university of groningen

faculty of behavioural and social sciences

ADHD Symptoms and Cognitive Motivation in University Students: The Mediating Role of Motivational Drive

Romée Nieske Anje Graveland

Bachelor Thesis

S4717775

July 3rd, 2024

Group number 39a

Supervisor: dr. N.A. Börger

Second evaluator: dr. S.A. van Dellen

Department of Psychology

PSB3E-BT15

In collaboration with: D. Velthuis, L. Laman, and D. Tarcatu

A thesis is an aptitude test for students. The approval of the thesis is proof that the student has sufficient research and reporting skills to graduate but does not guarantee the quality of the research and the results of the research as such. Therefore, the thesis is not necessarily suitable to be used as an academic source to refer to. If you would like to know more about the research discussed in this thesis and any publications based on it, to which you could refer, please contact the supervisor mentioned.

Abstract

This study aims to gain a better understanding of ADHD symptoms in adults, while specifically focusing on the effect of the symptoms on motivation. This is essential given that adults are often underdiagnosed or misdiagnosed, impacting the individual's daily life personally and professionally. The impact of ADHD symptoms on cognitive motivation in university students is researched while examining whether motivational drive serves as a mediator in this relationship. Using a sample of 27 students from the University of Groningen, the study employed the Conners' Adult ADHD Rating Scales (CAARS) and the Executive Function Index (EFI) to measure ADHD symptoms and motivational drive, respectively. Cognitive motivation was assessed by calculating the difference between reaction times in the fast stimulus condition (900 ms) and the slow stimulus condition (2200 ms) of the Go/No-Go task. These difference scores represent the student's performance, which consists of the reaction time, standard deviation, and the omission of the response on the task.

The findings indicate that students with higher ADHD symptomatology demonstrated a greater discrepancy in reaction times between fast and slow stimulus conditions, indicating decreased cognitive motivation. Contrary to expectations, the analysis revealed that students with more ADHD symptoms did not necessarily experience more problems with the executive function motivational drive, suggesting that university students with ADHD may have developed compensatory strategies to manage their symptoms effectively.

The study also explored the potential mediating role of motivational drive between ADHD symptoms and cognitive motivation. However, the results of the mediation analysis showed that motivational drive does not explain the relationship between ADHD symptoms and cognitive motivation. This outcome underscores the complexity of motivational processes in individuals with ADHD and highlights the need for further research to disentangle the association between these variables.

The sample sizes in this study are too small for a mediation analysis, so the outcomes must be interpreted carefully. Other limitations of the study are the use of a convenience sample of university students, which may affect the generalizability of the findings to the adult population. Future research should ensure large and more diverse samples that take cultural differences into account and explore additional measures of cognitive motivation. Addressing these limitations will contribute to a more comprehensive understanding of ADHD and its impact on cognitive functions in adults.

Keywords: ADHD, executive Functions, motivational drive, cognitive motivation, CAARS, EFI.

The Effect of Motivational Drive on ADHD Symptoms and Cognitive Motivation in University Students

Attention Deficit Hyperactivity Disorder (ADHD) is a widely discussed heterogeneous developmental disorder with neurological origins. For the last decades, more scientific research has been done about symptoms in adults with ADHD. However, the expression of the symptoms in adulthood remains poorly understood. Research has shown that the prevalence of the disorder drops from young children (7.6%) into older children (5.6%) and adulthood (3%) (Salari et al., 2023; Ayano et al., 2023). The symptoms differ between adults and children, requiring careful consideration during diagnosis (American Psychiatric Association, 2013).

