The Role of Executive Functions and Self-Regulatory Learning Skills in Students with ADHD Symptomology

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PSB3E-BT15: Bachelor Thesis

Group number 10

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April 16th, 2023

Abstract

Objective: Attention deficit and hyperactivity/impulsivity disorder (ADHD) has been linked to deficits in executive functioning and problems in self-regulation. For university students who want to achieve in an academic setting, those deficits and problems can influence their ability to succeed. To provide them with the necessary support, it is important to identify such challenges. This study aimed to investigate the influence of executive functioning (strategic planning and organization) and self-regulated learning strategies (cognitive learning strategies) on students who present with ADHD symptomology. Additionally, it was investigated how ADHD symptom clusters of inattention and hyperactivity/impulsivity relate to cognitive learning strategies, strategic planning and organization. **Method:** The study utilised a participant pool of first-year psychology students (N = 160) who completed the Conners' Adult ADHD Rating Scale, the Executive Functioning Index scale and the Motivated Strategies for Learning Questionnaire. The data was analysed using bivariate Pearson correlations and partial correlation. **Results:** Our results showed a significant correlation between ADHD symptomology and each executive functioning scale used, not influenced by the other executive functioning scale. The executive functions showed significant influence over the correlation between cognitive learning strategies and ADHD symptomology. Especially over the inattention symptom cluster. **Conclusion:** This paper corroborates previous findings regarding deficits in executive functioning and self-regulated learning strategies in students with ADHD symptoms. Furthermore, the results highlight the differences between ADHD symptom clusters. They suggest that executive functions only significantly influence the relation between inattentive ADHD symptoms and cognitive learning strategies.

Keywords: Executive Functions, Self-Regulated Learning, Attention Deficit and Hyperactivity/Impulsivity Disorder (ADHD), Students

What is the Role of Executive Function and Self-Regulatory Learning Skills in Students with ADHD Symptomology

Life consists of many transitions. One of these transitions for an individual is the change from school life to university life. With those changes often come along great challenges that university students have to face in their first year (Martin et al., 2006). Challenges that include demanding tasks such as getting settled in, organizing themselves, handling the increase in workload and meeting deadlines. These changes often cause great stress (Bayram & Bilgel, 2008; Howard et al., 2006) and emotional difficulty (Dyson & Renk, 2006), especially if students lack the needed resources or skills for coping. During those times students can become even more stressed, depressed and anxious (Bayram & Bigel, 2008; Howard et al., 2006). Having been put in an unfamiliar environment, many first-year students might struggle with the skills necessary to self-regulate their behaviour (Brown, 2003). According to Brown (2003), this might be the case because they don't know how to properly approach their goals, effectively use their resources, or how to organize themselves. Away from their usual routine and support systems, they need to adapt to keep their confidence, motivation and awareness to succeed in the academic setting (Pirozzi, 2021).

For students with ADHD symptoms, these transitions can be even more difficult as they hold the potential to exacerbate the symptoms that makeup Attention-Deficit/Hyperactivity Disorder (ADHD; American Psychiatric Association, 1994, 4th edition) symptomology (Suhr et al., 2008). These symptoms commonly include a pattern of inattention, concentration problems, hyperactivity or impulsivity (American Psychiatric Association, 1994, 4th edition). In recent years the numbers of university students who meet the full ADHD diagnostic criteria (Lee et al., 2008) and those with significant ADHD symptoms but who do not meet all of the necessary diagnostic criteria (DuPaul et al., 2001), have increased. According to self-report measures, two to eight percent of students present

with significant symptomology (Blasé et al., 2009; Weylandt & DuPaul, 2006). Hereby it should be noted, that most of those studies relied on self-reported ADHD symptoms which are not necessarily specific enough and greatly overlap with the symptomology of other disorders (Harrison, 2004; Suhr et al., 2009; Suhr et al., 2008).

To provide students with appropriate support, is it important to identify their areas of deficits.

ADHD in Adults/University Students and Executive Functions

Generally, it is assumed that ADHD symptoms influence executive functioning skills that are necessary to handle several of the challenges put forward by academic and university life (Dvorsky & Langberg, 2019). Executive functions hold universal importance, be it in the academic setting or daily life (Dvorsky & Langberg, 2019; Zhang et al., 2021). Previous studies already showed that they can quite possibly even be a mediator between ADHD symptoms and quality of life (Zhang et al., 2021). Executive functions broadly describe the systems necessary for motivational drive, strategic planning, organization, impulse control, and empathy (Spinella, 2005), only differing slightly based on which measurement was used. Studies have shown that university students with ADHD do suffer from deficits in executive functioning skills (Vélez-Pastrana et al., 2016; Dehili et al., 2017). However, those studies utilised different executive functioning scales than those used in this paper. Therefore, the definition of executive functioning differs slightly. That does not mean however, that all individuals with ADHD symptoms also present with executive functioning deficits (Doyle, 2006; Jonsdottir et al., 2006; Stavro et al., 2007; Spinella, 2005). Those that do present with executive functioning deficits, exhibit them regardless of which symptom cluster they present with (Carella, 1998).

ADHD Symptoms, Executive Functions and Functional/Academic Impairment

Studies have shown ADHD symptoms in students to be negatively related to study skills and adjustment to academic life (Norwalk et al., 2009). Thus, suggesting that students with ADHD face greater problems in the academic setting than their peers without ADHD symptoms (Norwalk et al., 2009). Interestingly, when comparing the different symptom clusters of ADHD, the inattention symptoms presented with greater difficulties in the academic setting (Norwalk et al., 2009, Wolf et al. 2009), as opposed to the hyperactivity/impulsivity symptoms cluster for which no links to academic deficits were found (Reaser et al., 2007; Shelton et al., 2019). However, the hyperactive/impulsive symptoms cluster showed greater behavioural and social problems (Wolf et al., 2009). An increase in ADHD symptomology showed to predict higher levels of impairment (Dorr & Armstrong, 2019). In contrast to that, higher levels of executive functioning were shown to be related to a decrease in functional impairments (Dorr & Armstrong, 2019). Even without testing positive for ADHD symptomology, if an executive dysfunction is present, the individual will suffer impairments correlational to the level of dysfunction (Dorr & Armstrong, 2019). University students who present with ADHD symptomology appear to have difficulties with the executive functioning skill of organization in particular. This is demonstrated by their difficulty in choosing and connecting main ideas during tasks, which is likely due to a lack of focus and concentration (Reaser et al., 2007; Newman, 2022). They further spend less time rehearsing and mainly rely on single-item recall instead of multi-recall during learning (O'Neill & Douglas, 1996). The rehearsal processes appear slightly poorer compared to individuals without ADHD symptomology (Alderson et al., 2013). Executive functioning has further been shown to highly impact the behaviour responsible for self-regulation (Hofmann et al., 2012).

Self-Regulated Learning, Academic Achievement and Executive Functions

In comparison to students without ADHD, students with ADHD appear to have difficulties in choosing self-regulated learning strategies that are effective (Reaser et al., 2007). Research suggests that executive functioning may impact the self-regulated learning strategies that university students choose (Reaser et al., 2007; Newman, 2022).

Self-regulated learning and our understanding of it has been pioneered by P.R.Pintrich (1991). He conceptualized the idea that self-regulated learning is regulated by four different categories; (1) cognitive, (2) metacognitive, and (3) resource management, as well as (4) motivation (Pintrich et al., 1993).

By modifying behaviour to achieve goals (Hofmann et al., 2021) self-regulated learning has been found to be connected to a variety of domains, such as addiction, emotional states (Wolters, 2010; Baumeister & Vohs, 2004), as well as academic achievement (Cleary et al., 2021). Each category and process that makes up self-regulated learning holds influence over the academic achievements of students by regulating the skills necessary in the academic context (Cleary et al., 2021). Cognitive learning strategies, for example, refer to processes that use skills such as rehearsal, organization or the use of strategies (Pintrich et al., 1991; Cleary et al., 2021). Being adept at regulating those skills in turn, influences academic success (Cleary et al., 2021). Here, one can see an overlap in concepts between self-regulated learning and executive functions through their shared use of components. The executive functions of planning, motivational drive and impulse control even showed to be significant predictors of cognitive learning strategies (Garner, 2009). While the concepts show to be related, the specifics of the relationship are still not clear (David et al., 2021). Davies et al. (2021), even proposed the idea that executive functioning might be the antecedent of self-regulated learning or they are perhaps just different views of what is simply the same construct. In the interest of providing students with the necessary support they need to excel in the academic

setting, it is important to exactly identify what students appear to show deficits in and what kind of interventions they would most profit from. This holds the potential to improve a student's quality of life and academic achievements (Zhang et al., 2021; Dvorsky & Langberg, 2019).

The Present Study

This study chose to focus on the executive functioning subscale of organization because previous research indicated this subscale to show greater links to ADHD symptomology (Reaser et al., 2007; Newman, 2022). Strategic planning was chosen because so far research has mostly been focused on children regarding the relationship between strategic planning and ADHD (Kofman et al., 2008; Reaser et al., 2007; Newman, 2022). Therefore, this study aims to investigate this relationship in an adult sample. Cognitive learning strategies were selected because of their apparent overlap with strategic planning and organization (David et al., 2021).

This study is attempting to explore the research question: How do organizational and strategic planning skills relate to cognitive/metacognitive learning strategies in university students with ADHD symptomology? For the sake of simplicity, this paper will only use the term cognitive learning strategies when referring to all cognitive subscales, including metacognitive self-regulation. To investigate this research question, the study employs a correlational, dimensional approach, making use of a participant pool consisting of a non-clinical group of first-year psychology students. The participants were asked to complete questionnaires to determine their respective ADHD symptomology (CAARS; Connors, 1998), their executive functioning skills (EFI; Spinella, 2005) and their self-regulated learning (MSLQ; Pintrich et al., 1993).

This study proposes the hypotheses that (1): A) ADHD symptomology is negatively associated with strategic planning and organization, B) both executive functioning are

independent of each other related to ADHD symptomology (2): A) Cognitive learning strategies are positively associated to strategic planning and organization and negatively to ADHD symptomology, B) both subscales of executive functioning hold significant influence over the relationship between cognitive learning strategies and ADHD symptomology.

