University Students with ADHD – The Impact of Executive Functions on Self-Regulated Learning Strategies

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Abstract

Going to university represents a time of major challenges and adjustments for many students. In particular, students with attention-deficit/hyperactivity disorder (ADHD) experience pronounced difficulties reflected in lower academic performance. Diminished executive functions (EFs) and self-regulated learning (SRL) strategies are also common observations in students with ADHD. To understand the mechanisms and reasons for their academic difficulties better, this study takes a closer look at these variables, postulating that EFs have a considerable influence on the way that ADHD symptoms affect SRL. Students from a Dutch university ($N = 215$) rated their level of ADHD symptoms and executive functioning, and their use of SRL strategies. The results indicated that ADHD was related to lower scores regarding only certain components of EFs and SRL. Moreover, the results provided some support for the influential role of EFs in the relationship between ADHD and SRL. Expected links between EFs and SRL strategies were also found. Overall, the findings highlighted two EFs (Strategic Planning and Motivational Drive) and two SRL factors (Self-Regulation and Value), in particular, that emerged repeatedly in significant results. In accordance with these factors, methods are proposed that could improve the functioning of SRL and EF, ameliorate ADHD symptoms, and ultimately result in better adjustment and performance in the university context.

Keywords: ADHD, students, executive functions, self-regulated learning strategies

University Students with ADHD – The Impact of Executive Functions on Self-Regulated Learning Strategies

Pursuing an education at a post-secondary institution like a university can be quite challenging in and of itself. However, this is the case all the more for individuals with attention-deficit/hyperactivity disorder (ADHD) who make up 2-8% of students in university, while up to 12% experience ADHD symptoms (Nugent & Smart, 2014). ADHD is a neurodevelopmental disorder that involves symptoms of inattention and/or hyperactivity and impulsivity and typically manifests itself in childhood but can continue its course into adulthood (American Psychiatric Association, 2013; Magnin & Maurs, 2017).

Generally, when students start their academic endeavor at a university many are at the developmental stage of transitioning from adolescents to young adults while having to navigate through new environments and social groups (Nugent & Smart, 2014). Additionally, students are confronted with increased academic demands and personal responsibility and simultaneously receive less direct support and structure from parents and teachers. All the while, their gain in independence also leaves them to deal with the allures of short-term rewards and distractions, e.g. in the form of multimedia and drug consumption, and sexual escapades.

Students with ADHD in University – An Emerging Question

Students with ADHD are, of course, not exempted from these university-contextual, developmental, and other challenges. In fact, they experience even more difficulties and under-perform academically, compared to their peers (DuPaul et al., 2021; Nugent & Smart, 2014; Weyandt et al., 2013). In their longitudinal study over four years, DuPaul et al. (2021) found that students with ADHD, compared to students without the disorder, had significantly lower grade-point averages (GPAs) enrolled for fewer semesters and applied less study skill

strategies. Moreover, they had increased anxiety symptoms and executive function deficits. Weyandt et al. (2013) found that, compared to controls, students with ADHD displayed higher levels of psychopathology with moderate to large effect sizes, as they showed significantly higher levels of depression, anxiety, hostility, and obsessive-compulsive behavior, the latter even to a clinical degree. Students with ADHD also had a more disturbed regulation of emotion and significantly lower grades. Furthermore, they employed study and organizational skills in a poorer manner, which was tied to one of the largest effect sizes in the study. Executive functions were also diminished.[1] Besides, it is more likely for students with ADHD to engage in unproductive or risky behavior, e.g. internet addiction, drug and alcohol abuse, increased cigarette smoking, and risky sexual behavior (Nugent & Smart, 2014).

As these findings lay out, individuals with ADHD may experience significant difficulties in the university context, one important area of concern being academic performance and achievement. To explore mechanisms that could account for why that is, in this paper, I will focus on the concepts of self-regulated learning and executive functions that have been hinted at above. More specifically, I want to deal with the question of the extent to which ADHD symptoms in university students affect self-regulated learning and what the influence of executive functions is in this relationship. By understanding the reasons and mechanisms that may underlie the difficulties that persons with ADHD face in university, indications could arise as to how affected individuals could be assisted and treated appropriately.

Self-Regulated Learning Strategies

[1]This observation regarding executive functions was clearer for self-reported indications than for objective measures, which were conducted for some executive function domains.

One explanation for subpar academic performance and achievements by students with ADHD could be that they use poorer self-regulated learning (SRL) strategies. What is meant by this are strategies by which one approaches and plans toward the achievement of personal learning or academic goals by controlling corresponding behavior, motivation, and cognition (Pintrich, 1995). For instance, Shelton et al. (2019) measured ADHD symptoms in university students and found that participants with inattention symptomatology indicated deficient use of all three SRL strategy factors that were assessed. These factors included (1) the expectancy of self-efficacy and the belief of individual effort impacting academic outcomes; (2) the perceived value, importance, and usefulness of academic task accomplishment; and (3) self-regulatory strategies for learning, e.g. planning, regulation, monitoring, and maintaining efforts despite distraction or lack of interest. However, hyperactivity/impulsivity symptomatology correlated positively with the SRL strategy factors of value strategies and self-regulation strategies. The authors noted that the bulk of research indicates that in university students, inattention, but not hyperactivity/impulsivity, has significant links to decreased academic skills and performance. In adulthood, the inattentive presentation of ADHD predominates, while hyperactivity and impulsivity tend to decrease (Magnin & Maurs, 2017). This is no different in (adult) university students (Lefler et al., 2021). Therefore, it is likely that most students with ADHD experience some degree of inattention symptoms and accompanying study or SRL difficulties.

Simon-Dack et al. (2016) provided another example demonstrating that students with ADHD symptoms use less effective study strategies and approaches. Students with a prevalence of ADHD symptoms that could warrant a diagnosis were significantly more likely to take a ‘surface’ study approach than a ‘deep’ one. That is, they desired to do what was necessary to pass a studied subject rather than showing intrinsic motivation and engagement

with the study material. The reasons for learning the material as well as the strategies used to learn the materiel were also superficial rather than deep among ADHD students. That is, their motivation to study was characterized by the fear of failure, they studied with a narrow target result, used rote learning, and collaborated less with peers in the study process. Control participants with no or non-significant ADHD symptoms, on the other hand, preferred the deep study approach. Hence, as the work by Simon-Dack and colleagues as well as other researchers (see e.g. DuPaul et al.; 2021; Shelton et al., 2019; Weyandt et al., 2013) indicates, deficits in SRL strategies are common among students with ADHD. On the other hand, SRL strategies are malleable and can be improved, which could in turn increase academic performance and achievement. For instance, Reid et al. (2014), found that self-regulated strategy development in schoolboys -and girls was associated with improved writing and increased planning time. Therefore, SRL strategies will be of particular interest in this paper.