The symptoms of ADHD in children and adults are categorized into inattention and hyperactivity/impulsivity symptoms in the fifth edition of the Diagnostic Statistical Manual of Mental Disorders Text Revised (DSM-5-TR). Symptoms like motor hyperactivity may diminish in adulthood, but restlessness, inattention, poor planning, and impulsivity often persist. Diagnosis also requires impairment with occupational functioning, exclusion of alternative medical or mental disorders, and the expression of symptoms in various settings, which are not confined to a specific context like work. Symptoms must be present before the age of 12 to get a diagnosis (DSM-5-TR; American Psychiatric Association, 2013), but for adults, it is challenging to meet this criterion due to recall difficulties. This can unfortunately lead to a misdiagnosis of these individuals. If ADHD is left undiagnosed or misdiagnosed and individuals miss the benefit of proper treatment, the symptoms can result in behavioural, emotional, social, academic, and occupational problems (Ginsberg et al., 2014). This research attempts to fill the knowledge gap of the expression of ADHD symptoms in adults, aiming for an improvement of the diagnostic process in adults to reduce misdiagnosis in the future.

Underlying Mechanisms

When the aim is to understand the expression of ADHD symptomology in adulthood to improve the diagnostic procedure, it is crucial to increase our understanding of the underlying mechanisms of the disorder. Researchers have tried to find the best-fitting explanation for ADHD symptoms. Although there is not one 'grand theory', there is a consensus of two mechanisms responsible for the expression of ADHD symptoms. The first mechanism is dysregulation of thought and action, where executive functions play a key role (Sonuga-Barke., 2002). These executive functions are higher cognitive abilities that regulate behaviour like inhibitory control (Barkley, 1997). The second mechanism motivational style is suggested to explain the expression of ADHD symptoms through an aversion for a delay or preference for an immediate response (Sonuga-Barke, 2002). Delay aversion and poor inhibitory control are independent co-existing characteristics of ADHD (Sonuga-Barke et al., 2008).

Dysregulation of thought and action and Executive Functions

Dysregulation of the thought and action mechanism, results in both behavioural (i.e. impulsiveness, inattention, and overactivity) and cognitive ADHD symptoms (i.e. executive function difficulties like poor-quality task management, attentional flexibility, planning and working memory problems). Executive functions play a key role in this explanatory mechanism of ADHD symptoms (Sonuga-Barke 2002). Although the literature has given various definitions for executive functions, the definition adopted in this report is the ability of planning, flexibility, conceptual thinking, and set-shifting (Spinella, 2005). When these higher cognitive abilities are limited, an individual often experiences problems with controlling inhibitory behaviour (Barkley, 1997), affecting the ability to direct and regulate emotions, thoughts, and behaviour to accomplish goals (Roselló et al., 2020). Consequently, an impairment in these higher cognitive functions can result in difficulties in daily life (Arellano-Virto, 2021). The executive function difficulties associated with ADHD symptoms are suggested to persist from childhood into adulthood (Mostert et al., 2015).

ADHD and Executive Functions

So far, executive functioning has been discussed as an underlying mechanism of ADHD symptoms, but how is this related to motivation? Motivational Drive is one of the subscales of the Executive Function Index Scale (EFI) and addresses behavioural drive, activity level, and interest in novelty (Spinella, 2005). The EFI is often used to measure problems with executive functioning. Motivational drive might be related to the dysregulation of thought and action through its connection to self-regulation and goal-directed behaviour. Individuals with ADHD often struggle with self-regulation and maintaining effort towards goals, which can manifest as reduced motivation on tasks requiring sustained attention or persistence (Arellano-Virto, 2021). In the context of DTA, deficits in motivational drive may reflect underlying impairments in the executive functions involved in initiating, organizing, and sustaining goal-directed behaviour. These deficits contribute to difficulties with self-regulation and may exacerbate symptoms of impulsivity and inattention in individuals with ADHD. This illustrates the possible effect of behavioural motivation on ADHD symptoms in students.