Additionally, this study explores potential differences in ADHD symptom clusters on cognitive learning strategies and executive functions. Based on previous findings, the study proposes the hypothesis that (3) the second hypothesis is only significant for inattentive ADHD symptoms and not for hyperactive/impulsive symptoms regarding cognitive learning strategies.

Method

Participants

For this study, participants were recruited from a pool of first-year psychology students of the University of Groningen. This study consists of two surveys which were administered at two separate times. Only participants who completed both surveys were included in the analysis. Out of the n = 303 people that participated in the first survey, and the n = 257 that participated in the second one, only N=160 were included in this study. To participate in this study, the students had to be enrolled in the course 'Introduction to Psychology' which is a mandatory course for all first-year psychology students. If the participant gave consent to look up their grades for this specific course, the data will be used in other studies regarding academic achievement. Additionally, sufficient command of the English language was required. Ultimately, data was excluded if the participant was under the age of 18 or did not identify as either woman or a man since the norm scores of the CAARS are not equipped to properly assess those cases. Data was further excluded if participants did not complete both surveys properly or failed the check-up questions which required their

attention. Data was also excluded according to the cut-off scores of the Infrequency and the Inconsistency Index of one of the measures (see CAARS).

The final sample consisted of $N = 160$ participants with ages ranging from 18 years to 35 years old *(*$M = 19.7$*,* $SD = 2.1$*)*. Of these participants, $n = 128$ identified as women, and $n = 32$ identified as men. The sample presents as predominantly European with the majority being either Dutch or German.

All the participants for this study were recruited through SONA. This is an online research platform where students can participate in scientific research in exchange for credits, as part of a course. Before participating, all participants were informed of their rights, the 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 has a correlational design and investigates connections between levels of ADHD symptoms, executive functioning and cognitive learning strategies through the use of quantitative analysis methods. As such, we made no predictions about the causality of these associations. A correlational analysis was chosen to reflect the dimensional nature of the studied variables. This approach allowed us to analyze the differences in the strength of association between ADHD, executive functions and different cognitive self-learning strategies in a more nuanced way. This is further relevant because of the 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. Using Qualtrics, they completed multiple surveys measuring

their executive functioning and 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 both surveys was estimated to be around 100 minutes. After participants completed the second survey, they were compensated with SONA credits for their participation. The study was available on SONA from January 25th until February 14th 2023. Participants were free to sign up for and complete the study at any time within this period.

Measures

CAARS

The Conners' Adult ADHD Rating Scales (CAARS) is used to measure the ADHD-symptoms. The CAARS is a self-rating scale intended for adults aged 18 and up who present with ADHD symptoms (Conners et al., 1998). It makes use of a four-point Likert scale (from 0 = *never* to 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. It consists of 66 items which represent nine different subscales. The long form of the CAARS will take most adults approximately less than 30 minutes.

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).

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 symptomology 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.”.

The total score of the CAARS varies between 0 and 198. For the analysis, the raw scores of the CAARS subscales first had 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 enables the comparison of subscale results. A norm score was used to transform the raw scores into T-scores using the correct age and gender categories.

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

This study has found a Cronbach’s alpha of .96 for all nine scales of the CAARS. Other studies have found the alpha of the CAARS self-report measures to fall between .66 and .90 (Conners et al., 1998). The Cronbach’s alpha for the DSM scales of this study is .88. This is approximately in line with previous studies that found the DSM scales Cronbach’s alphas between .78 and .86 (Conners et al., 1998). The CAARS questionnaire has been shown to have good internal consistency, acceptable test-retest reliability and holds a high sensitivity towards distinguishing between healthy control groups and individuals diagnosed with ADHD (Christiansen et al., 2012; Erhard et al., 1999). This study further makes use of the Infrequency Index and the Inconsistency Index of the CAARS. The Total Infrequency Index (CII) for the CAARS-S-L, created to detect possible feigning, has a Cronbach’s alpha of .86.

In comparison, this study found a Cronbach's alpha of .77. As recommended by the CAARS manual, this study utilizes a cut-off score of 20. A score of 20 or less occurred in 90.1% of the ADHD group (Suhr et al., 2011). The CII has a generally modest sensitivity (30%) and a high specificity (95%) (Wallace & Walls, 2020). The Inconsistency Index is used to identify the internal and external consistency in the item response pattern by comparing it to the response pattern of individuals of the same age and sex. Again, we followed the recommendation of the CAARS manual and used a cut-off score of eight and only identified scores of seven or lower as valid responses. Usually, the symptoms measured in the total score of the DSM are more appropriate for a younger demographic. Since this study's sample primarily belongs to the age category of young adults, we only utilized the DSM scales in this study (CAARS_TscoreDSMTotal, CAARS_TscoreDSM_Inattention, CAARS_TscoreDSM_HypImp).

MSLQ

The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, 1991) is a self-report measure 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 item responses in this study were based on the participants' attitude and behaviour towards the course "Intro to Psychology".

The first section assesses motivation with 31 items and asks for goals-value beliefs, control beliefs and self-efficacy. The second section that assesses learning strategies includes 31 items to assess different cognitive and metacognitive strategies. This part further includes 19 items to assess resource management. Examples of questions from the cognitive and metacognitive strategies scales include: “I memorize keywords to remind me of important concepts in this class.”, “Before I study new course material thoroughly, I often skim it to see how it is organized.” and “I try to play around with ideas of my own related to what I am learning in this course.”. Overall, the entire questionnaire was estimated to take about 20-30 minutes to complete.

Scales for the MSLQ are constructed by taking the mean of the items making up that scale. The score will be computed by summing up the items and taking the average. The scores of the “reversed” items have to be reversed. For example, an individual scoring a one on an item now receives a seven. A higher score like four, five, six, or seven is better than a lower score like one, two, or three. Scores above three are indicative of an individual’s well-being, everything below that suggests that help might be needed. The only exception to this is the Anxiety scale where a higher score is more worrying.

This study primarily focuses on the subscales that together make up cognitive and metacognitive strategies. Those subscales are the ones for Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation (MSLQ_CMS_Total).

Past research has reported Cronbach’s alpha of the MSLQ to fall between .52 and .93 (Pintrich et al., 1993). The Cronbach’s alpha for the separate cognitive learning strategies scales fell between .69 and .80 (Pintrich et al., 1993). This study has found a Cronbach’s alpha of .89 for the total measure as well as separately for the cognitive learning strategies scales only. The MSLQ has so far demonstrated good reliability of its subscales, as well as

reasonably good predictive validity of performance (Pintrich et al., 1993). Given the sample characteristics, the MSLQ is an appropriate and well-fit research tool (Davenport, 2003)

EFI

The Executive Function Index Scale (EFI; Spinella, 2005) is a self-assessment scale to measure executive functions used in daily life (Mohamed et al., 2021). It utilizes a five-point Likert scale response format (1 = not at all, to 5 = very much) for 27 items. Those items are representative of five subscales: Motivational Drive (motivation, energy levels), organization (multitasking, sequencing), Impulse Control (self-inhibition, propensity for risky behaviour), Empathy (interest in the well-being of others, pro-social behaviour), and Strategic Planning (planning, thinking ahead, making use of strategies) (Spinella, 2005). Questions for the scale of Strategic Planning include, for example: “I save money on a regular basis.” or “I think about the consequences of an action before I do it.”. For the scale of Organization, questions include: “When doing several things in a row, I mix up the sequence.” or “I sometimes lose track of what I am doing.”. 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 scores, executive functioning improves as well (Spinella, 2005).

Different studies have reported the internal consistency to be acceptable (Spinella, 2005; Gwenny et al., 2009). Originally, the reported Cronbach’s alpha for the EFI scale falls between .70 to .82 (Spinella, 2005). In comparison, this study reports a Cronbach’s alpha of .75. This study focuses on the subscales of Organization and Strategic Planning (EFI_ORG, EFI_SP). This study found a Cronbach’s alpha for organization of .62 and .64 for strategic planning.

Data Analysis

After extracting the raw data from the Qualtrics software, exclusion criteria were applied to clean the data. The results from the CAARS, MSLQ, and EFI were analysed.

Descriptive statistics were obtained for each of the variables used in this study (see Appendix A, Table A1). The means and standard deviation of the variables were created to check that all the variables were within an appropriate range. We chose to test for linearity (Appendix A, Table A2, Table A3, Figure A7-A13), normality distribution (Appendix A, Figure A1-A6) and outliers (Appendix A, Figure 14), using SPSS. The specifics of the assumptions check can be found in Appendix A. It was decided to conduct partial correlation analyses.

To explore the relationship between the variables, using bivariate Pearson's correlations, a correlation analysis was first conducted between the variables for each hypothesis. A correlation was considered significant if the p-value fell below .05. Finally, partial correlations were conducted to investigate the unique contributions of each variable in the relationship between CAARS, MSLQ, and EFI.

Results

Hypothesis 1: ADHD symptoms levels and executive functioning subscales

For the first hypothesis, the association between ADHD symptomology and the strategic planning and organizational skills subscales of executive functioning was examined. It was hypothesised that students with a greater score on the total DSM scale would score more poorly on both executive functioning subscales. The results are shown in Table 1.

Table 1

Correlations Matrix

Variable	1	2	3	4	5	6
1. CAARS_TscoreDSM_Total						
2. CAARS_TscoreDSM_Inattention	.918**					

3. CAARS_TscoreDSM_HypImp	.867**	.602**			
4. EFI_ORG	-.590**	-.627**	-.410**		
5. EFI_SP	-.396**	-.418**	-.281**	-.306**	
6. MSLQ_CMS_Total	-.166*	-.186*	-.093	.075	.369**

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

A partial correlation analysis was run to determine the relationship between the total DSM scale and the organization scale of executive functioning whilst controlling for strategic planning. The results showed a significant, moderate, negative partial relationship ($r(157) = -.536$, $n = 160$, $p<.001$). Zero-order correlation had shown a statistically significant, moderately negative relationship ($r(158) = -.590$, $n = 160$, $p<.001$). Compared to partialling out strategic planning, the correlation is not significantly different.

Another partial correlation analysis was run to investigate the relationship between the total DSM scale and strategic planning while controlling for organizational skills. There was a moderate, negative relationship between the variables, which appears to be statistically significant ($r(157) = -.280$, $n = 160$, $p<.001$). Again, zero-order correlations had shown a statistically significant, moderately negative relationship ($r(158) = -.396$, $n = 160$, $p<.001$). When compared to the correlation when partialling out strategic planning, the correlation does not change significantly.

