our results thus ultimately do not replicate the findings of Shelton et al. (2019).

However, it should be noted that the study by Shelton et al. (2019) differed from ours in a number of ways. Namely, they used the Barkley Adult ADHD Rating Scale-IV (BAARS-IV) to assess ADHD symptom level, while our study made use of the CAARS. Additionally, Shelton et al. (2009) conducted their analyses using an alternative factor structure of the MSLQ developed by Hilpert et al (2013). Hilpert et al. proposed the use of three factors (value, expectancy, and self-regulation), represented by six of the original 15 subscales of the MSLQ, to assess the use of SRL strategies (Shelton et al., 2019). Therefore, it is possible that the differing results regarding the possibility of ADHD HI acting as a protective factor are due to the use of different or modified measurement scales for the assessed constructs. Their use of a larger sample could also be a cause of divergence in our results, although it, like ours, comprised university-level psychology students, most of whom were female. Therefore, it would be advisable for future studies to try to replicate the findings of Shelton et al. in order to obtain a more conclusive view of their exploratory hypothesis, explore the theoretical underpinnings of their proposal in more depth, and assess the generalizability of their findings.

Strengths and limitations

One of the advantages of our study is that we were able to conduct our analyses on a larger sample size than many other studies investigating similar topics, improving the statistical power of our analysis. Additionally, it seems that research into the student population specifically is lacking in the field of ADHD in relation to SRL strategies, despite students being a group of particular relevance in this subject area. Therefore, our assessment of university students may contribute valuable insights to the existing body of research on this topic. The use of validated questionnaires and checks for reliable responding are also strengths of our study, as they improve the reliability and validity of our findings. Additionally, our use of a dimensional approach to assessing the reported level of ADHD

symptoms likely allowed us to consider a greater number of participants with more varied symptom levels than if we had used an arbitrary cut-off value for selecting participants. This choice was in line with accumulating evidence of dimensionality for ADHD ((McLennan, 2016). A histogram showing the distribution of ADHD symptoms in our sample can be found in the Appendix.

There are a few limitations we kept in mind when interpreting the findings of our study. Namely, our study sample consisted entirely of psychology students of the University of Groningen, limiting the generalizability of our findings to the general student population. Additionally, our final sample consisted of 160 participants, which was sufficient to conduct our statistical analyses on and draw reasonable conclusions; however, a replication study with a larger sample could be useful, as it would increase the statistical power of the analysis and could result in more generalizable findings. Furthermore, our original regression analysis was hampered by the high multicollinearity between our predictors, prompting us to modify our approach and opt for a correlational analysis instead. In the future, studies could attempt to investigate these variables in a different manner, perhaps using mediation analysis or path analysis, and assess the predictive value of these predictors for SRL cognitive strategies.

Implications and directions for future research

Relating to the previous point, our study mainly focused on the cognitive and metacognitive SRL strategies. Hilpert et al. (2013) used a three-factor structure of the MSLQ, with factors value, expectancy, and self-regulation. Their findings suggest that value and expectancy, both well-established constructs in motivation theory, are as important to assess as self-regulation, being some of the most useful and empirically relevant constructs from the MSLQ (Hilpert et al., 2013). Hence, it could be informative for future research to explore whether a different pattern of results would emerge when considering other subscales of the

MSLQ, such as the motivational subscale, or when a different form of the MSLQ, such as a factor-analysed model, is used.

Additionally, a variable not included in our study design, but which could influence the interpretation of the results, is need for cognition (NFC). Need for cognition reflects the personality trait referring to the relatively stable level of motivation an individual has to engage in mentally effortful tasks (Gärtner et al., 2021). It has been deemed likely that ADHD is associated with lower NFC, as per one of the criteria for ADHD in the DSM-5 which describes "a reluctance to engage in activities that require mental effort" as a symptom of ADHD (Zadelaar et al., 2020). On the other hand, Zadelaar et al. (2020) also found no relationship between ADHD and NFC to begin with, although inattention (and not hyperactivity/impulsivity), was linked to a reduced need for cognition. Therefore, although considering NFC and its influence in the association between ADHD and EF seems theoretically relevant, studies investigating NFC present conflicting results, and the research in this area is still very limited. However, perhaps the relevance of NFC could be seen more clearly when assessing motivational aspects of SRL, as opposed to learning strategies. Future research could consider the effect of NFC on aspects of SRL related to motivation, such as the motivation scales of the MSLQ or the task value factor of the factor-analysed version of the MSLQ proposed by Hilpert et al. (2013).