However, ADHD should not be seen as a static, but as a dynamic disorder that is influenced by environmental conditions. Theories of motivation, particularly self-determination theory (Deci & Ryan, 1985), suggest that motivation is a multifaceted construct influenced by intrinsic and extrinsic factors. The human brain uses arousal regulation to adapt the activity level to the environment (Huang et al., 2015). Individuals with ADHD have dysregulated arousal regulation in their brains, resulting in hyperactivity and inattention symptoms (Hegerl, 2014). This system plays an important role in reward processing and motivational drive. This dysregulation can lead to inconsistent levels of motivation, impacting the individual's ability to initiate and sustain cognitive tasks (Volkow et al., 2009). In stimulating environments people become focused and attentive, in less stimulating environments more hyperactive and inattentive behaviour is shown (Laskly, 2016). Individuals with ADHD are easily overactivated and under-activated (Sonuga-Barke, 2002).

Motivational style and delay aversion

The second mechanism suggested to explain the expression of ADHD symptoms concerns motivational style. The motivational style is characterized by poor self-reinforcement and delay aversion and is associated with altered reward mechanisms. When people experience delay aversion, immediate rewards are preferred over delayed rewards. Individuals with ADHD must motivate themselves more to wait for the delayed reward than individuals without ADHD. These motivation problems result in mostly behavioural symptoms (i.e. impulsiveness, inattention, overactivity and poor task engagement) (Sonuga-Barke, 2002).

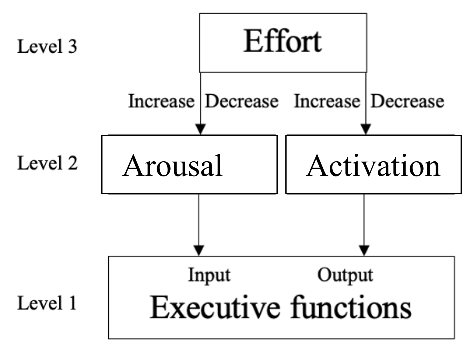
Delay aversion suggests that individuals with ADHD have difficulty both waiting for rewards and working effectively over extended periods of imposed delay ((Marco et al., 2009; Scime and Norvilitis., 2006). Delay aversion is especially expressed when individuals have no choice, resulting in increased activation, frustration, and inattention compared to control groups (Sonuga-Barke, 2008). Delayed reward is reduced by choosing impulsively, seeking other interesting parts of the environment or acting on this environment to make it more interesting. This behaviour can be characterized as an expression of the inattention and hyperactivity/impulsivity symptoms (Sonuga-Barke, 2005).

ADHD and Cognitive Motivation / State Regulation Model

In addition to behavioural motivation, it is also suggested that cognitive motivation is involved in the expression of ADHD symptoms in students. The State Regulation Model is a psychophysiological model, that explains ADHD symptoms (Van der Meere et al., 2010). The model illustrates that a deficit in motivation on a cognitive level impacts an individual's cognitive and social functioning (see Figure 1). The quality of executive functions depends on arousal and activation, regulated by motivation (effort). Arousal and activation are energetic levels needed for processing, where arousal is the ability to detect stimuli, and activation is the ability to act on them. A suboptimal state of arousal and activation can be influenced by an increase or decrease in motivation, indicating that resources can be controlled through strategic resource-management decisions. Motivation is a key factor in regulation, maintenance and initiation of action (Van der Meere et al., 2010).

Figure 1:

The State Regulation Model



Go/No-Go task

The Go/No-Go task is designed to measure the motor control inhibition difficulties linked to impulsiveness symptoms (Dillo et al., 2010), but it can also be used to manipulate effort. Manipulating incentives (e.g. stimulus presentation speed) in the task can have a direct effect on motivation since it creates a feeling of boredom in the participant, affecting the reaction time. Individuals with ADHD experience less arousal and activation to stimulate executive functioning in the slow condition (2200 ms). Therefore, motivation intervenes to compensate for the lower levels of arousal and activation in the slow condition. In the fast condition, individuals with ADHD get overstimulated by the fast stimulus presentation rate (900 ms). Here, motivation must step in to ensure that arousal and activation are decreased, to perform well on the task. Individuals with ADHD especially experience problems with activation and the compensatory use of motivation. This results in a close to or slightly shorter reaction time of people with

ADHD in the fast presentation rate of stimuli compared to the control group without ADHD, and longer in the slow presentation rate of stimuli (Van der Meere, 2005).