The results showed that both executive functioning subscales were negatively correlated with the total DSM scale and that their contributions were independent of each other. Thus, supporting both parts of the first hypothesis

Hypothesis 2: Cognitive learning strategies, ADHD symptoms levels and executive functioning subscales

The second hypothesis examined the association between cognitive learning strategies, ADHD symptomology and the executive functioning subscales.

It was hypothesised that individuals with a greater score on the total DSM scale would comparatively score poorer on the scales for cognitive learning strategies. Additionally, it was hypothesised that the relationship between cognitive learning strategies and the executive functioning subscales of organization and strategic planning would be positive. Thus, if an individual scores higher on the scales for strategic planning and organizational skills, they would get greater scores on the cognitive learning strategies scales. The results of the correlational analysis are provided in Table 1.

To determine the relationship between cognitive learning strategies, ADHD symptomology and executive functioning subscales, two partial correlations were conducted. This was done using the variables for the total cognitive learning strategies score and the total DSM score while controlling for strategic planning. The analysis showed a non-significant, weakly negative relationship ($r(157) = -.024$, $n = 160$, $p = .769$). Zero-order correlations had shown that there appears to be a significant, moderate, negative relationship ($r(158) = -.166$, $n = 160$, $p = .036$). Compared to partialling out strategic planning, the correlation is significantly different.

The second partial correlation was run for the variables of cognitive learning strategies and the total DSM score while controlling for organizational skills. The results revealed a non-significant, weak, negative relationship ($r(157) = -.151$, $n = 160$, $p = .058$). Zero-order correlation had shown a significant, weak, negative relationship ($r(158) = -.166$ $n = 160$, $p =$

.036). When compared to the correlation of cognitive learning strategies and the total DSM score while partialling out organizational skills, the correlation is significantly different.

The results showed partial support for the first part of our hypothesis, and full support for the second part.

Hypothesis 3: Cognitive learning strategies, ADHD symptom clusters and executive functioning subscales

To investigate the correlational relationship between cognitive learning strategies, the executive functioning subscales and the DSM symptoms clusters of inattention and hyperactivity/impulsivity, a correlation matrix was calculated (see Table 1).

Six partial correlation analyses were conducted to further determine the correlation between cognitive learning strategies, executive functions and ADHD symptomology, now split up into two symptom clusters. The first partial correlation investigates the relationship between the total cognitive learning strategies scale and the symptom cluster of inattention while controlling for hyperactivity/impulsivity. The results had shown a statistically significant, weak, negative relationship ($r(157) = -.163$, $n = 160$, $p = .040$). Zero-order correlation showed to be significant ($r(158) = -.186$ $n = 160$, $p = .019$). When controlling for hyperactivity/impulsivity, the correlation is not significantly different.

The second partial correlation was run between cognitive learning strategies and hyperactivity/impulsivity, controlling for inattention. The results showed a non-significant, weak, positive relationship ($r(157) = .024$, $n = 160$, $p = .766$). The zero-order correlation revealed a statistically non-significant, weak, negative relationship ($r(158) = -.093$ $n = 160$, $p = .241$). When controlling for inattention, the correlation is not significantly different.

The next two partial correlations were conducted on cognitive learning strategies and the system cluster of Inattention while controlling for strategic planning and organization. When controlling for strategic planning, the partial correlation appeared to be non-significant

($r(157) = -.037$, $n = 160$, $p = .641$). The zero-order correlation, however, was significant ($r(158) = -.186$, $n = 160$, $p = .019$). When compared to the correlation between cognitive learning strategies and the DSM symptom cluster of inattention, there is a significant difference. When controlled for organization, the partial correlation between cognitive learning strategies and the inattention symptom cluster had shown to be significant ($r(157) = -.178$, $n = 160$, $p = .024$). The zero-order correlation had shown to be significant as well ($r(158) = -.186$, $n = 160$, $p = .019$). These results do not show a significant difference.

For the last two partial correlations, the relation between cognitive learning strategies and the symptom cluster of hyperactivity/impulsivity was further investigated while alternately controlling for strategic planning and organization. The results showed a non-significant partial correlation ($r(157) = .012$, $n = 160$, $p = .885$), as well as a non-significant zero-order correlation ($r(158) = -.093$, $n = 160$, $p = .241$) when controlling for strategic planning. When controlling for organization, neither the partial correlation ($r(157) = -.069$, $n = 160$, $p = .360$) nor the zero-order correlation ($r(158) = -.093$, $n = 160$, $p = .241$) were shown to be significant. Compared to the correlation with all other variables partialled out, the results do not differ significantly.

This analysis has shown that the only significant negative correlation is between the symptom cluster of inattention and cognitive learning strategies. The results show support for the third hypothesis. Thereby, only inattention symptoms of ADHD hold a significant influence on cognitive learning strategies but not hyperactive/impulsive symptoms. This relation is significant, independent of hyperactivity/impulsivity symptoms and organisation.

Discussion

The main objective of this study was to investigate the relationship between executive functioning and cognitive learning strategies in university students who present with ADHD symptomology.

Hypothesis 1: Relationship between executive functioning subscale and ADHD symptoms levels

The first hypothesis focuses on the relationship between executive functions and ADHD symptoms. Specifically, how do organizational skills (e.g. “I have trouble doing two things at once; Spinella, 2005) and the tendency to use strategies (e.g. “I plan for the future”; Spinella, 2005) relate to symptoms typically found in ADHD (e.g. “I can’t get things done unless there is an absolute deadline”, Conners et al., 1998)?

The results showed support for all parts of our first hypothesis. Organization and strategic planning are negatively correlated with ADHD symptomology, independently from each other. The results suggest that an individual’s organization, as well as strategic planning skills, decrease when more ADHD symptomology is present. This fits in very well with previous studies by establishing a link between executive functioning deficit and ADHD symptomology (Vélez-Pastrana et al., 2016; Dehili et al., 2017). Since the same results were found using different measures from previous studies, it further underlines the relevance of our results, as well as the robustness of the relationship (Vélez-Pastrana et al., 2016; Dehili et al., 2017). Although previous studies have already focused on the executive functions of organization in university students (Reaser et al., 2007; Neuman, 2022), strategic planning in relation to ADHD symptomology had so far only ever been investigated in children (Kofman et al., 2008). The present study has shown that there are significant relations to be found in university students too.

Hypothesis 2: Relationship between cognitive learning strategies, executive functioning subscales and ADHD symptoms levels

For the second hypothesis, cognitive learning strategies were added as an additional variable. This was done to gain greater insight into how ADHD symptoms, organization and strategic planning skills related to concepts such as rehearsal, elaboration, critical thinking,

and metacognitive self-regulation (e.g., “When studying for this course, I go over my class notes and make an outline of important concepts, “I make lists of important terms for this course and memorize the list”; Pintrich, 1991).

Cognitive learning strategies showed to be negatively correlated to ADHD scores, and positive to strategic planning. However, since there was no significant correlation found to organization, the results only partially support the first hypothesis. The second hypothesis was supported because strategic planning and organization were shown to hold significant influence over the relationship between cognitive learning strategies and ADHD symptomology. It can be concluded that the effectiveness of cognitive learning strategies in an individual with ADHD symptoms, is significantly influenced by their executive functions. This aligns well with previous studies in establishing that ADHD symptoms can negatively impact an individual’s cognitive learning strategies (Reaser et al., 2007). The current findings show that this is partly caused by difficulties with the executive functions of strategic planning and organization (Reaser et al., 2007; Newman, 2022).

While the positive correlation between cognitive learning strategies and strategic planning is in line with previous research (Hofmann et al., 2012; Garner, 2009), studies so far have not investigated this in the context of ADHD.

Hypothesis 3: Relationship between cognitive learning strategies and ADHD symptom clusters

The last hypothesis specifically focuses on two different symptom clusters of ADHD symptomology and their relation to cognitive learning strategies and executive functions. The symptom clusters are described by their characteristics of Inattention (e.g., “I don’t like homework or job activities where I have to think a lot”; Conners et al., 1998) and Hyperactivity/Impulsivity (e.g. “I am restless or overactive”; Conners et al., 1998).

Inattention appears to be the only symptom cluster negatively and significantly related to cognitive learning strategies. Although there appears to be some influence of the hyperactivity/impulsivity symptom cluster, it holds little influence over the effect of inattention symptoms. This relation appears to be further influenced by the executive functions of strategic planning and organization. Especially organization has been shown to hold influence over the relationship between inattention and cognitive learning strategies. While a previous study has proposed that hyperactive/impulsive symptoms potentially hold protective properties (Shelton et al., 2019) to protect against deficits in cognitive learning strategies, our findings showed no support for this proposition. However, our findings are in line with previous studies that revealed no significant links between hyperactivity/impulsivity and self-regulated learning (Reaser et al., 2007). It can be concluded that students who present with inattentive ADHD symptoms have less effective cognitive learning strategies. This is in accordance with previous research (Norwalk et al., 2009, Wolf et al. 2009). Our study further suggests that an executive functioning deficit implies greater impairments of the cognitive learning strategies in individuals who present with the inattention symptom cluster than with hyperactivity/impulsivity. This can potentially imply that those individuals find it more difficult to succeed in the academic setting.

Strengths and Limitations

When compared to a categorical approach, a dimensional approach reduces the risk of misinterpretation of an illness or disorder due to the false use of cut-off scores. Since it is well suited for a non-clinical sample, and ADHD symptoms are commonly viewed dimensionally rather than categorically, this approach is an appropriate fit for this study. The usage of a categorical approach might impact clinical decision-making in a way that impairs treatment (Kraemer et al., 2004). For example, if the patient falls just short of the cut-off score which would provide them with a diagnosis, they would not be given the option of treatment for

their symptoms. A dimensional approach identifies symptoms on a spectrum. This allows for a more sensitive approach to treatment since the subtleties in the severity of different symptoms can be better identified. More specific treatments can be administered that way. This further allows for better identification of an individual's strengths and weaknesses. The dimensional approach is more applicable to real-world conditions and increases the utility of the results because one is not reliant on cut-off scores which enables binary decision-making.