These results could have relevant clinical implications, as executive (dys)functioning could perhaps be assessed keeping in mind its predictive value for SRL, possibly allowing for a different treatment approach with more keen focus on specific components of EF related to SRL, such as planning, impulse control and organization (Garner, 2009), to be developed for university students and adults with ADHD symptomatology.

Conclusion

While the pattern of results observed in our study certainly replicated some of the findings of previous studies on the relationships between ADHD, EF and SRL, we also did not find evidence to support our exploratory analysis of the differing effects of inattentive versus hyperactive/impulsive ADHD symptoms. That is, a higher level of reported ADHD symptoms was associated with poorer executive functioning and use of cognitive SRL strategies in our sample. Contrastingly, lower levels of reported ADHD symptomatology were associated with better executive functioning and cognitive SRL strategy use. However, executive functioning was found to be a better predictor of cognitive SRL strategy use than level of ADHD symptoms, and EF significantly impacted the association between ADHD and SRL. As for the exploratory analysis we conducted, although our findings fail to replicate those of Shelton et al. (2019), it is difficult to draw many meaningful conclusions as to why, as our studies differed in several important ways. Additional research would thus be useful to verify our findings. In particular, the proposed protective properties of hyperactive/impulsive ADHD symptoms and the role of EF in the relationship between ADHD and SRL should be explored in more depth, as the evidence surrounding these hypotheses is limited, while the outcomes of investigations on these topics could alter our current understanding of the effects of ADHD symptoms.

References

American Psychiatric Association. (1994) Diagnostic and statistical manual of mental disorders (4th ed.).

Biederman, J., Petty, C., Fried, R., Fontanella, J., Doyle, A. E., Seidman, L. J., & Faraone, S. V. (2006). Impact of psychometrically defined deficits of executive functioning in adults with attention deficit hyperactivity disorder. *The American Journal of Psychiatry*, *163*(10), 1730–1738. https://doi-org.proxyub.rug.nl/10.1176/appi.ajp.163.10.1730

Boonstra, A. M., Oosterlaan, J., Sergeant, J. A., & Buitelaar, J. K. (2005). Executive functioning in adult ADHD: a meta-analytic review. *Psychological medicine*, *35*(8), 1097–1108. https://doi.org/10.1017/s003329170500499x

Christiansen, H., Kis, B., Hirsch, O., Matthies, S., Hebebrand, J., Uekermann, J., Abdel-Hamid, M., Kraemer, M., Wiltfang, J., Graf, E., Colla, M., Sobanski, E., Alm, B., Rösler, M., Jacob, C. K., Jans, T., Huss, M., Schimmelmann, B. G., & Philipsen, A. (2012). German validation of the Conners Adult ADHD Rating Scales (CAARS) II: Reliability, validity, diagnostic sensitivity and specificity. *European Psychiatry*, *27*(5), 321–328. https://doi.org/10.1016/j.eurpsy.2010.12.010

Conners, C. K., Erhardt, D., & Sparrow, E. (1998). Conners Adult Attention Rating Scale–Self-Report: Long Version. North Tonawanda, NY: Multi-Health Systems.

Davenport, M. A. (2003). Modelling motivation and learning strategy use in the classroom: An assessment of the factorial, structural, and predictive validity of the motivated strategies for learning questionnaire [ProQuest Information & Learning]. In *Dissertation Abstracts International Section A: Humanities and Social Sciences* (Vol. 64, Issue 2–A, p. 394)

Dorr, M. M., & Armstrong, K. (2019). Executive Functioning and Impairment in Emerging Adult College Students With ADHD Symptoms. *Journal of Attention Disorders*, *23*(14), 1759–1765. https://doi.org/10.1177/1087054718787883

Erhardt, D., Epstein, J. I., Conners, C. K., Parker, J. W., & Sitarenios, G. (1999). Self-ratings of ADHD symptomas in auts II: Reliability, validity, and diagnostic sensitivity. *Journal of Attention Disorders*, *3*(3), 153–158. https://doi.org/10.1177/108705479900300304

Follmer, D. J., & Sperling, R. A. (2016). The mediating role of metacognition in the relationship between executive function and self-regulated learning. *British Journal of Educational Psychology*, *86*(4), 559–575. https://doi.org/10.1111/bjep.12123