In the context of the motivational style mechanism, deficits in cognitive motivation, as assessed by performance on the Go/No-Go task, may reflect impairments in regulating behaviour in pursuit of long-term goals and resisting immediate rewards or distractions. Delay aversion contributes to deficits in cognitive motivation and impairments in goal-directed behaviour, illustrating the possible role of cognitive motivation in ADHD in students.

Current study

It is crucial to get a more complete understanding of the expression of ADHD in adults, so that the diagnostic procedure can be improved, and misdiagnosis is reduced. The goal of my research is to better understand the effect of ADHD symptoms on the student's motivation, and research what explains the cognitive motivation difficulties in adults with the disorder. This research builds on prior research to understand the mechanism behind ADHD symptoms and the role of motivation on both a behavioural and cognitive level. ADHD symptoms are measured with the DSM-total scale of the CAARS, behavioral motivation is measured using the motivational drive subscale of the EFI, and cognitive motivation is measured using the difference scores of the reaction times by subtracting the fast from the slow condition in the Go/No-Go task.

In previous research, dysregulation of thought and action and motivational style are the two mechanisms considered foundational for the expression of inattention and hyperactivity/impulsivity symptoms in ADHD (Sonuga-Barke, 2002). The first mechanism is considered the more behavioural component of motivation, linked to executive functioning (Barkley, 1999). Decreased executive functioning results in impaired inhibitory control associated with the EFI subscale motivational drive (Spinella, 2002). The second mechanism is considered the more cognitive component of motivation, which is linked to delay aversion

(Sonuga-Barke, 2005) and the explained by the State Regulation Model (Van Meere, et al., 2010). The expression of ADHD symptoms is dependent on the context and can be influenced by environmental conditions (McFadden, 2023). Since university students have good executive functions, I investigated the expression of ADHD symptoms in students, specifically focusing on the effect of motivation. If motivational drive has a mediating influence on ADHD symptoms and cognitive motivation, interventions can be better tailored to enhance motivational strategies, thereby improving cognitive outcomes for individuals with ADHD. This theoretical perspective aligns with empirical findings that highlight the importance of motivation in managing ADHD-related cognitive deficits and suggests pathways for targeted therapeutic approaches (Solanto, 2001).

Research question 1: is there an overall association between ADHD symptoms and cognitive motivation in students?

The State Regulation Model illustrates the effect of effort (i.e. motivation) on executive functions through arousal and activation. When an individual makes strategic resource management decisions, executive functioning can be enhanced. The model shows that cognitive motivation impacts ADHD symptoms (Van der Meere et al., 2010). How ADHD symptoms affect cognitive motivation is explained through delay aversion. Individuals with ADHD symptoms prefer immediate rewards over delayed rewards, resulting in impulsiveness symptoms (Sonuga-Barke 2005). The State Regulation Model and delay aversion suggest evidence for a link between ADHD symptoms and cognitive motivation, but these theories are based on children. This study investigates whether this also holds in students by measuring the difference in the students' reaction time in the Go/No-Go task by subtracting the reaction time in the fast condition from the reaction time in the slow condition. In line with previous research, it is hypothesised that individuals who score higher on the CAARS, have a longer reaction time on the Go/No-Go task in the slow condition, and a shorter reaction time in the fast condition. The discrepancy between the reaction times in the different conditions represents the level of cognitive motivation. The worse the students' cognitive motivation, the bigger the difference in reaction times between the fast and slow conditions. The level of ADHD symptoms is measured using the DSM-total score of the CAARS. In conclusion, it is hypothesized that students with more ADHD symptoms experience more problems with cognitive motivation.

Research question 2: is there an association between ADHD symptoms and the executive function motivational drive?