Executive Functions

Executive functions (EFs) are necessary to regulate behavior contextually and uphold a response set. They include various cognitive processes such as response inhibition, planning, concept formation, flexibility, and more. EFs have been emphasized in neuropsychological theories on ADHD for decades (Mahone & Denckla, 2017; Nigg et al., 2005) and are embedded in the diagnostic criteria for ADHD (American Psychiatric Association, 2013). Among the inattentive symptoms, for instance, are frequent problems organizing tasks and activities, which entails, e.g., disorganized work, failing to meet deadlines, and being messy. A suitable example for a hyperactivity/impulsivity symptom is frequently having trouble awaiting one’s turn, e.g. in class or when waiting in line. It is consistently found that people with ADHD, including university students, have diminished EFs. For instance, Weyandt et al. (2017) found that first-year students with ADHD performed

worse than students without ADHD on EF tasks, including indices of impulse control, (sustained) attention, and vigilance, as well as on self-report EF measures. Moreover, EFs were even poorer among ADHD students if they had at least one comorbid psychiatric disorder. Use of stimulant medication, on the other hand, was associated with better EF outcomes. An intelligence assessment yielded no significant differences between groups. The authors noted that university students with ADHD may constitute a special sub-group of people with the disorder, having higher intellectual and cognitive functioning than those not attending university. Therefore, intellectual functioning did not seem to protect against EF deficits in ADHD, and Weyandt et al. (2017) pointed out links that these deficits could have with academic requirements, e.g. difficulties with task shifting leading to problems managing simultaneous demands for different classes, the job, and personal life.

Nigg et al. (2005), provided another finding of young adults with ADHD performing poorer than controls on EF tasks from a neuropsychological battery. Further, the researchers found that these deficits were uniquely linked to inattention-disorganization symptoms rather than symptoms of hyperactivity-impulsivity. Therein the authors saw support for a neuropsychological account of ADHD, postulating that at least two neural systems be involved in the disorder, with a fronto-striatal system being linked to EF deficits, and another neural network to speed, alertness and activation. Moreover, the findings were controlled for intelligence, education, sex, age, and comorbidity, which consolidates the idea of EF deficits being an integral aspect of ADHD in adulthood. Nevertheless, it is worth noting that EF deficits do by no means exclusively occur in ADHD and are associated with impairment in persons without ADHD (Dorr & Armstrong, 2019). Moreover, Dorr and Armstrong (2019) observed that better EFs could not significantly protect against the impairment associated with ADHD symptoms. That is, although EF deficits may be an important aspect of ADHD, they

are not the only source of impairment linked to the disorder and do occur in people without ADHD as well. Nevertheless, EF problems in ADHD may be implicated in the diminished academic success of affected individuals.

Self-Regulated Learning and Executive Functions Combined – Emerging Hypotheses

Garner (2009) examined relations between EFs and SRL conceptually and statistically and concluded that EFs and SRL are overlapping but distinct rather than equal concepts. EFs and SRL have the commonalities of both being goal-directed and having certain similar or related components. The EF domain of motivational drive, for instance, correlated significantly with several of the motivational factors of SRL, most notably intrinsic motivation (or intrinsic goal orientation). Moreover, impulse control, strategic planning, and motivational drive were aspects of EFs that significantly predicted SRL components of (meta-)cognitive strategy use and effort regulation. However, certain SRL components, namely control of learning beliefs, critical thinking, and affection/test anxiety, were not associated with EFs. This indicates that EFs support or contribute to processes of SRL but do not solely drive them. In the words of Garner, EFs can be conceptualized as "domain general abilities", while SRL is more of a "developing skill set" rather specific to the educational or academic context.

Sibley et al. (2019) conceptualized (goal-directed) EFs and intrinsic and extrinsic motivation to be bolstering factors for SRL, or rather even constitutive aspects of SRL. The researchers examined high-school students with and without ADHD and found that SRL was impaired in students with ADHD as they exhibited deficits in extrinsic motivation and EFs. In particular, the EF components of flexibility and meta-cognition played a key predictive role concerning GPA. Hence, whether EFs are an actual constitutive part of SRL, as denoted by Sibley and colleagues, or whether EFs and SRL are seen as distinct concepts (see Garner,

2009), EFs do seem to possess the role of critically influencing SRL processes and, as a downstream effect, potentially also academic outcomes.

As mentioned above, with the observation in mind that students in university with ADHD experience pronounced academic difficulties, in this study, EFs and SRL will be investigated in students with and without ADHD symptoms by means of self-report in an online survey. A first hypothesis is that elevated ADHD symptoms correlate with poorer SRL strategies. Likewise, I hypothesize that ADHD symptoms correlate with diminished EFs. Moreover, EFs will be examined in their role in the relationship between ADHD and SRL strategies. In other words, the underlying hypothesis here is that ADHD students have compromised EFs relative to students without ADHD symptoms and therefore make inferior use of SRL strategies. Specifically, in line with findings by Garner (2009), I expect to detect links between EF motivational drive and SRL Value (a factor including intrinsic goal orientation; Hilpert et al., 2013), as well as between EF strategic planning and SRL Self-Regulation (a factor including Metacognitive Self-Regulation).

Methods

Participants

The sample for this study comprised undergraduate psychology students from a Dutch university. To be included in the data analysis, participants had to be in the age range from 18 to 29 years. Participants were also required to have completed the study sufficiently and to have partaken in two survey projects described below. The final sample (N =215) consisted of 156 female and 59 male students (M_{age} = 19.68, SD = 1.86). Regarding first language, 51.6% were Dutch speakers, 31.2% were German speakers, and 3.7% were English speakers, while 13.5% indicated other languages. Participants were asked if they had been diagnosed with any physical, psychiatric, or neurological condition. Most answered that not to be the case

(86.5%), while 1.4% reported a diagnosis with ADHD. Besides, 0.5% were diagnosed with ADHD plus at least one more condition, and 11.6% mentioned diagnoses of other conditions. At the time of assessment, 1.4% of participants were taking medication for ADHD and 8.4% for other reasons. All included participants provided informed consent.

Procedure and Design

Data were collected in the context of previous research projects from 2020 to 2021 through an online participant pool in exchange for course credits. This time line includes the dawn of the COVID-19 pandemic. In one of these study projects, participants completed the Conner's Adult Attention-Deficit/Hyperactivity Rating Scale (CAARS; Conners et al., 1998). The CAARS is a self-report questionnaire and will serve here as a measure of one key variable, namely ADHD symptomatology.

In a second previously conducted research project, for which participants from the other project described above had been invited, participants answered a set of self-report questionnaires. Among them were the Executive Function Index (EFI; Spinella, 2005) and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991). These measures concern two further key variables in this study: EFs and SRL strategies, respectively. Participants also completed the Student Adjustment to College Questionnaire (Baker and Siryk,1989), which will be of no further interest in this paper.