Garner, J. K. (2009). Conceptualizing the Relations Between Executive Functions and Self-Regulated Learning. *The Journal of Psychology*, *143*(4), 405–426. https://doi.org/10.3200/jrlp.143.4.405-426

Gärtner, A., Grass, J., Wolff, M., Goschke, T., Strobel, A., & Strobel, A. (2021). No relation of Need for Cognition to basic executive functions. *Journal of Personality*, *89*(6), 1113–1125. https://doi.org/10.1111/jopy.12639

Grizenko, N., Paci, M., & Joober, R. (2010). Is the inattentive subtype of adhd different from the combined/hyperactive subtype? Journal of Attention Disorders, 13(6), 649–657. https://doi.org/10.1177/1087054709347200

Harp, J. P., Walls, B. D., Berry, D., Wallace, E., Schmitt, F. A., Balthrop, K. C., Koehl, L. M., Garcia-Willingham, N. E., & Borger, T. N. (2020). Conners' Adult ADHD Rating Scale Infrequency Index Validation and Pilot Comparison of Administration Formats. *Psychological Disorders and Research*. https://doi.org/10.31487/j.pdr.2020.01.02

Hilpert, J. C., Stempien, J., van der Hoeven Kraft, K. J., & Husman, J. (2013). Evidence for the Latent Factor Structure of the MSLQ: A New Conceptualization of an Established Questionnaire. *SAGE Open*, *3*(4). https://doi.org/10.1177/2158244013510305

Janssen, G., De Mey, H., & Egger, J. I. M. (2009). Executive Functioning in College Students: Evaluation of the Dutch Executive Function index (EFI-NL). *International Journal of Neuroscience*, *119*(6), 792–805. https://doi.org/10.1080/00207450802333979

McLennan, J. (2016). Understanding attention deficit hyperactivity disorder as a continuum. *Canadian Family Physician*, *62*(12), 979–982.

Mohamed, S. A., Borger, N., Geuze, R. H., & Van Der Meere, J. (2016). Linking state regulation, brain laterality, and self-reported attention-deficit/hyperactivity disorder (ADHD) symptoms in adults. *Journal of Clinical and Experimental Neuropsychology*, *38*(8), 831–843. https://doi.org/10.1080/13803395.2016.1167174

Mohamed, S. A., Borger, N., & Van Der Meere, J. (2021). Executive and Daily Life Functioning Influence the Relationship Between ADHD and Mood Symptoms in University Students. *Journal of Attention Disorders*, *25*(12), 1731–1742. https://doi.org/10.1177/1087054719900251

Pintrich, P. R. (1995). Understanding self-regulated learning. *New Directions for Teaching and Learning*, *1995*(63), 3-12. https://doi.org/10.1002/tl.37219956304

Pintrich, P. R., Smith, D. A. F., Garcia, T., & Mckeachie, W. J. (1993). Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (Mslq). Educational and Psychological Measurement, 53(3), 801–813. Doi:10.1177/0013164493053003024

Rutherford, T., Buschkuehl, M., Jaeggi, S. M., & Farkas, G. (2018). Links between achievement, executive functions, and self-regulated learning. *Applied Cognitive Psychology*, *32*(6), 763–774. https://doi.org/10.1002/acp.3462

Shelton, C. T., Addison, W. E., & Hartung, C. M. (2019). ADHD and SCT Symptomatology in Relation to College Students' Use of Self-Regulated Learning Strategies. *Journal of Attention Disorders*, *23*(14), 1719–1728. https://doi.org/10.1177/1087054717691134

Spinella, M. (2005). Self-rated executive function: Development of the Executive Function Index. *International Journal of Neuroscience*, *115*(5), 649–667. Doi:10.1080/00207450590524304

Suhr, J. A., Buelow, M. T., & Riddle, T. M. (2011). Development of an Infrequency Index for the CAARS. *Journal of Psychoeducational Assessment*, *29*(2), 160–170. https://doi.org/10.1177/0734282910380190

Wu, Z. M., Wang, P., Liu, L., Liu, J., Cao, X. L., Sun, L., Cao, Q. J., Yang, L., Wang, Y. F., & Yang, B. R. (2022). ADHD-inattentive versus ADHD-Combined subtypes: A severity continuum or two distinct entities? A comprehensive analysis of clinical, cognitive and neuroimaging data. *Journal of Psychiatric Research, 149*, 28-36. https://doi.org/10.1016/j.jpsychires.2022.02.012

Weyandt, L. L. (2005). Executive function in children, adolescents, and adults with attention deficit hyperactivity disorder: introduction to the special issue. Developmental Neuropsychology, 27(1), 1–10.