That individuals with ADHD symptoms often experience difficulties with executive functioning has been researched previously (Barkley, 1999). Specifically for the executive function motivation drive, it has been found that an increase in ADHD symptoms results in a decrease in motivational drive, resulting in more difficulties initiating, organizing, and sustaining goal-directed behaviour (Arellano-Virto, 2021). In the context of the dysregulation of thought and action mechanism, deficits in motivational drive may reflect underlying impairments in executive functions (Sonuga-Barke, 2002). These deficits contribute to difficulties with self-regulation and may exacerbate symptoms of impulsivity and inattention in individuals with ADHD. This illustrates the possible role of motivational drive in ADHD symptoms in students. The effect of ADHD symptoms on motivational drive is measured by comparing the student's DMS-Total score of the CAARS to the Motivational Drive score of the EFI. In line with previous research, it is hypothesized that individuals with a high score on the CAARS DSM-Total scale, score lower on the EFI subscale Motivational Drive. This suggests that students with more ADHD symptoms experience more problems with goal-directed behaviour.

Research question 3: is the relation between ADHD symptoms and cognitive motivation in students mediated by motivational drive?

If ADHD symptoms are indeed associated with cognitive motivation in students, there is still the question of how this relationship could be explained. Why do ADHD symptoms result in decreased cognitive motivation? The hypothesis that motivational drive mediates the relationship between ADHD symptoms and cognitive motivation is based on several theories that describe how ADHD, motivation, and cognitive processes interact. ADHD symptoms of inattention, hyperactivity, and impulsivity can disrupt an individual's ability to sustain attention and regulate effort over time (Barkley, 1997). These symptoms have been linked to deficits in executive functions, including working memory and self-regulation, which are critical for cognitive engagement and performance (Brown, 2006).

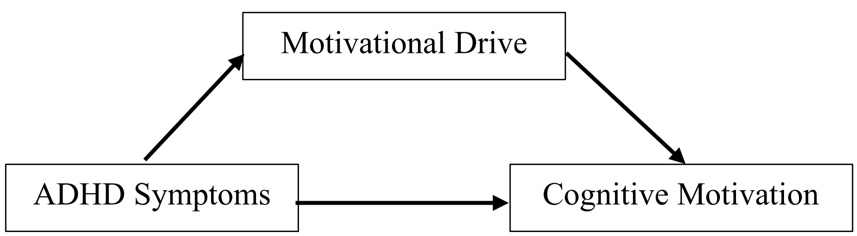
Theories of motivation, like self-determination theory (Deci & Ryan, 1985) and the State Regulation Model (Van der Meere et al., 2010) illustrate that intrinsic and extrinsic factors influence motivation. A dysregulation of the neurological arousal system that plays a vital role in reward processing and motivational drive may be responsible for fluctuating motivation in individuals with ADHD (Volkow et al., 2009; Sagvolden et al., 2005). This dysregulation can lead to inconsistent levels of motivation, impacting the individual's ability to initiate and sustain cognitive tasks.

Given this context, it is plausible that cognitive motivation in individuals with ADHD is not a direct outcome of their symptoms but is complexly linked to their motivational drive. Motivational drive can be understood as the internal force that sustains goal-directed behaviour. It regulates an individual’s behavioural drive, activity level, and interest in novelty (Spinella, 2005). For individuals with ADHD, their capacity for cognitive motivation is likely influenced by how their motivational drive interacts with their executive function deficits. This interaction may exacerbate the ADHD symptoms.

Therefore, the hypothesis suggests that motivational drive is a mediator translating the impact of ADHD symptoms into varying levels of cognitive motivation (see Figure 2). This mediating role of motivational drive helps to capture the dynamic and multifaceted characteristics of motivation in individuals with ADHD, offering a more comprehensive understanding of how ADHD symptoms influence cognitive motivation.