This study appears to have a well-fitting sample. Our research questions are specifically directed towards a university population which this sample managed to represent well. This allowed us greater insight into the relations between ADHD symptomology, executive functions and self-regulated learning in the daily environment of students. No attempt was made to influence the students' usual environment or their physical or psychological conditions.

However, this might also suggest some limitations regarding the applicability of the results. Since the study used such a specific convenience sample, the findings might not apply to a clinical sample, or groups outside of this age category and this specific academic background. This lack of generalizability decreases the external validity of this study. Future research could increase external validity by using a sample that includes adult, student participants outside of the pool of first-year psychology students of the University of Groningen. Including students from different departments and universities could increase the applicability of the findings.

Another limitation is the multicollinearity between the variables which affects the analysis of the data. By definition, all of the different CAARS measures, as well as the two EFI measures, have some overlap. That makes it more difficult to assess them as independent of each other. Therefore, this created the need to run multiple tests instead of one comprehensive model. Conducting multiple tests increases the chances of false positive

findings due to inflated alpha levels. When conducting a posthoc Bonferroni test to reduce the chances of false positives occurring, some of the findings of this study would stop being significant. If we were to lower the alpha level to <.01 for example, the zero-order correlation between cognitive learning strategies and the total DSM scale would not be considered significant anymore. The same would happen to the correlation between cognitive learning strategies, the inattention cluster and the executive functioning subscales. The change in alpha would be significant enough to affect the results and therefore the interpretation of our findings. However, our findings are still reliable since this study does not deploy a single universal hypothesis but multiple specific ones, does not use multiple comparisons across means and has a decent sample size. Due to this, there is no justification for using the Bonferroni test. To avoid potential risks to studies in the future, research should be conducted on single models of analysis instead of multiple ones to decrease the potential of false positive findings.

Implications and Future Research

This study found a clear link between executive functions and ADHD symptoms in university students. Especially strategic planning has shown itself to be rather influential in the relationship between inattention symptoms and cognitive learning strategies. Since our study did not rely on actual ADHD diagnoses but rather experienced symptoms that are typical of ADHD, students might benefit from support in the form of training of their self-regulated learning strategies and executive functions. Studies have shown that cognitive training of executive functions helped to relieve some of the symptoms experienced by people with ADHD (Shuai et al., 2021) Previous research into executive functioning training has already documented their effectiveness (Shepard et al., 2022). Some studies even suggest a combined training and medication approach to be beneficial (Shepard et al., 2022). Regrettably, there is not much literature to be found on their effectiveness in adults since

executive functions appear to be increasingly stable the older an individual gets (Sandberg et al., 2014). Studies on children and young adolescents, however, yielded promising results (Shepard et al., 2022; Tamm et al., 2014). This highlights the importance of early detection of executive functioning deficits for treatment.

Our results suggest that specific training to increase strategic planning and organization skills might help to indirectly strengthen self-regulated learning strategies. This might include tasks or games where participants are encouraged to develop and use strategies. Next to the indirect training of self-regulated learning, more direct training can be conducted by teaching effective self-regulated learning strategies. Previous studies have shown that it is indeed possible to increase academic achievement through direct training of self-regulation and effective learning strategies (Turner et al., 2020, Gagne & Nwadinobi, 2018, Reid et al., 2005). An example of this are courses which teach students how to plan and structure papers. Most first-year students will encounter them as they are often mandatory, such as the course "Academic Skill" at the University of Groningen for first-year psychology students.

This study is part of very limited research on strategic planning and organization in adults with ADHD symptoms. These results show that there is still important research to be conducted on executive functions in general. They present as another addition to the belief that ADHD should be viewed as a dimensional construct rather than a categorical one. Since there is so little research to be found on executive functioning and self-regulatory learning training in adults, there appears to be a lot of significance in future studies focusing on that age group. As exploratory research, it would be important to focus on other executive functioning domains apart from organization and strategic planning to potentially uncover other confounding influences. Future research should further focus on research on adults, achievement, and daily support of individuals with ADHD symptoms.

Conclusion

In sum, this study was able to provide additional support for existing findings about the general links between executive functioning, cognitive learning strategies and ADHD symptomology, now in university students (Reaser et al., 2007; Garner, 2009; Newman, 2022). In that, executive functions and cognitive learning strategies are less effective in students with higher scores on scales for ADHD symptomology. Therefore, suggesting that individuals with ADHD symptomology have difficulties with effective learning strategies. This study was further able to showcase the influence of executive functions on the relationship between cognitive learning and ADHD symptoms. This might speak to their conceptual overlap as well as executive functions' potential as a predictive factor (Garner, 2009). Additionally, this study provided support for previous research into the differences in the relationship between ADHD symptom clusters to cognitive learning strategies (Norwalk et al., 2009; Wolf et al., 2009; Reaser et al., 2007). More specifically, these findings greatly support the idea that the inattention symptom cluster shows great links to self-regulated learning, which is influenced by executive functions.

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Appendix A

Table A1

Descriptive Statistics

Variable	*n*	*M*	*SD*	*Minimum*	*Maximum*
1. CAARS_TscoreDSM_Total	160	52.7	9.4	33.75	79.62
2. CAARS_TscoreDSM_Inattention	160	54.2	10.8	34.63	83.65
3. CAARS_TscoreDSM_HypImp	160	50.7	8.7	34.59	83.74
4. EFI_ORG	160	15.1	3.4	5	23
5. EFI_SP	160	24	4.2	14	34
6. MSLQ_CMS_Total	160	4.5	0.8	2.45	6.62
Valid N (listwise)	159				

Assumptions

We chose to test for linearity (Appendix A, Table A2, Table A3, Figure A7-A13), normality distribution (Appendix A, Figure A1-A6), outliers (Appendix A, Figure A14), multicollinearity (Appendix A, Table A4) and homoscedasticity (Appendix A, Figure A15-A18) using SPSS. The Boxplot (see Appendix A, Figure A14) showed one outlier in the CAARS data, one in the EFI data and one in the MSLQ_CMS_Total data. However, since our sample size is fairly large (N = 160) we decided that they were not deviant enough to significantly affect the data (See Appendix A, Figure A14). Since we are using a dimensional approach to ADHD symptomology and the exclusion of the data is not justified, the outliers were included. The linearity assumption was investigated using scatterplots. None of the scatterplots showed a deviation from linearity, therefore the assumption was accepted.

The Normality assumption was further investigated by analyzing skewness, kurtosis, the Shapiro-Wilks test and QQ plots for all relevant variables.

Table A2

Skewness and Kurtosis

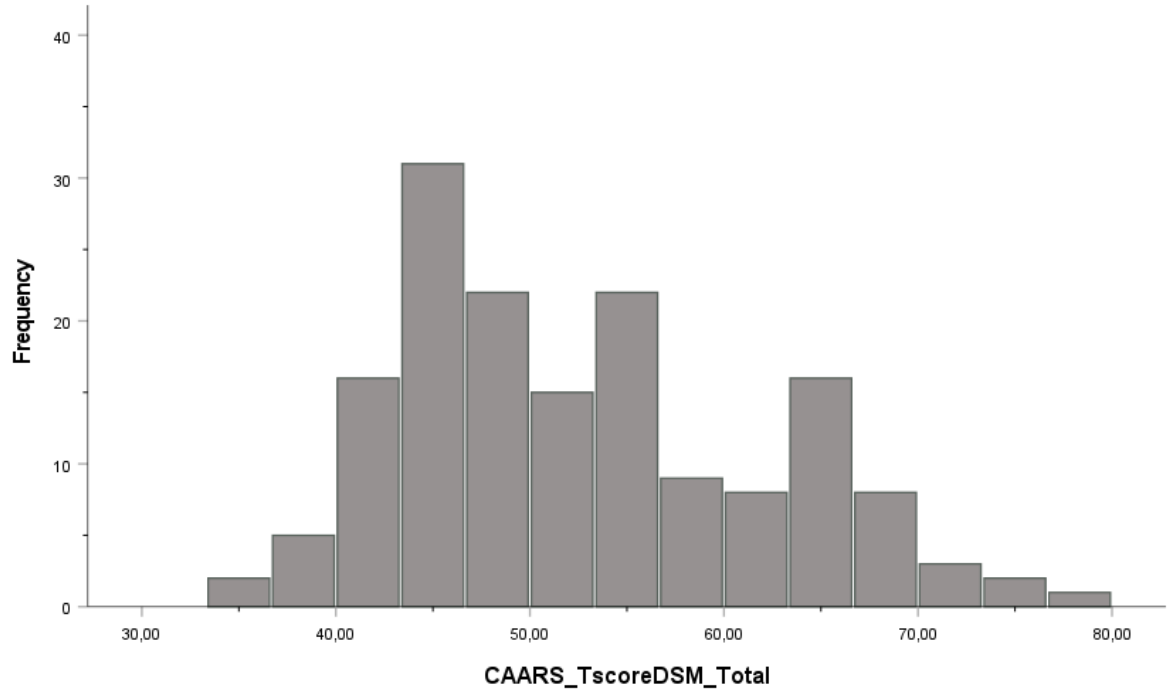
	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
CAARS_TscoreDSM_Inattention	.54	.19	-.40	.38
CAARS_Tscore_DSM_HypImp	.80	.19	.66	.38
CAARS_TscoreDSM_TotalTotal	.58	.19	-.38	.38
EFI_ORG	-.25	.19	.14	.38
EFI_SP	.06	.19	-.57	.38
MSLQ_CMS_Total	-.10	.19	-.11	.38

Note. The skewness and kurtosis are shown for the variables of the total ADHD symptoms scale, the ADHD symptom clusters, Executive functioning subscales and cognitive learning strategies.

The variables for the total DSM score (skewness = 0.580, see Figure 1), the DSM symptoms score for inattention (skewness = 0.541) and the DSM symptoms score of hyperactivity/inattention (skewness = 0.801) showed moderate right skewness of the data as can be observed in Figure 1.

Figure 1

Data distribution of the CAARS_TscoreDSM_Total



The decision was made not to make any alterations to the data, since the normality distribution assumptions violations appear to be minor without any large effect on the data. Therefore, the normality assumption was accepted. The Linearity assumption was

investigated using scatterplots. None of the scatterplots showed a deviation from linearity, therefore the assumption was accepted.