A number of $N = 215$ participants was the result of the data cleaning and merging and represents the final sample of this observational study (see Appendix A for the data cleaning procedure). This research was approved by the Ethical Committee of Psychology from the Faculty of Behavioural and Social Sciences at the University of Groningen (PSY-2021-S-0054).

Measures

ADHD Symptoms

ADHD symptoms were measured with the long version of the Conner's Adult Attention-Deficit/Hyperactivity Rating Scale (CAARS; Conners et al., 1998), which quantifies ADHD symptomatology in adults. The 66 items of the CAARS are rated on a four-point scale (0 = "not at all / never", 3 = "very much / very frequently"). Additionally, an infrequency index for the CAARS was embedded in the questionnaire assessing the credibility of responses (Suhr et al., 2011), which resulted in 81 items for the CAARS in total. An example for an item evaluating inattention is: "It's hard for me to keep track of several things at once". A hyperactivity item, for instance, is: "It's hard for me to stay in one place very long." Finally, an example for an impulsivity item is: "I blurt out things". In terms of test-retest reliability, the CAARS scales have yielded significant ($p < .05$) and high (.80 to .91) correlations, and internal reliability of the CAARS scales was demonstrated to be good to excellent with coefficient alphas in the range from .86 to .92. (Erhardt et al., 1999). Regarding concurrent validity, Erhardt, et al. (1999) found that the CAARS scales were significantly correlated ($p < .001$, $r = .37$ to .67) with the total score on the Wender Utah Rating Scale (a self-report measure evaluating retrospective childhood ADHD symptoms).

Executive Functions

EFs were assessed with the Executive Function Index (EFI; Spinella, 2005), which consists of 27 items that are answered on a 5-point scale (1 = "Not at all", 5 = "Very much"). The EFI's five sub-scales are Motivational Drive (MD; e.g. "I have a lot of enthusiasm to do things"), Organization (ORG; e.g. "When doing several things in a row, I mix up the sequence"), Impulse Control (IC; e.g. "I take risks, sometimes for fun"), Empathy (EM; e.g. "I have a lot of concern for the well being of other people"), and Strategic planning (SP; e.g. "I try to plan for the future"). As regards concurrent validity, the EFI correlates strongly with

with other validated measures of self-rating EFs (Spinella, 2005). Reliability scores of the EFI's sub-scales ranged from bordering poor to acceptable values (see Table 1 for reliability scores and descriptive statistics).

Table1

Cronbach's α and Descriptives for all EFI Scales

EFI Scales	Cronbach's α	*M*	*SD*	SS
MD	0.59	3.53	0.44	14.13
ORG	0.69	3.11	0.32	15.56
IC	0.63	3.38	0.46	16.87
EM	0.70	4.32	0.54	25.89
SP	0.47	3.36	0.28	23.49

Self-Regulated Learning Strategies

The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) was used to assess SRL strategies. Participants were asked to answer the MSLQ bearing in mind their attitudes and learning strategies regarding a particular introductory psychology course. The MSLQ consists of 81 items in total, which are rated on a 7-point Likert scale (1 = "not at all true of me", 7 = "very true of me"). There are two main sections of the MSLQ with six motivation scales on the one hand, and nine learning strategies scales on the other. One motivation scale, for example, is Intrinsic Goal Motivation, which is incorporated in one of my hypotheses, and includes items such as: "In a class like this, I prefer course material that really challenges me so I can learn new things". Metacognitive Self-Regulation is an example for a learning strategies scale that I also pay closer attention to in one of my hypotheses. An example for a corresponding item is: "I ask myself questions to make sure I understand the material I have been studying in this class". For the analysis of the data, a factor structure of the MSLQ will be used that was derived through confirmatory factor analysis and is more parsimonious and clearly related to EFs (Hilpert et al., 2013). Two of these factors include the

aforementioned sub-scales of Intrinsic Goal Orientation and Metacognitive Self-Regulation. In total there are three factors: (1) Self-Regulation, which consists of the sub-scales of Metacognitive Self-Regulation and Effort Regulation, (2) Value, which comprises the sub-scales of Intrinsic Goal Orientation and Task Value, and (3) Expectancy, which includes the sub-scales of Self-Efficacy for Learning and Performance and Control of Learning Beliefs. The internal reliability values for these factors were acceptable to good. Reliability scores and descriptive statistics for all sub-scales and factors of the MSLQ can be found in Table 2. In the manual for the MSLQ (Pintrich et al., 1991), the authors demonstrated the measure's predictive validity in terms of significant and moderate correlations with final grade. Moreover, confirmatory factor analysis indicated reasonable factor validity of the MSLQ.

Table2

Cronbach's α and Descriptives for all MSLQ Scales and Factors

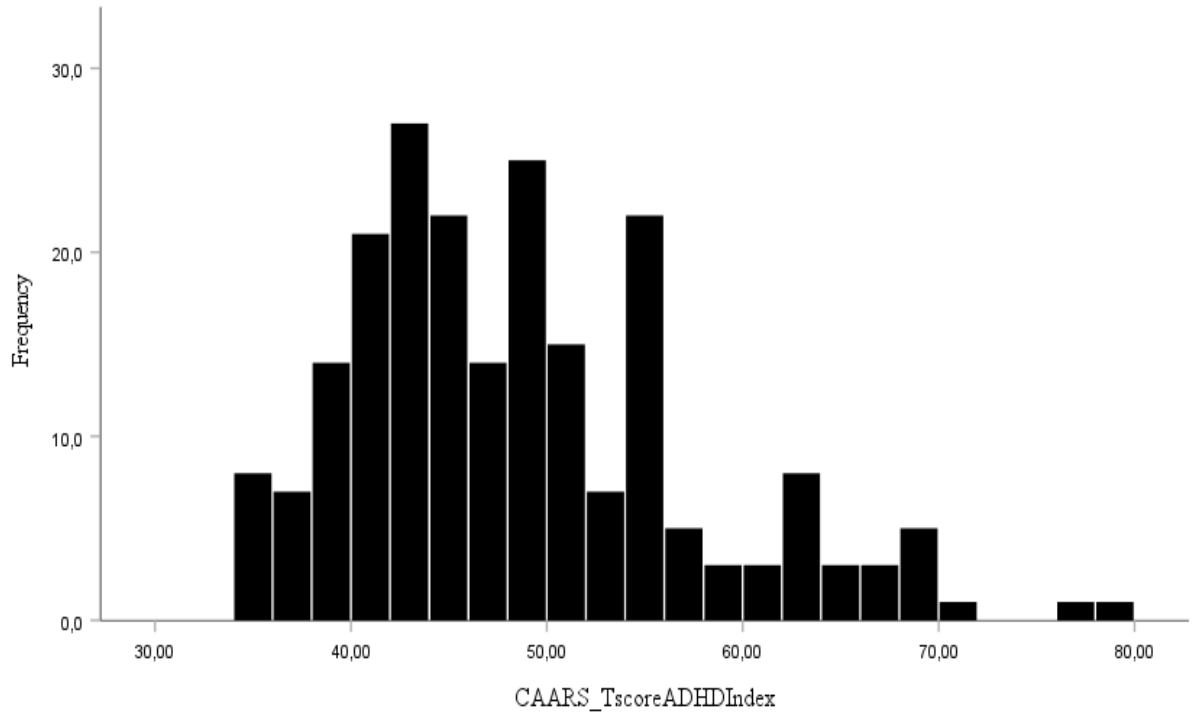
MSLQ Scales and Factors	Cronbach's *α*	*M*	*SD*	SS
Intrinsic Goal Orientation	0.55	3.40	0.45	13.60
Extrinsic Goal Orientation	0.44	3.24	0.34	12.96
Task Value	0.82	4.44	0.57	26.66
Control of Learning Beliefs	0.60	4.43	0.50	17.72
Self-Efficacy for Learning and Performance	0.75	3.98	0.55	31.87
Test Anxiety	0.35	3.31	0.38	16.55
Rehearsal	0.72	4.31	0.61	17.23
Elaboration	0.73	4.94	0.30	29.61
Organization	0.74	4.38	0.98	17.53
Critical Thinking	0.80	3.93	0.23	19.62
Metacognitive Self-Regulation	0.77	4.26	0.57	51.16
Time and Study Environment	0.76	4.81	0.644	38.47
Effort Regulation	0.72	4.77	0.34	19.08
Peer Learning	0.71	3.04	0.69	9.12
Help Seeking	0.67	3.36	0.48	13.45
Self-Regulation	0.82	4.39	0.56	70.24
Value	0.79	4.03	0.73	40.27
Expectancy	0.76	4.13	0.55	49.60