Figure 2:

Conceptual mediation model



Method

Participants

In the study, a non-clinical convenience sample was used, in which 554 first-year psychology students (126 males, 397 females, 16 reported other, 3 declined to answer) participated. The participants had to finish the CAARS and the EFI to be invited to the experiment. Since 15 participants did not complete the study, they were excluded from the analysis. The final sample consists of 538 participants, of which 125 (23.2%) identified as male, 394 (73.2%) as female, 17 (3.1%) as other, and 2 (0.4%) participants declined to answer (see Appendix A, Table 1). The participants' age ranged from 16 to 35 years old with a mean of 19 years old (*N* = 515*;* *M* = 19; *SD* = 2.20) (see Appendix A, Table 2).

All participants who filled out the CAARS and the EFI questionnaires were invited for the follow-up experimental study. The experimental sample consists of 30 participants (*N* = 30). 3 participants were excluded from the analysis since they were underaged. The age requirement for this study is at least 18 years old. Therefore, final sample consists of 27 participants aged 18 to 26 years old and an average age of 20 (*N* = 27*; M* = 20; *SD* = 1.955) (see Table 1). To compare the participants' scores in the analysis, the experimental sample is divided into two groups based on their CAARS DSM-Total score. Participants with a score of 60 or higher on this subcategory are categorized as the high ADHD group and below 60 as the low ADHD group (Vizgaitais et al., 2023). The group with a low score on the CAARS DSM-Total contains 13 students (*N* = 13), and the group with a high score consists of 14 participants (*N* = 14, see Table 1). The Ethical Committee of the Faculty of Behavioral and Social Sciences of the University of Groningen approved the first and the second part of the study.

Table 1:

Frequencies and Descriptive Statistics of the Final Sample

What is your age?

Groups	Mean	N	Std. Deviation
Low	20.62	13	2.142
High	19.71	14	1.729
Total	20.15	27	1.955

Note: DSM-Total T-score of below 60 is considered the low group; 60 and above is considered the high group.

Measurements

Conners' Adults ADHD Rating Scales

ADHD symptoms were measured with the Conners' Adult ADHD Rating Scales (CAARS, Conners, 1999). The CAARS is a self-report tool specifically adapted for adults from the DSM-4 criteria (American Psychiatric Association, 1994). It includes 81 questions covering behavioural symptoms (e.g., 'I talk too much') and cognitive symptoms (e.g., 'I don't plan ahead'), rated on a 4-point scale from 0 (Not at all/Never) to 3 (Very much/Very frequently). It provides two main scores: the ADHD-Index and the DSM-Total score. The CAARS is divided into several subscales a) inattention/memory problems, b) hyperactivity/restlessness, c) impulsivity/emotional liability, d) problems with self-concept, e) DSM-IV: inattentive symptoms, f) DSM-IV: hyperactivity/impulsivity symptoms, g) DSM-IV: total ADHD symptoms, and h) ADHD index (Macey, 2003). This study only focuses on the subcategory DSM-IV: Total symptom score (DSM-TS), because this measure is specifically tailored to the original symptoms of ADHD in children, which is linked to executive functioning. The student's raw CAARS scores are transferred into a T-score. The higher the T-score, the higher the indication that an individual has ADHD symptoms (Macey, 2003). CAARS has good reliability ($\alpha = 0.968$), high specificity and sensitivity, and is a valid cross-cultural measure (Christiansen et al., 2012).

Executive Function Index Scale

The executive function motivational drive is measured using the Executive Function Index Scale (EFI; Spinella, 2005). This self-report measures the participants' executive functions in daily life. Specifically, it aims to capture individuals' ability to initiate and sustain goal-directed action, maintain motivation, and regulate behaviour to achieve desired outcomes. The scale consists of 27 items covering the five subcategories a) Motivational Drive, b) Organization, c) Impulse Control, d) Empathy, and e) Strategic Planning (Spinella, 2005). In this research the focus is on the Motivational Drive subscale, measuring aspects of motivation, goal-directed behaviour, and self-regulation in daily life activities. Items of the motivational drive subscale of the EFI consist of questions related to behavioural drive, activity level, and interest in novelty. The participants were asked to rate themselves on a 5-point Likert scale, ranging from '1 *not at all'* to 5 '*very much'*. The raw EFI score is transferred into a T-score. The higher the T-score, the better the participant's executive functioning. The EFI has good reliability (α = 0.69 to α = 0.82; Spinella, 2005).