Zadelaar, J. N., Dekkers, T. J., & Huizenga, H. M. (2020). The association between risky decision making and attention-deficit/hyperactivity disorder symptoms: A preregistered assessment of need for cognition as underlying mechanism. *Journal of Behavioral Decision Making*, *33*(5), 579–592. https://doi.org/10.1002/bdm.217

Appendix

Assumption checks

Normality

Figure 1

Q-Q Plot of total CAARS score

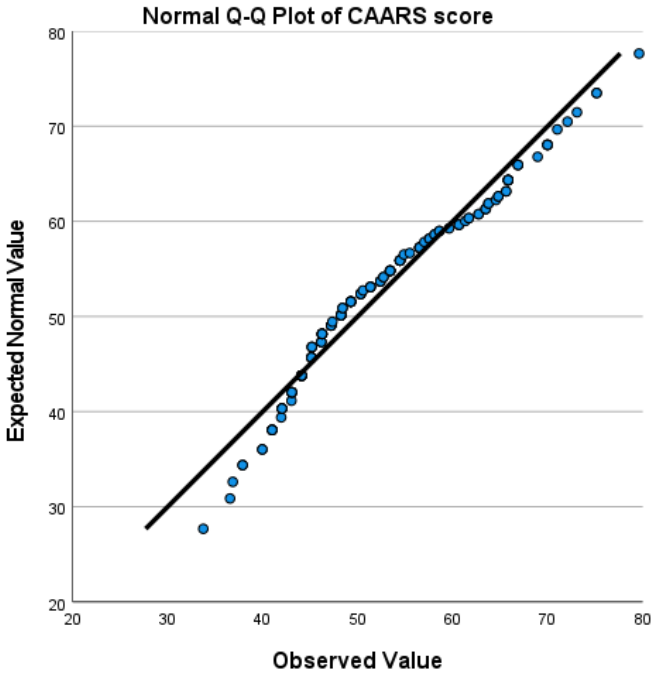


Figure 2

Q-Q Plot of CAARS Inattentiveness score

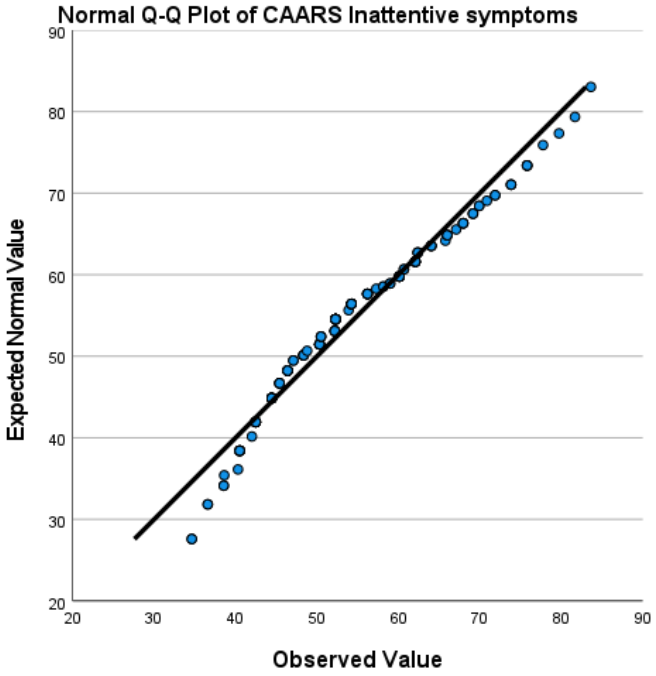


Figure 3

Q-Q Plot of CAARS Hyperactivity/Impulsivity score

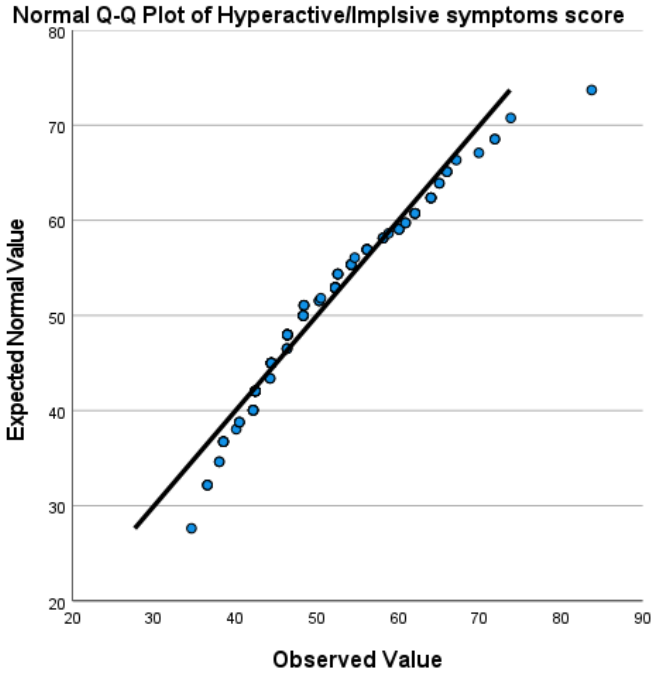


Figure 4

Q-Q Plot of Cognitive and Metacognitive SRL Strategies score

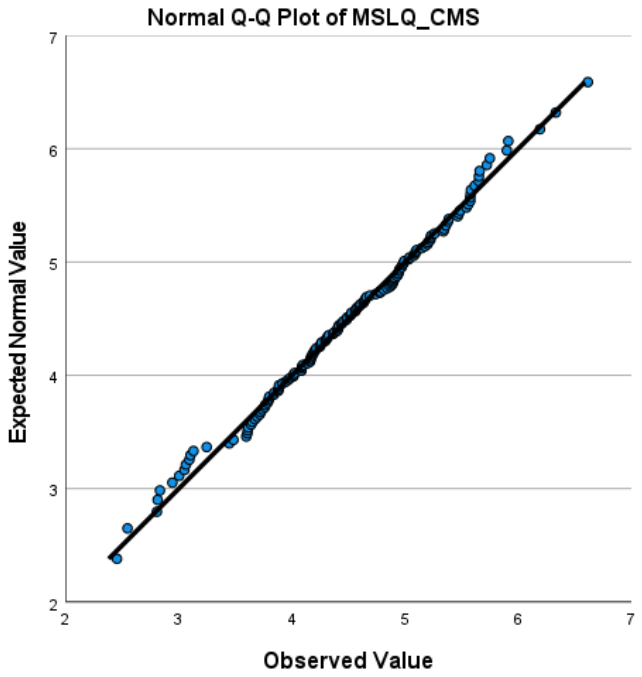
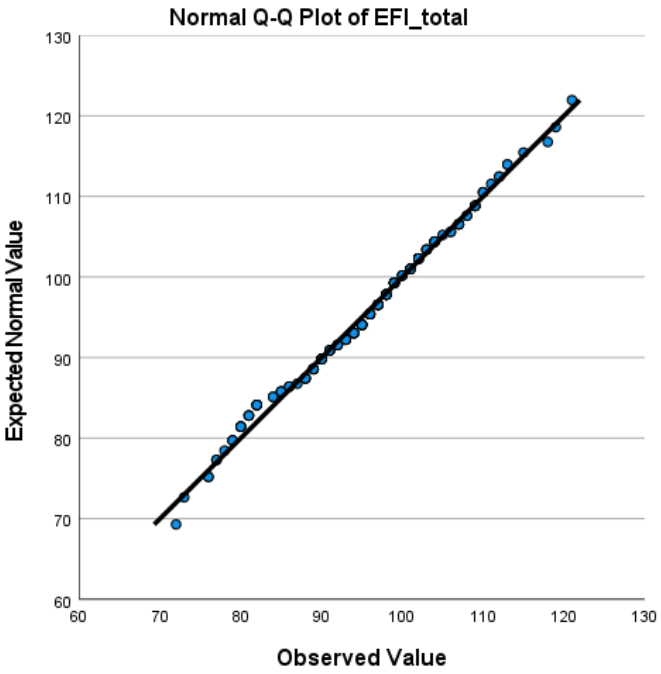