Statistical Analysis

The statistical analysis was conducted with the use of IBM Statistical Package for the Social Sciences (SPSS) Statistics 28. For all statistical tests I used an alpha level of .05. The t-scores of the CAARS ADHD index, which I used as a variable representing ADHD symptomatology, were roughly normally distributed with a slight skew to the right (M = 48.6, SD = 8.7; see Figure 1).

Figure 1

Simple Histogram of CAARS_TscoreADHDIndex



To look into the relationship between ADHD symptoms and SRL strategies as well as EFs, and to inspect hypothesized links between specific EFs and SRL strategies, I computed Pearson correlation coefficients.

To examine the relationship between SRL, ADHD, and EFs, I conducted linear regression analyses.Variance inflation factors (VIFs) were used to assess multicollineartity and values below 4 were set as a requirement to meet the assumption of collinearity. One

linear regression served to predict ADHD symptoms based on the three SRL factors. Tests of the assumption of collinearity indicated that multicollinearity was not a concern (Self-Regulation, *VIF* = 1.30; Value, *VIF* = 1.44; Expectancy, *VIF* = 1.31). Residual plots indicated appropriate homoscedasticity and normality of the residuals (see Appendix B). I used those SRL factors significantly predicting ADHD for further analysis of their association with EFs.

Results

Regarding the relationship between ADHD symptoms and SRL strategies, the correlations were negative and significant but weak concerning the SRL factors of Self-Regulation and Value (see Table 3 for all correlations). These correlations support the hypothesis that ADHD symptoms are associated with poorer SRL strategies. The correlation between ADHD symptoms and the expectancy factor was negative but non-significant and weak and did, therefore, not affirm this hypothesis.

Concerning the relationship between ADHD symptoms and EFs, there were significant and weak negative correlations between CAARS t-scores and Motivational Drive as well as Strategic Planning. These correlations provide support for the hypothesis that ADHD symptoms are related to diminished EFs. The correlation between CAARS t-scores and Impulse Control as well as the EFI total score were significant, positive and weak. Moreover, there was a very weak, positive, non-significant correlation with Empathy and a positive, strong, significant correlation with Organization. These positive or non-significant correlations contradict the hypothesis of an inverse relation between ADHD and EFs.

Table 3

Correlations Among Variables

		1	2	3	4	5	6	7	8	9	10
1	**ADHDIndex**										
2	**MSLQ_SR**	-.38**									
3	**MSLQ_V**	-.17*	.45**								

4	**MSLQ_Exp**	-.13	.35**	.46**						
5	**EFI_total**	.29**	.1	.13	-.01					
6	**EFI_IC**	.37**	-.11	.02	-.04	.58**				
7	**EFI_EM**	.02	.1	.15*	-.05	.59**	.01			
8	**EFI_MD**	-.17*	.22**	.28**	.21**	.43**	.11	.26**		
9	**EFI_ORG**	.63**	-.32**	-.16*	-.1	.51**	.42**	.07	-.15*	
10	**EFI_SP**	-.30**	.43**	.13	.04	.31**	-.29**	.26**	.12	-.32**

Note. $N = 215$. *$p < .05$; ** $p < .01$

To examine which SRL factor(s) would have the most meaningful relationship with ADHD symptom scores, I conducted a linear regression to predict ADHD symptoms based on the three SRL factors. The overall model was significant, $F(3, 443) = 11.62$, $p < .001$, with an R^2 of .14. Participants' predicted ADHD t-score was equal to 65.33 – 3.8 (SELF-REGULATION) + 0.08 (Value) - 0.03 (Expectancy). Only Self-Regulation was a significant predictor of ADHD symptomatology ($p < .001$). Moreover, out of the three SRL factors, Self-Regulation had the strongest correlation with ADHD symptomatology, as can be seen above in Table 3. Therefore, Self-Regulation represented the SRL component that was of further interest in the analysis of the relationship between ADHD, SRL, and EFs. More precisely, I tested which of the five EFI sub-scales would constitute viable predictors of SRL Self-Regulation with ADHD symptoms as a fixed factor in a forward stepwise regression. Tests of the assumption of collinearity showed that multicollinearity was not a concern regarding the proposed final model (ADHD Index T-Score, *VIF* = 1.12; Strategic Planning, *VIF* = 1.11; Motivational Drive, *VIF* = 1.03). Residual plots indicated appropriate homoscedasticity and normality of the residuals (see Appendix C).The overall model was significant, $F(3, 211) = 26.12$, $p < .000$, with an R^2 of .27. Participants' predicted SRL Self-Regulation score was equal to 2.95 – 0.03 (ADHD) + 0.09 (STRATEGIC PLANNING) + 0.06 (MOTIVATIONAL DRIVE). The ADHD index ($p < .001$), Strategic Planning ($p < .001$), and Motivational Drive

(p = .026) were all significant predictors of SRL Self-Regulation, whereas Impulse Control, Motivational Drive, and Organization were excluded from the model. These regression analyses provide some support for the hypothesis that EFs are involved in the relationship between ADHD and SRL in that certain EFs accounted for additional variance on top of ADHD symptoms to explain SRL.