Go/No-Go task

Cognitive motivation was measured with an impulsivity task, called the Go/No-Go task. The task consisted of two experimental blocks, the first consisting of short (900 ms), and the second of long (2200 ms) stimulus presentation time for each trial. In the first experimental block the fixation had a fast duration (300 ms) while in the second block, the fixation had a long duration (5000 ms). The participant had to give a response when the target stimulus (the letter O) appeared on the screen and inhibit the response when another stimulus (the letter Q) appeared. For each trial, participants had to fixate on the center of the screen, and then either press the 'B' key (if the letter 'O' appeared) or not press anything (if the letter 'Q' appeared. In the first block, the participant gets motivated by the speed of the task, but in the second task, they must motivate themselves to stay focused. Thus, motivation is measured by comparing the students' reaction times between the two conditions (slow condition reaction time – fast condition reaction time).

Procedure

The study consists of two voluntary parts, where the students could stop at any time. In the first part, the participants participated in the CAARS and the EFI through the questionnaire platform Qualtrics, respectively. By doing this, the students acquired credits for a university course through the research platform SONA. The information about the study and its purpose was described shortly and the informed consent was presented. The goal of the study was explained, and it was emphasized that the participation is completely voluntary, they can quit at any time and ask questions if they want to. Then, demographic information was gathered (i.e. age, job, language, gender, and biological sex). The students were asked whether they had received a formal diagnosis of ADHD and had been prescribed medication, after which the student was directed to the CAARS. Lastly, the student could leave a comment or question if preferred. In the EFI, it is first stressed again that the students can always email when there are questions and that they can quit at any time, after which informed consent is asked for this specific questionnaire. After the students finished the EFI, we again provided the possibility to leave comments or questions if preferred. The estimated time to complete the two questionnaires is 50 minutes in total.

The students who finished the CAARS and the EFI were invited via email to the second part of the study. In the second part of the study, the participants participated in five experimental tasks through the experimental research program OpenSesame on a computer in the controlled research lab of the University of Groningen. The tasks were given in a randomized sequence, to ensure that the other tasks have not affected the performance of the students on the Go/No-Go task. After a general introduction about the task, the participants had a chance to practice shortly to know what they could expect. After this trial, the first experimental block started. When the first block (short duration) finished, all participants had a two-minute break after which the second block (fast duration) started. Including two breaks of 2 minutes, the time to complete the second part of the study was estimated to be 40 minutes. The tasks varied all in time, ranging from 2 to 20 minutes. The informed consent for all five experiments was implemented in the Go/No-Go task.

Data analysis

Before the analysis could start, the data had to be prepared. First, the raw data of the EFI and the CAARS were converted from Qualtrics into an SPSS file. For the EFI and CAARS, the relevant sum scores and T-scores were calculated. Then, all the raw data from all the participants in the Go/No-Go task was inserted into a Microsoft Excel file, where the variables for the SPSS data file were calculated. The variables that are calculated are the mean reaction times of correct responses in milliseconds (*ms*) ([mRT_fast_corr]; [mRT_slow_corr]), standard deviations of mean reaction times in *ms* ([mSD_fast]; [mSD_slow]), the percentages of errors in ms ([%_error_fast]; [%_error_slow]), and the errors of commissions in percentages ([%_omissie_fast]; [%_omissie_slow]). These variables are calculated for each participant for the slow and the fast conditions. Then, the difference scores were calculated for each participant by subtracting the fast condition score from the slow condition score for the means, standard deviations, and errors ([Diff_RT_SlowFast]; [Diff_M_RT_SlowFast]; [Diff_Error_RT_SlowFast]). The Excel file with the experimental data was merged into the SPSS file with the data of the questionnaires, resulting in the data file with the questionnaire's combined variables and the study's experimental part. The 29th version of IBM SPSS Statistics was used to analyse the data. After the data was prepared, the assumptions were checked for the three hypotheses.