Originally, we contemplated conducting a regression analysis but multicollinearity appeared to be a concern (see Appendix A, Table A4). Instead, we decided on pursuing partial correlations to test the hypotheses.

The Homoscedasticity assumption was checked using scatterplots of residuals (Appendix A, Figure A7-A13, Figure A15-A18). Since there was no apparent pattern to be found, the assumption of homoscedasticity was accepted.

Table A3

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CAARS_TscoreDSM_Inattent	.12	160	<.001	.96	160	<.001
CAARS_TscoreDSM_HypImp	.13	160	<.001	.95	160	<.001
CAARS_TscoreDSM_Total	.11	160	<.001	.95	160	<.001
EFI ORG	.10	160	<.001	.98	160	.080
EFI SP	.07	160	.034	.98	160	.133
MSLQ_ CMS_Total	.04	160	.200*	.99	160	.74

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Note: This table test for the normality of the total ADHD scale, the ADHD symptoms clusters, Executive Functioning subscales and the cognitive learning strategies.

Table A4

Coefficients[a,b]

	Collinearity Statistics	
	Tolerance	*VIF*
CAARS_TscoreDSM_Total[a]	.002	543.095
CAARS_TscoreDSM_Inattention[a]	.005	214.307
CAARS_TscoreDSM_HypImp[a]	.007	133.737
EFI_ORG[a]	.600	1.665
EFI_SP[a]	.817	1.224
EFI_ORG[b]	.907	1.103
EFI_SP[b]	.907	1.103