With respect to hypothesized links between particular EFs and SRL strategies, indeed, EF Motivational Drive and the SRL factor of Value were correlated positively and significantly, but weakly (see Table 3). Moreover, as expected, EF Strategic Planning and the SRL factor of Self-Regulation had a positive, significant, and moderate correlation. Therefore, these hypothesized associations were supported by the results.

Discussion

Looking into the relationships between ADHD, EFs, and SRL is quite complex because these variables are multifaceted and are partially overlapping. EFs lack a universal definition and incorporate many cognitive processes (Barkley, 1997). SRL refers to numerous strategies pertaining to behavioral, motivational, and cognitive control toward the achievement of a learning goal (Pintrich, 1995). ADHD has two dimensions of symptoms, whose predominance varies by age (Magnin & Maurs, 2017) and seems to be differentially related to the variables of EFs (Nigg et al., 2005) and SRL (Shelton et al., 2019). This study used a systematic statistical approach to contribute to the understanding of the complex relations between EFs, SRL, and ADHD. The question therein was to what extent ADHD symptoms in university students affect SRL and what the influence of EFs is in this relationship. Indeed, in this thesis I found complex relations between these constructs that give useful implications and are detailed in the following section.

The first hypothesis was that ADHD would negatively correlate with SRL strategies, which the results partially supported. Two SRL factors, namely Self-Regulation and Value, did correlate negatively and significantly with ADHD, whereas a third SRL factor, Expectancy, did not correlate significantly with ADHD. Related to SRL Self-Regulation, the results suggest that students with ADHD symptoms may have difficulties planning, regulating, and monitoring their learning and maintaining effort. With respect to SRL Value, the results indicate that students with ADHD symptoms may find the accomplishment of academic tasks not very important and useful. Regarding SRL Expectancy, the results imply that students with ADHD symptoms did not differ from students without symptoms in perceived self-efficacy and the belief that individual effort would have an impact on academic outcomes. In my analysis, I looked at ADHD holistically. In contrast, Shelton et al. (2019) considered symptomatic presentation of ADHD in their study and found that inattention symptomatology was related to deficits regarding the SRL factors. However hyperactivity/impulsivity symptomatology was positively associated with SRL. Therefore, the findings of Shelton and colleagues and this study can not be compared one-to-one. One commonality is, however, that the SRL factors seem to be related to ADHD differentially and not merely in an inverse fashion.

Expectancy, which is the SRL factor that did not correlate significantly with ADHD in this study, includes two sub-scales, one of which is Control of Learning Beliefs. Interestingly, Garner (2009) found that this exact component of SRL was not associated with EFs, which she interpreted as part of the evidence that EFs support but not exclusively drive processes of SRL as these are overlapping but distinct concepts. The finding that this SRL factor also did not correlate with ADHD actually corroborates the idea that EFs may play a mediating role here, or at least that these three variables are interrelated.

My second hypothesis was that ADHD symptomatology would correlate with diminished EFs. That was indeed the case for the EF components of Strategic Planning and Motivational Drive, for which significant negative correlations could be determined. Hence, with respect to these two areas of EFs, the results are in line with previous findings of lower scores on self-report but also laboratory measures of EFs in university students with ADHD symptoms compared to those without symptoms (Weyandt et al., 2013, 2017). However, in our study, the correlation between ADHD and EF Empathy was non-significant and positive. Perhaps a significant association between ADHD and EF Empathy could not be established in our sample of psychology students because care for and interest in human behavior is central to psychology (and its students with or without ADHD). The EF components of Impulse Control and Organization as well as the EFI total score even had significant positive correlations with ADHD. These correlations contradict my hypothesis. One conceivable reason for these unexpected findings could be that I did not take the distinction between symptoms of inattention and hyperactivity/impulsivity into account in my analysis. EF deficits are more uniquely related to inattention symptomatology rather than hyperactivity/impulsivity (Nigg et al., 2005). Another explanation of these unexpected findings could also be related to our sample of psychology students. Since these students probably chose their study because they are interested in psychology, they may be already better informed about ADHD, a subject related to psychology, especially if they have symptoms or even a diagnosis of ADHD themselves. Consequently, they might have acquired strategies to compensate for their deficits and be able to mask or even rectify them. Moreover, a high IQ (IQ $\geq$ 110) may also compensate for EF deficits, as Milioni et al. (2017) found that among adults with ADHD, a higher IQ is associated with fewer EF deficits in contrast to a standard IQ.

The third hypothesis about the influencing role of EFs between ADHD and SRL strategies could be substantiated, at least with certain components of EFs and SRL – namely Strategic Planning and Motivational Drive for EFs and Self-Regulation for SRL. In the analysis involving all three key variables, Self-Regulation resulted as the SRL factor that was most closely related to ADHD symptoms. It was the best SRL predictor of ADHD symptoms and correlated most strongly with ADHD symptoms compared to the other two SRL factors. Furthermore, the EF components of Strategic Planning and Motivational Drive resulted as relevant predictors of SRL Self-Regulation above and beyond the impact of ADHD. This provides support for the hypothesis that EFs, or at least some of them, play a role in the relation between ADHD and the self-regulatory aspect of SRL.

The fourth hypothesis that there would be a significant associations between EF Motivational Drive and the SRL Value factor was supported by the results. This is in line with Garner's (2009) work, who found a significant relationship between EF Motivational Drive and Intrinsic Goal Orientation, which is a sub-scale that is included in the Value factor of SRL. Moreover, the results supported the hypothesis of a significant link between EF Strategic Planning and the SRL Self-Regulation factor. This is also in agreement with Garner (2009), who found a significant association between EF Strategic Planning and Metacognitive Self-Regulation, which is a sub-scale that is included in the Self Regulation factor of SRL. These findings affirm the idea that there is a predictable interplay between EFs and SRL, or at least aspects of them, that might apply to deficits associated with ADHD.