Figure 5

Q-Q Plot of EFI score



Linearity

Figure 6

Scatter plot of Cognitive SRL strategies and level of ADHD symptoms

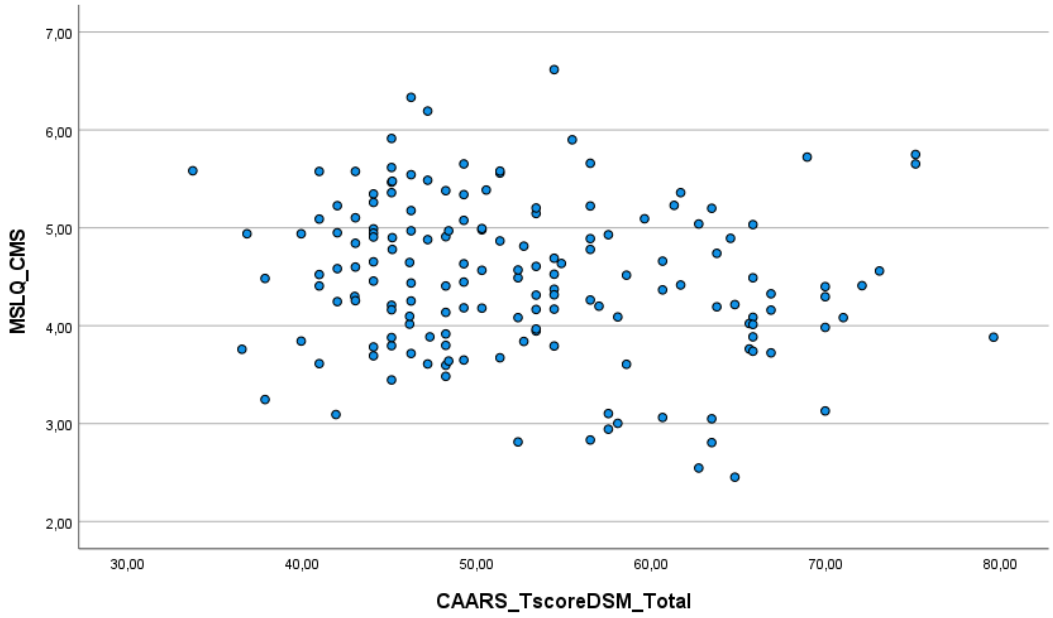
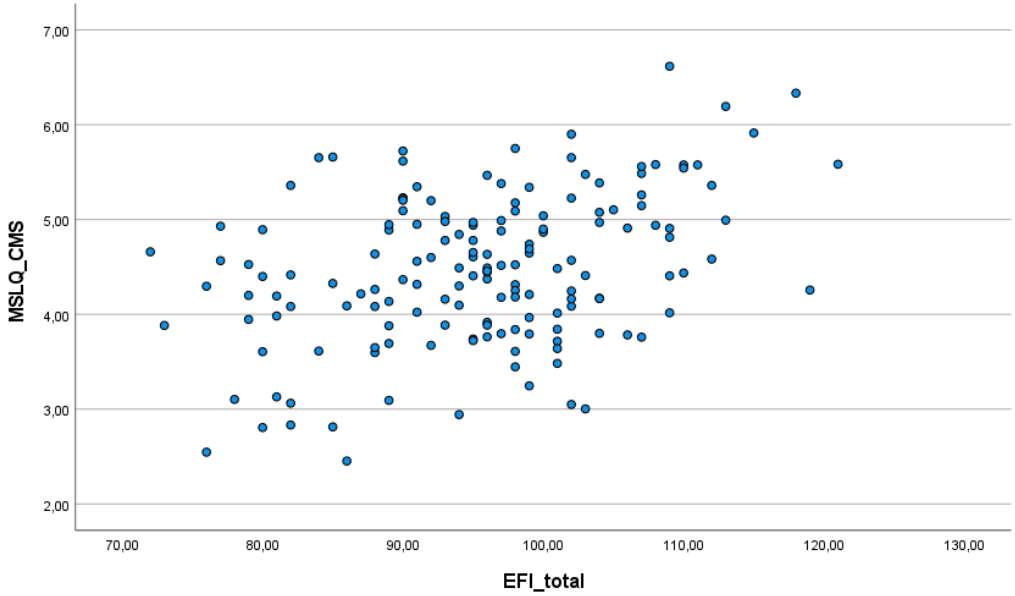


Figure 7

Scatter plot of Cognitive SRL strategies and EFI score



Reliability of used scales

Table 1

Reliability statistics for the CAARS, EFI and MSLQ

Scale	Cronbach's Alpha	N of Items
CAARS	,959	66
EFI	,750	27
MSLQ	,894	81

Distribution of ADHD symptom levels

Figure 8

Histogram showing distribution of CAARS scores