a. Dependent Variable: MSLQ_CMS_Total

b. Dependant Variable: CAARS_TscoreDSM_Total

Figure A1

QQ Plot For CAARS_TscoreDSM_Total

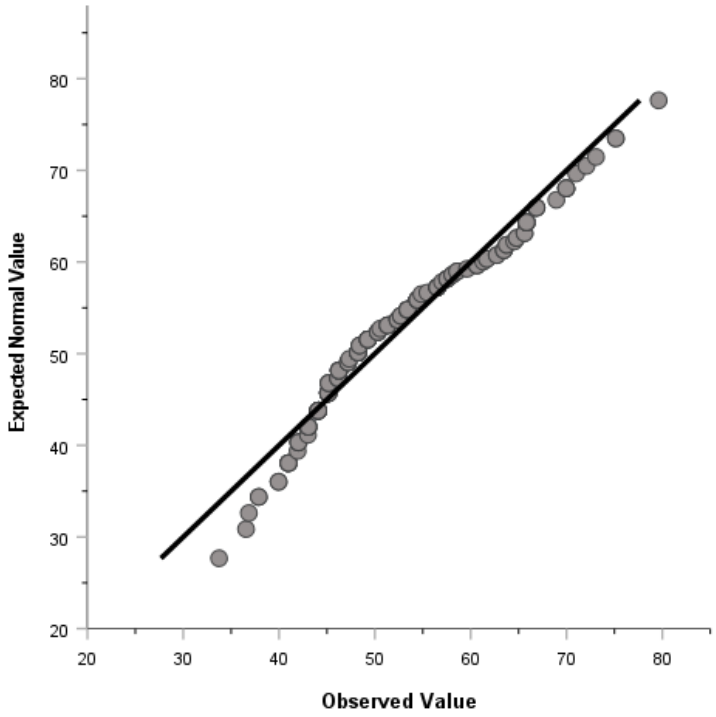


Figure A2

QQ Plot For CAARS_TscoreDSM_Inattention

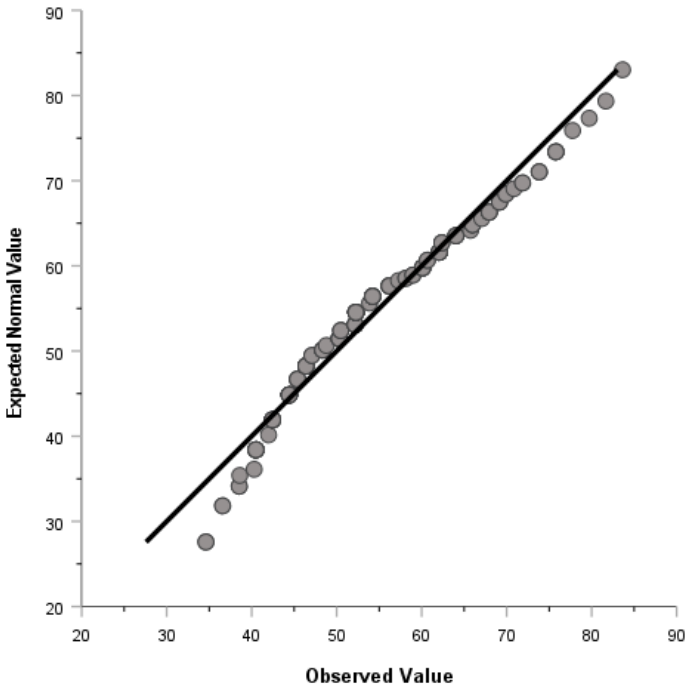


Figure A3

QQ Plot For CAARS_TscoreDSM_HypImp

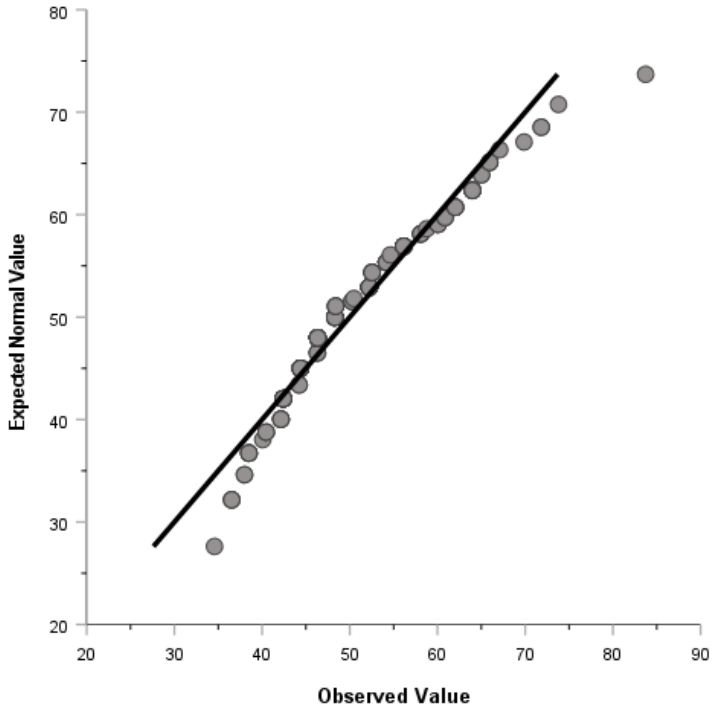


Figure A4

QQ Plot for EFI_ORG

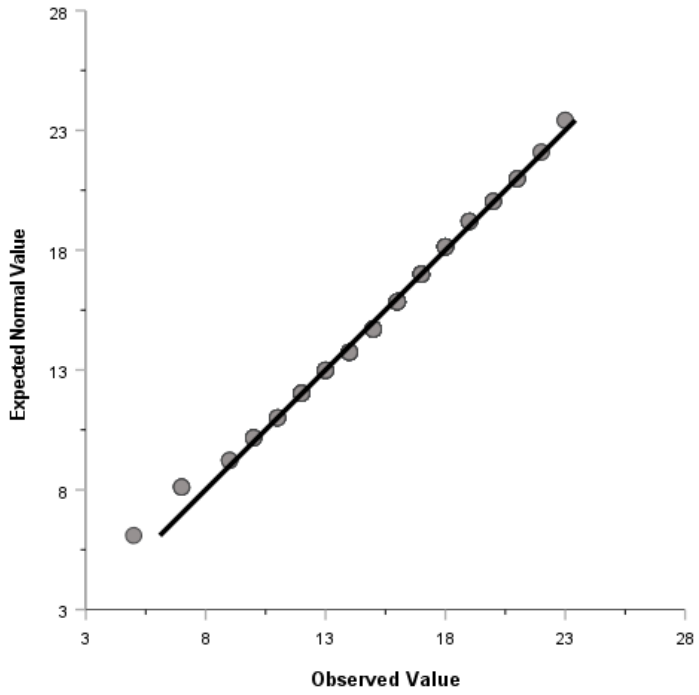


Figure A5

QQ Plot For EFI_SP

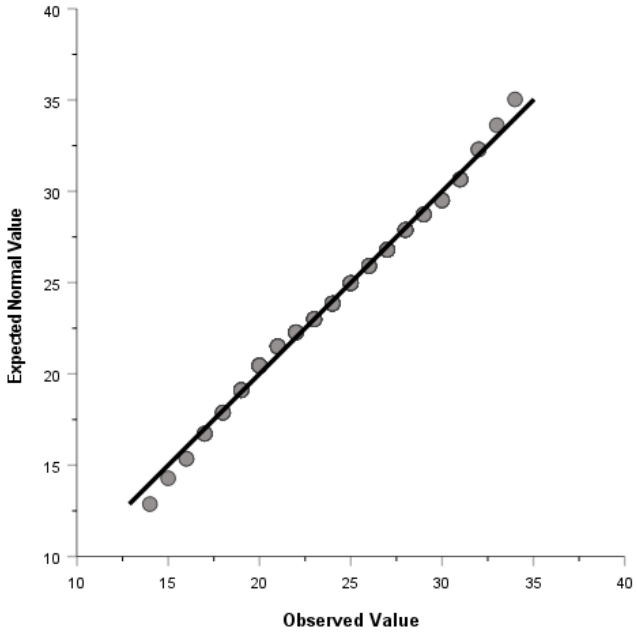


Figure A6

QQ Plot For MSLQ_CMS_Total

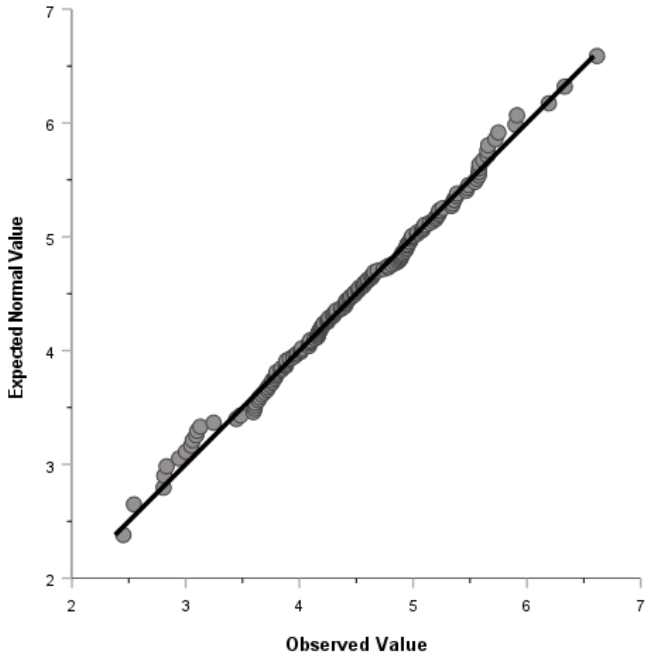


Figure A7

Scatterplot of CAARS_TscoreDSM_Total and EFI_ORG

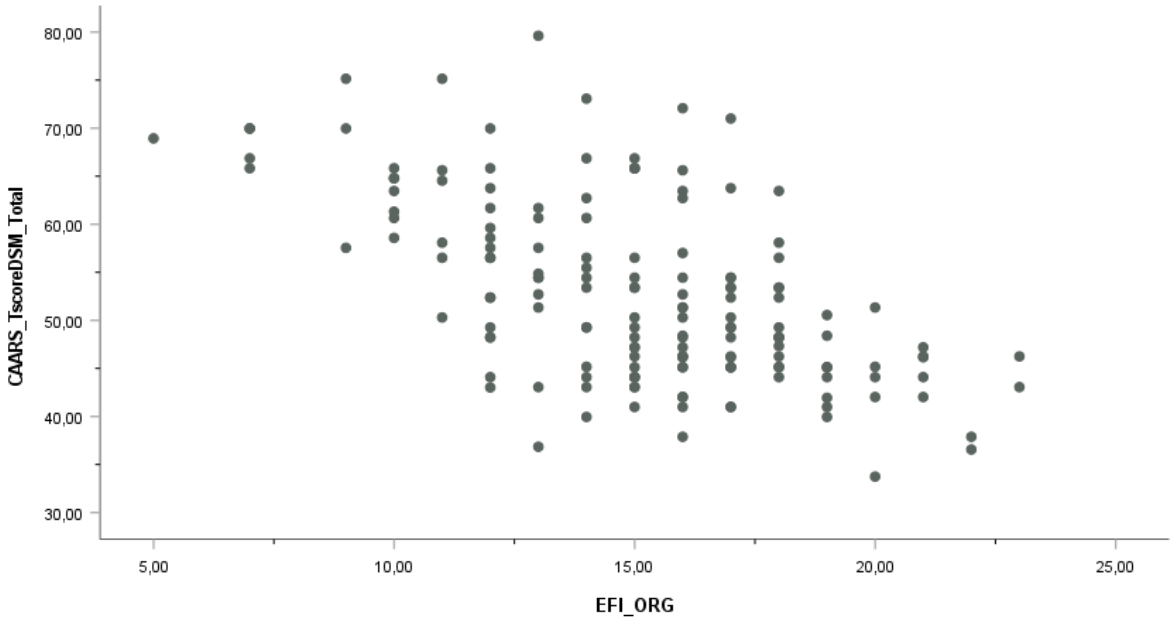