Theoretical and Practical Implications

In this thesis, connections between the constructs of ADHD, EFs, and SRL were revealed that are in line with my hypotheses and give useful implications. The EFs of Strategic Planning and Motivational Drive were significantly related to the SRL factors of

Self-Regulation and Value. ADHD correlated negatively with all these EF and SRL components. This implies that improvement in these EFs may go hand in hand with improvement in the according SRL strategies, and vice versa. The findings also imply that ADHD symptoms may ameliorate, consequently. Stimulant medication is one way through which EF outcomes may be improved in students with ADHD (Weyandt et al., 2017). Cognitive training may also be a remedial action and can be adjusted to the relevant EF. For instance, regarding EF Strategic Planning, which involves thinking ahead, planning, and strategy use (Spinella, 2005), complex planning exercises could be applied. EF Motivational Drive, on the other hand, refers to novelty interest, activity level, and behavioral drive. Deficits in this domain may be targeted with motivational interventions or even therapeutic approaches such as behavioral activation (Barlow, 2021). Alternatively, or additionally, SRL strategies may also be directly developed and trained. Perhaps it would even be sensible to include SRL strategy development in the university curriculum, as these strategies are of importance to all student. However, students with ADHD may need additional support. There is some evidence that SRL strategy development may improve writing in school-aged students with ADHD (Reid et al., 2014). However, more research into the development and training of SRL strategies for university students with ADHD is needed. There is also a need for further research on whether improvement of EFs and/or SRL strategies, may result in better academic outcome and decreased difficulties in the university context for students with ADHD.

Strengths and Limitations

This is the first study that investigates the three variables ADHD, EFs, and SRL together and relates them to one another, while previous research commonly focused on a constellation of two of these variables. Moreover, we used validated questionnaires measuring

these three variables and included checks of serious responding and reliability embedded in these measures. Responses on the MSLQ (Pintrich et al., 1991), our measure of SRL strategies, were analyzed using an improved factor structure (Hilpert et al., 2013). Despite these strengths, some limitations should be considered.

One limitation is that, with the EFI (Spinella, 2005), we only used a self-report measure of EFs. Including data from informant consultation or objective measures, that is cognitive tasks regarding EFs, could make the assessment more complete. For instance, Fuermaier et al. (2015) found that in a cognitive evaluation of adults with ADHD the effect sizes were larger for self-report measures than for objective measures. Moreover, subjective and objective measures failed to predict each other although both measures indicated significant cognitive deficits. The authors concluded that both types of measurement may provide important and distinct information that complements each other.

A second limitation is that the results of this study were not controlled for the distinction between inattentive and hyperactive/impulsive symptomatology of ADHD. Instead, I conducted a more holistic analysis of ADHD. Shelton et al. (2019) found that hyperactivity/impulsivity had positive correlations with the SRL factors, whereas inattention symptomatology was related to deficient use of SRL strategies regarding all factors. Nigg et al. (2005) found that EF deficits were uniquely related to inattention symptoms rather than hyperactivity/impulsivity symptoms. This indicates that the symptomatic presentation of ADHD should be considered when analyzing associations with EFs and SRL. A larger sample size than ours of N=215 might be appropriate for such analyses.

Another point is that the MSLQ was administered to the participants soon after the initiation of their study. At that point, they were probably in the process of getting acquainted with student life and might have been developing their SRL strategies still. In future studies,

an SRL strategy assessment could take place at a later point as well to evaluate possibly established SRL strategies. For this purpose, a longitudinal study may be suitable to investigate the development of or change in SRL strategies among students closer over the long term.

Finally, our participants may not be representative of all university students, e.g. in terms of sex ratio. Rather, our sample represents predominately female first-year psychology students at a Western university. Therefore, the generalizability of our findings does not extend to the clinical population, e.g. because of age. Other reasons are that we adopted a dimensional approach to ADHD and did not exclusively examine individuals who have an official diagnosis of ADHD. Moreover, those with ADHD attending university may have higher intellectual functioning than those who do not go to university (Weyandt et al., 2017).

Conclusions

Taken together, many links between ADHD symptoms in university students, EFs, and SRL strategies could be established in this study that concur with the findings of previous research. There were some contradicting findings regarding these variables in this study, however, that point to the intricacy of this topic and suggest that aspects such as inattentive versus hyperactive/impulsive symptomatology should be controlled for in future studies. In general, two EF components, Strategic Planning and Motivational Drive, and two SRL factors, Self-Regulation and Value, yielded significant associations with each other and with ADHD. The typology of these variables indicates that students with ADHD, and their academic performance, may benefit from cognitive training, planning exercises in particular, motivational and activating interventions, learning strategy development, and stimulant medication. The findings, furthermore, reinforce the idea that EFs may function as a relevant factor in the relationship between ADHD and SRL.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed). Arlington: American Psychiatric Publishing

Baker, R. W., & Siryk, B. (1989). Student Adaptation to College Questionnaire (SACQ). Los Angeles, CA: Western Psychological Services.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Barlow, D. H. (2021). *Clinical Handbook of Psychological Disorders : A Step-by-Step Treatment Manual: Vol. Sixth edition*. The Guilford Press.

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

Dorr, M. M., & Armstrong, K. J. (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

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

Erhardt, D., Epstein, J. N., Conners, C. K., Parker, J. D. A., & Sitarenios, G. (1999). Self-ratings of ADHD symptoms in adults: II Reliability, validity, and diagnostic sensitivity. *Journal of Attention Disorders*, *3*(3), 153–158. https://doi-org.proxy-ub.rug.nl/10.1177/108705479900300304

Fuermaier, A. B. M., Tucha, L., Koerts, J., Aschenbrenner, S., Kaunzinger, I., Hauser, J., Weisbrod, M., Lange, K. W., & Tucha, O. (2015). Cognitive impairment in adult ADHD—Perspective matters! *Neuropsychology*, *29*(1), 45–58. doi:10.1037/neu0000108

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

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), 2158244013510305. https://doi.org/10.1177/2158244013510305

Lefler, E. K., Flory, K., Canu, W. H., Willcutt, E. G., & Hartung, C. M. (2021). Unique considerations in the assessment of ADHD in college students. *Journal of Clinical and Experimental Neuropsychology*, *43*(4), 352–369. https://doi.org/10.1080/13803395.2021.1936462

Magnin, E., & Maurs, C. (2017). Attention-deficit/hyperactivity disorder during adulthood. *Revue Neurologique*, *173*(7), 506–515. https://doi.org/10.1016/j.neurol.2017.07.008

Mahone, E. M., & Denckla, M. B. (2017). Attention-Deficit/Hyperactivity Disorder: A Historical Neuropsychological Perspective. *Journal of the International Neuropsychological Society*, *23*(9–10), 916–929. https://doi.org/10.1017/S1355617717000807

Milioni, A. L. V., Chaim, T. M., Cavallet, M., de Oliveira, N. M., Annes, M., dos Santos, B., Louzã, M., da Silva, M. A., Miguel, C. S., Serpa, M. H., Zanetti, M. V., Busatto, G., & Cunha, P. J. (2017). High IQ may “mask” the diagnosis of adhd by compensating for

deficits in executive functions in treatment-naïve adults with ADHD. *Journal of Attention Disorders*, *21*(6), 455–464. https://doi-org.proxy-ub.rug.nl/10.1177/1087054714554933