Figure A8

Scatterplot of CAARS_TscoreDSM_Total and EFI_SP

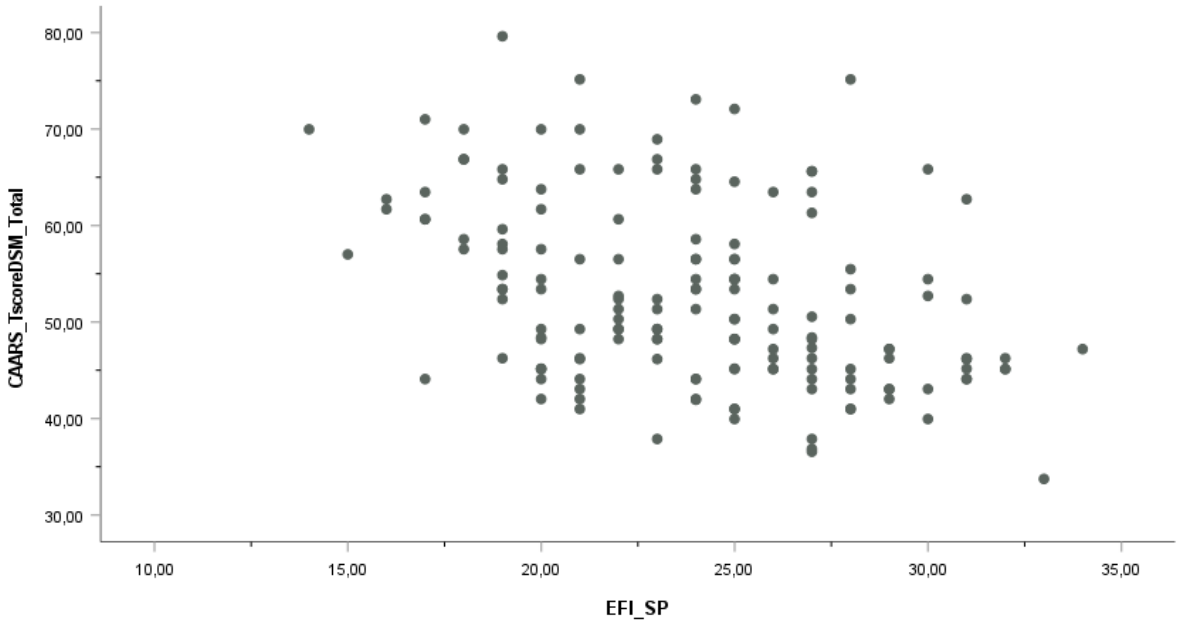


Figure A9

Scatterplot of MSLQ_CMS_Total and CAARS_TScoreDSM_Total

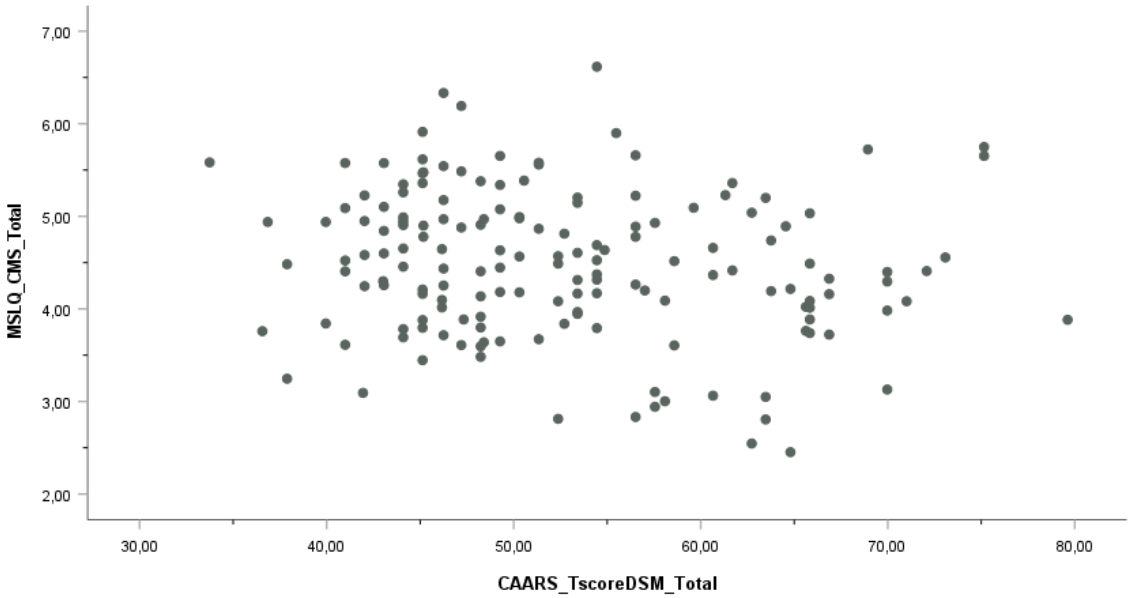


Figure A10

Scatterplot of MSLQ_CMS_Total and EFI_ORG

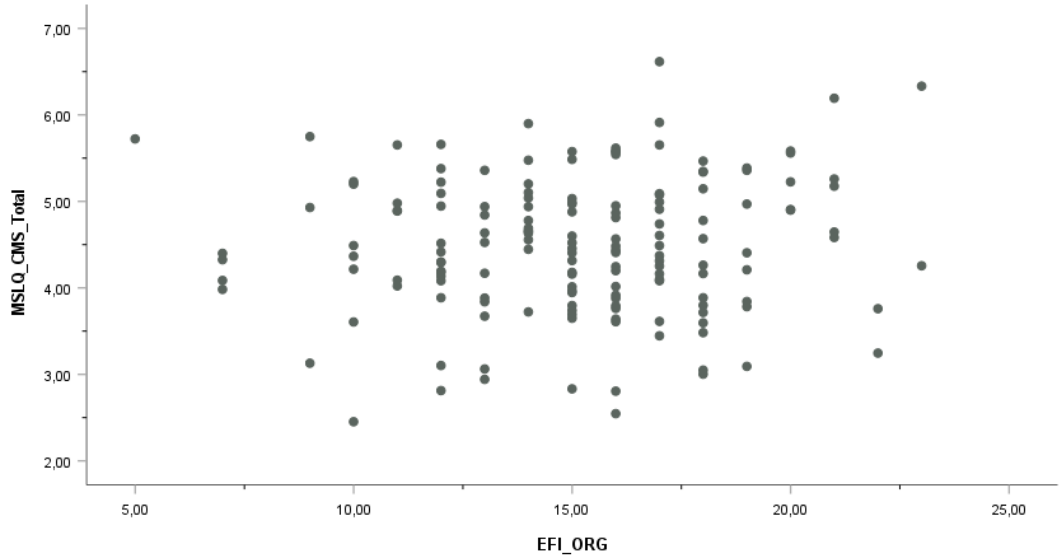


Figure A11

Scatterplot of MSLQ_CMS_Total and EFI_SP

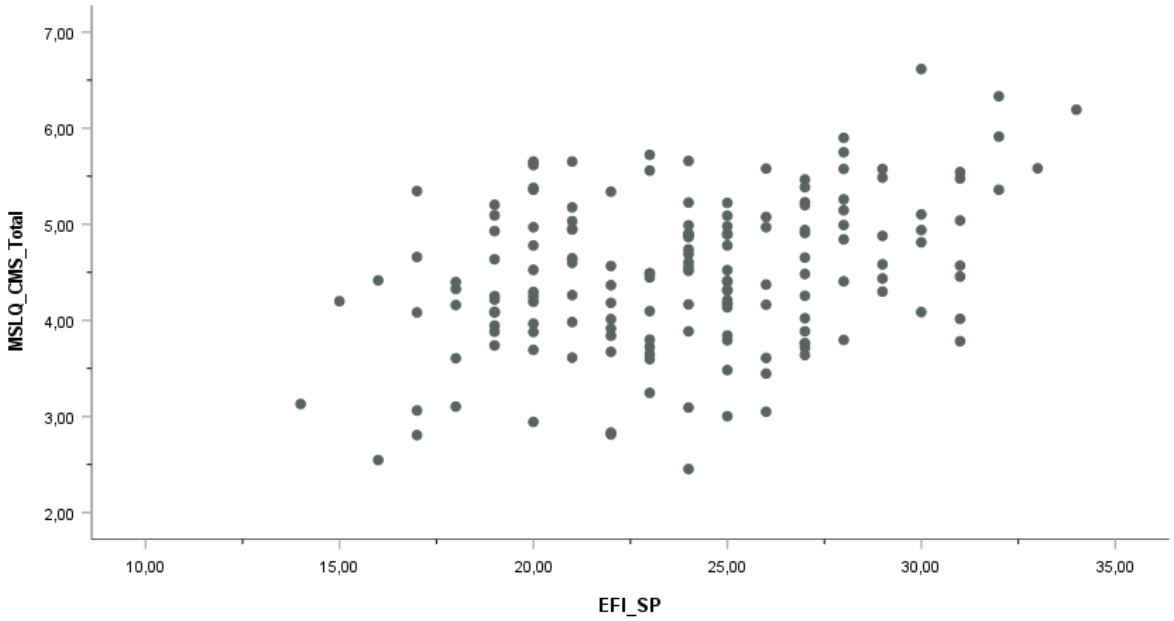


Figure A12

Scatterplot of MSLQ_CMS_Total and CAARS_TscoreDSM_Inattention

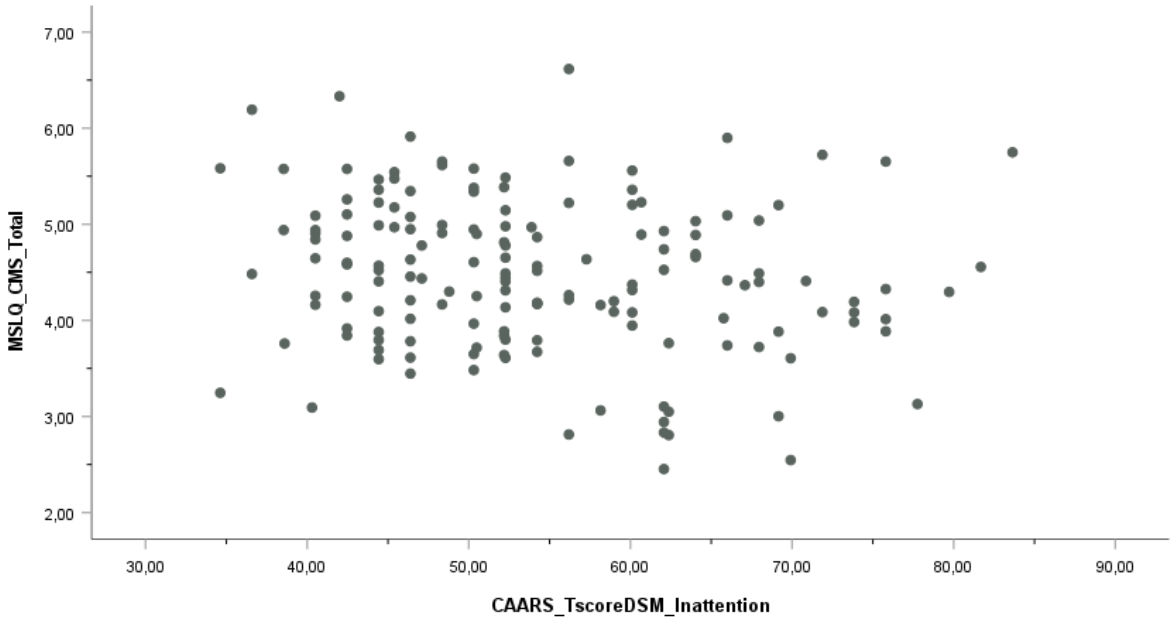


Figure A13

Scatterplot of MSLQ_CMS_Total and CAARS_TscoreDSM_HypImp

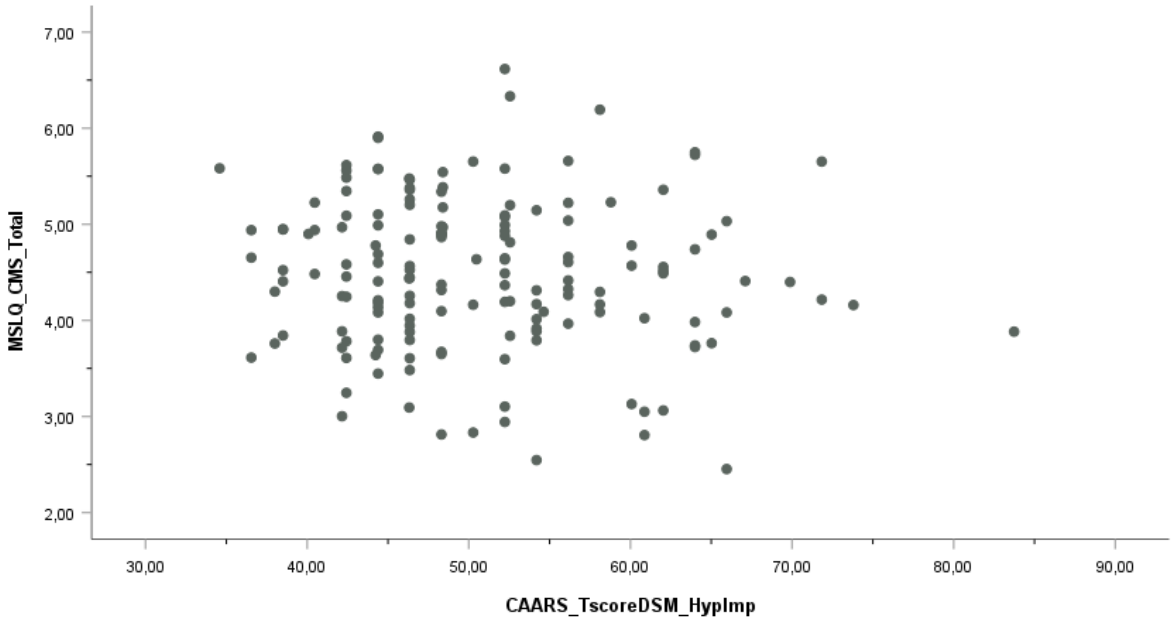
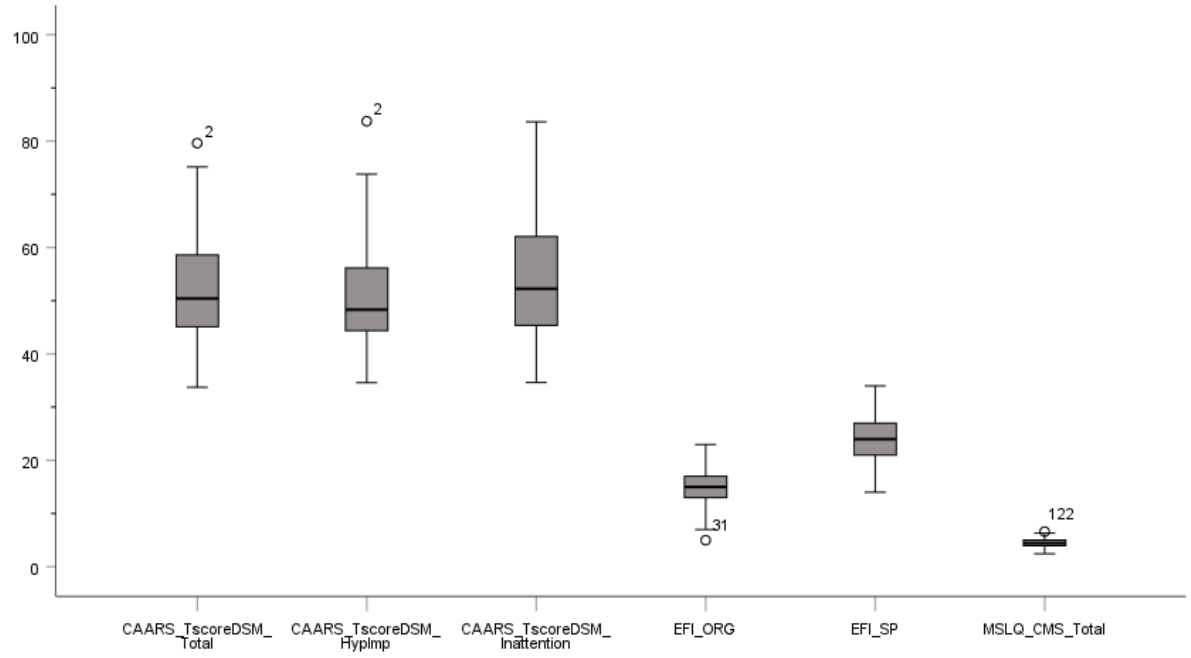