Nigg, J. T., Stavro, G., Ettenhofer, M., Hambrick, D. Z., Miller, T., & Henderson, J. M. (2005). Executive functions and adhd in adults: Evidence for selective effects on ADHD symptom domains. *Journal of Abnormal Psychology*, *114*(4), 706–717. https://doi.org/10.1037/0021-843X.114.3.706

Nugent, K., & Smart, W. (2014). Attention-deficit/hyperactivity disorder in postsecondary students. *Neuropsychiatric Disease and Treatment*, *10*, 1781–1791. https://doi.org/10.2147/NDT.S64136

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., & Others, A. (1991). *A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. https://eric.ed.gov/?id=ED338122

Prevatt, F., Proctor, B., Best, L., Baker, L., Van Walker, J., & Taylor, N. W. (2012). The Positive Illusory Bias: Does It Explain Self-Evaluations in College Students With ADHD? *Journal of Attention Disorders*, *16*(3), 235–243. https://doi.org/10.1177/1087054710392538

Reid, R., Hagaman, J. L., & Graham, S. (2014). Using self-regulated strategy development for written expression with students with attention deficit hyperactivity disorder. *Learning Disabilities: A Contemporary Journal*, *12*(1), 21–42.

Shelton, C. R., 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

Sibley, M. H., Graziano, P. A., Ortiz, M., Rodriguez, L., & Coxe, S. (2019). Academic impairment among high school students with ADHD: The role of motivation and goal-directed executive functions. *Journal of School Psychology*, *77*, 67–76. https://doi.org/10.1016/j.jsp.2019.10.005

Simon-Dack, S. L., Rodriguez, P. D., & Marcum, G. D. (2016). Study Habits, Motives, and Strategies of College Students With Symptoms of ADHD. *Journal of Attention Disorders*, *20*(9), 775–781. https://doi.org/10.1177/1087054714543369

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

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

Weyandt, L., DuPaul, G. J., Verdi, G., Rossi, J. S., Swentosky, A. J., Vilardo, B. S., O'Dell, S. M., & Carson, K. S. (2013). The Performance of College Students with and without ADHD: Neuropsychological, Academic, and Psychosocial Functioning. *Journal of Psychopathology and Behavioral Assessment*, *35*(4), 421–435. https://doi.org/10.1007/s10862-013-9351-8

Weyandt, L. L., Oster, D. R., Gudmundsdottir, B. G., DuPaul, G. J., & Anastopoulos, A. D. (2017). Neuropsychological functioning in college students with and without ADHD. *Neuropsychology*, *31*(2), 160–172. https://doi.org/10.1037/neu0000326

Appendix A

Data Cleaning Procedure

For the first study project, which included the CAARS, the number of recorded answers was $N = 451$. The desired age range for this study, however, reached from age 18 to 29. Therefore, seven participants under the age of 18 and three participants over 29 years of age were excluded. Nine additional participants were excluded for whom scores were missing. Scores of eight or greater on the CAARS's inconsistency index, suggesting inconsistent responses across similar items, prompted us to exclude 73 further participants. Finally, 11 more participants were excluded, as they scored 21 or higher on the infrequency index of the CAARS, which indicates non-credible, exaggerated responses (Suhr et al., 2011). Hence, we arrived at a number of $N = 348$ participants for this dataset. In the dataset of the second study project $N = 323$ responses were initially listed. However, we excluded 19 participants from this dataset with missing values and three further participants who admitted to not having responded honestly, resulting in 301 participants for this dataset.

After cleaning both datasets as described above, we merged them. For the purpose of this study, those participants were of interest who had scores for all three key variables (ADHD symptoms, EFs, and SRL strategies) measured in the two datasets. From the merged dataset we, therefore, excluded 84 participants who did not have ADHD symptom scores as measured by the CAARS. Conversely, we excluded 133 participants who had no EF and SRL strategy scores. Two additional responses had to be deleted because of matching complications.

Appendix B

Residual Plots Regarding the Linear Regression Predicting ADHD Symptomatology Based on the Three SRL Factors Self-Regulation, Value, and Expectancy