Figure A14

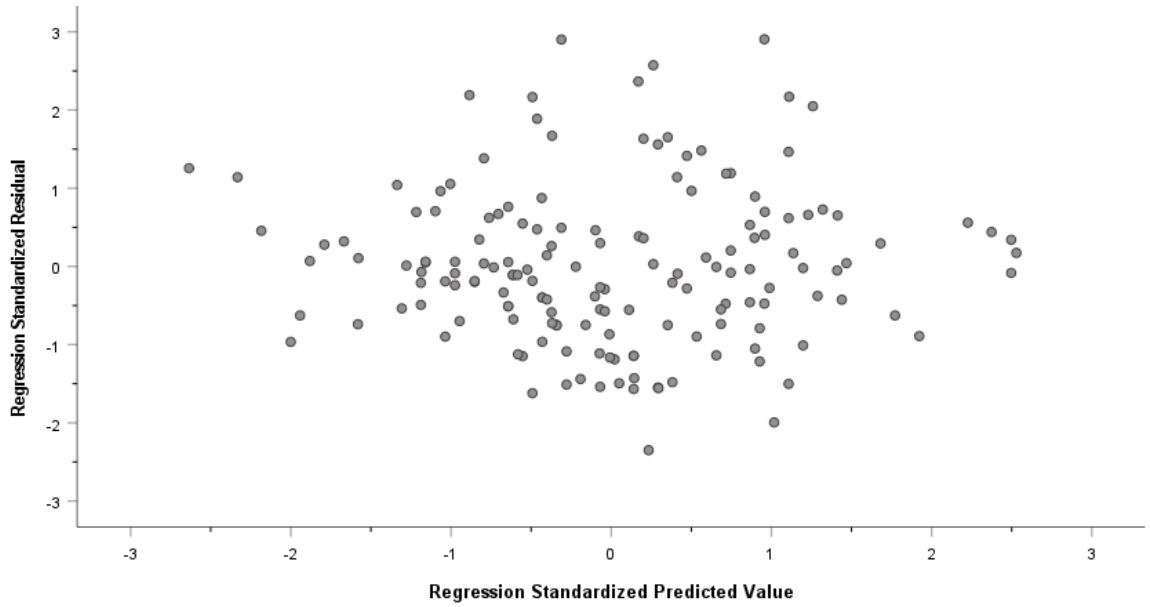
Boxplot For CAARS_TscoreDSM_Total, CAARS_TscoreDSM_Inattention, CAARS_TScoreDSM_HypImp, EFI_ORG, EFI_SP, MSLQ_CMS_Total



Note. Potential Outliers are Marked

Figure A15

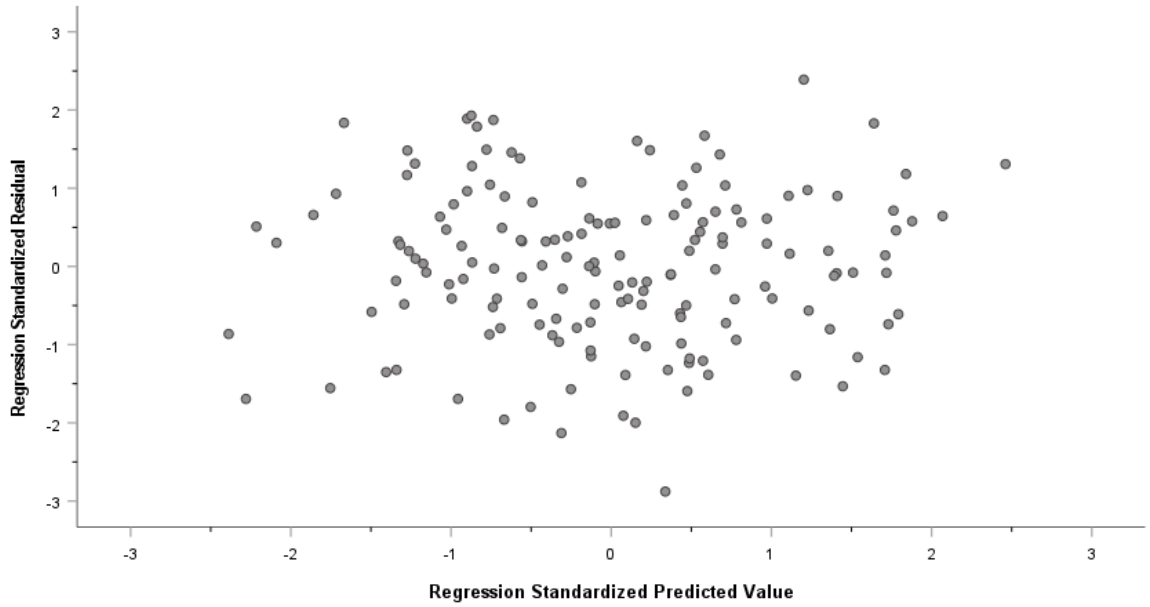
Scatterplot Of Residuals



Note. Dependant variable: CAARS_TScoreDSM_Total, Independent variables: EFI_ORG, EFI_SP

Figure A16

Scatterplot of Residuals

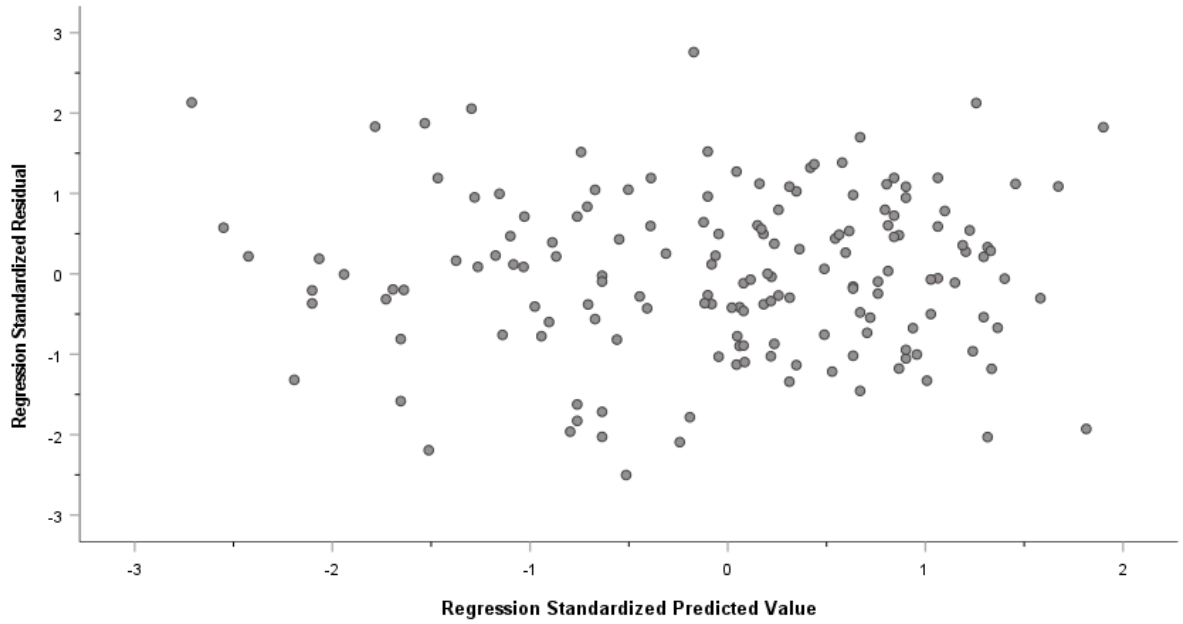


Note. Dependant variable: MSLQ_CMS_Total, Independent variables:

CAARS_TScoreDSM_Total, EFI_ORG, EFI_SP

Figure A17

Scatterplot Of Residuals

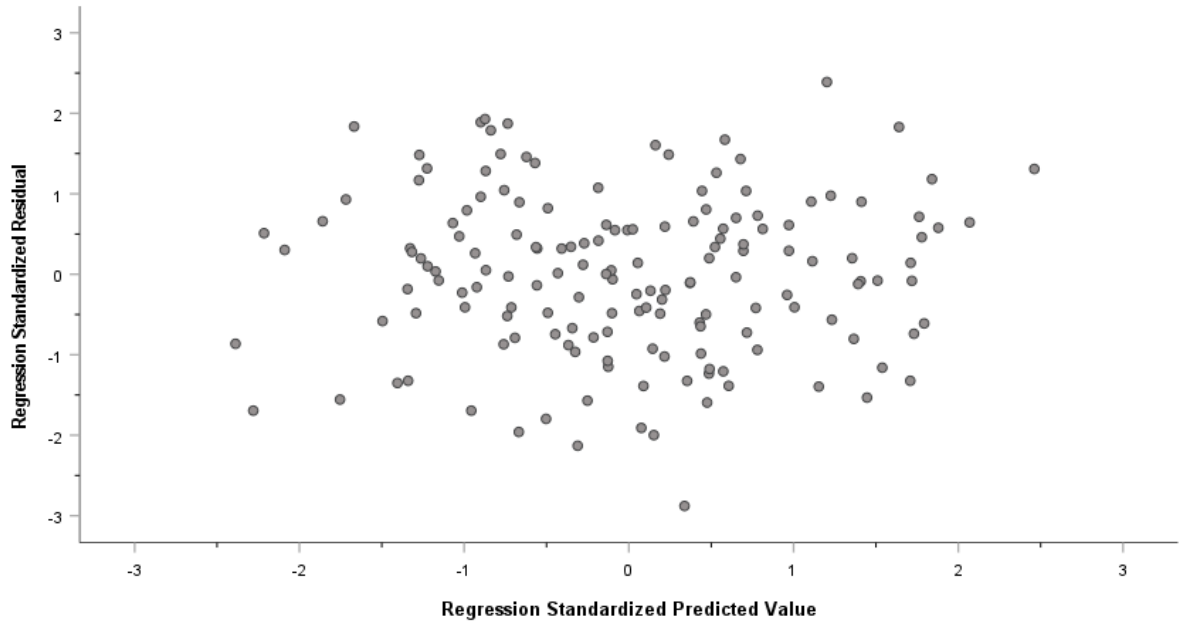


Note. Dependant variable: MSLQ_CMS_Total, Independent variables:

CAARS_TscoreDSM_Inattention, CAARS_TScoreDSM_HypImp

Figure A18

Scatterplot Of Residuals



Note. Dependant variable: MSLQ_CMS_Total, Independent variable:

CAARS_TscoreDSM_Inattention, CAARS_TscoreDSM_HypImp, EFI_ORG, EFI_SP