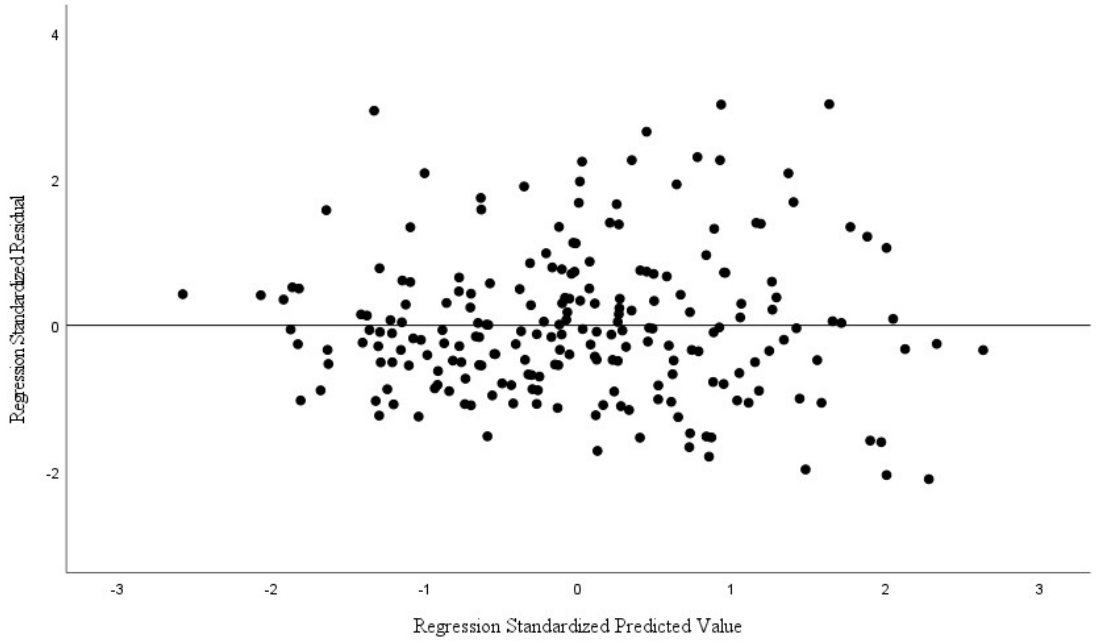


Figure B1. Residual vs. predicted plot indicating homoscedasticity

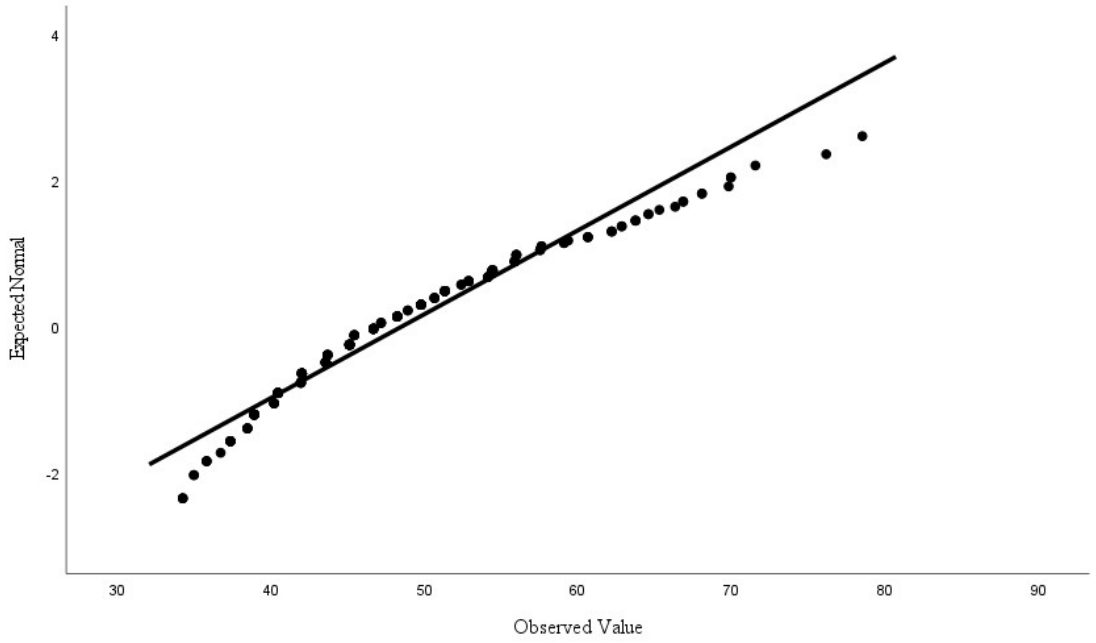


Figure B2. Normal Q-Q plot of CAARS_TscoreADHDIndex indicating normality of residuals

Appendix C

Residual Plots Regarding the Forward Stepwise Regression Predicting Self-Regulation with ADHD symptoms as Fixed Factor and EFI Sub-Scales as Predictors

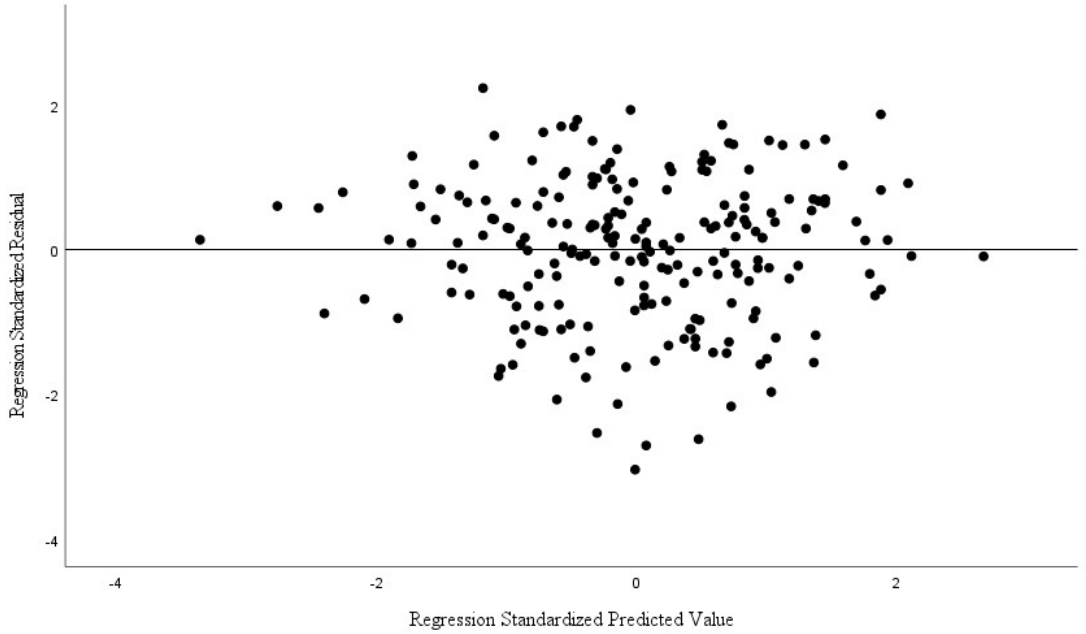


Figure C1. Residual vs. predicted plot indicating homoscedasticity

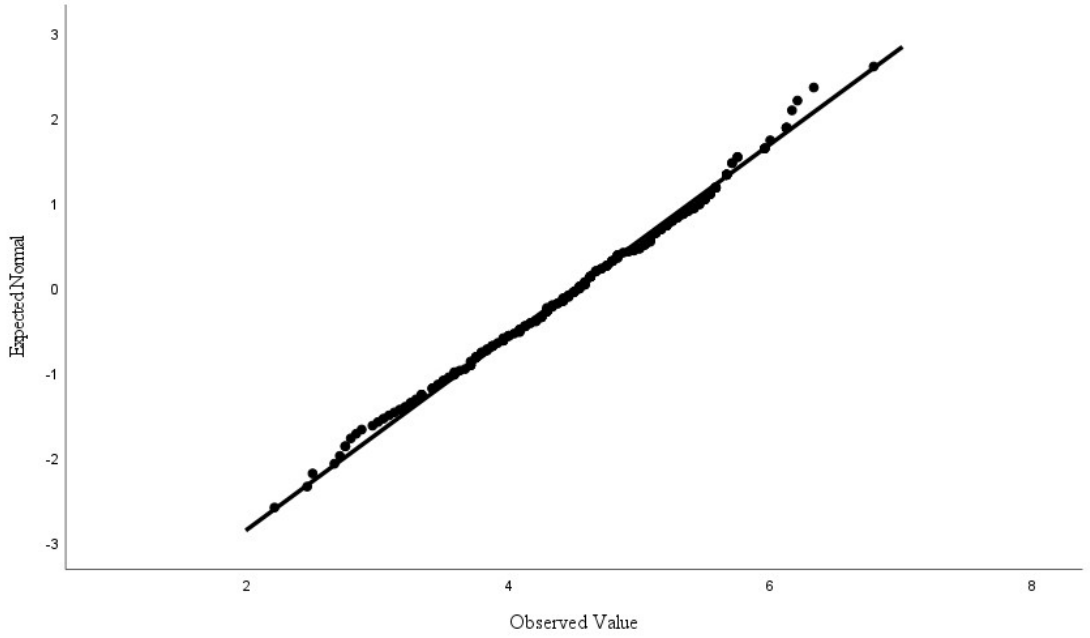


Figure C2. Normal Q-Q plot of MSLQ_Factor_SelfRegulation indicating normality of residuals