Research question 1: is there an overall association between ADHD symptoms and cognitive motivation in students?

First, the assumptions for a single linear regression had to be checked. The Shapiro-Wilk test was used to test for a normal distribution of the data. The output clearly shows a non-normal distribution of the data, except for the mean and standard deviation of the reaction time in the fast condition ([mRT_fast_corr]; [mSD_fast]) (see Appendix A, Table 5). The non-normal distribution of the other variables does not cause a problem for the analysis, since it is in line with literature suggesting heterogeneity of ADHD symptoms (Sonuga-Barke, 2002). Furthermore, the Central Limit Theorem states that non-normality does not cause a problem when the sample size is 30 or above. The sample size for the EFI and CAARS are far above 30 (n = 538), so this should not cause any issues. The Q-Q plots indicate that the data conforms to a linear distribution, as the data generally forms a straight line (See Appendix A, Figures 3, 5 and 9).

There is no indication of outliers that might influence the outcome of the analysis. The first hypothesis suggests that students with more ADHD symptoms experience more problems with cognitive motivation. The association between ADHD-TS and CM is tested with non-parametrical Pearson's correlation coefficients. The main effect of the experimental conditions 'fast' and 'slow' on the reaction times of the students and the variability of the mean reaction times are checked using repeated measures ANOVA. The assumptions for a linear regression analysis are in line with the assumptions for the ANOVA.

Research question 2: is there an association between ADHD symptoms and the executive function motivational drive?

Also, for the second hypothesis, the assumptions for a linear regression had to be checked. The output of the Shapiro-Wilk test for normality again showed a non-normal distribution of the data (see Appendix A, Table 4). As mentioned in hypothesis one, this does not cause a problem for the analysis due to the heterogeneity of ADHD symptoms (Sonuga-Barke, 2002). The Q-Q plots indicate that the data on motivational drive follows a linear distribution, but the data on ADHD symptoms does not (See Appendix, Figures 1 and 2). However, this does not cause a problem according to the Central Limit Theorem and the heterogeneity of ADHD symptoms as discussed before. Again, there is no indication of outliers that might influence the outcome of the analysis. The second hypothesis suggests that students with more ADHD symptoms experience more problems with the executive function motivational drive. This is tested using non-parametrical Pearson's correlation coefficients.

Research question 3: is the relation between ADHD symptoms and cognitive motivation in students mediated by motivational drive?

For the last hypothesis, the assumptions for a mediation analysis had to be checked. Again, the Shapiro-Wilk test shows a non-normal distribution of the data, and the Q-Q plot shows the linearity of the relationships between the variables (See Appendix A, Tabel 5, Figures 3 until 12). The homoscedasticity assumption is validated by analyzing the results of Levene's test. The output shows that this assumption is met for the percentage of errors in the fast and slow conditions ([%_error_fast]; [%_error_slow]) and for the percentage of omissions in the slow condition ([%_omissie_slow]). However, it is not met for the percentage of omissions in the fast condition ([%_omissie_fast]) (see Appendix A, Tables 6 and 7). Lastly, the Variance Inflation Factor (VIF) is calculated to ensure that the independent variable DSM-Total score and the mediator motivational drive are not highly correlated. The VIF value of 1 indicates that the assumption for multicollinearity is met, according to the rule of thumb (VIF < 4, see Appendix A, Table 8).

Results

This section presents the results of the validation check of the experimental conditions and the findings of the mediating effect of motivational drive on the relationship between ADHD symptoms and cognitive motivation in university students.

Descriptive Statistics

The mean and standard deviation of the CAARS DSM-Total score, EFI Motivational Drive score and the Mean Reaction Time of the Go/No-Go task are presented in Table 2 below.

Table 2:

Descriptive Statistics for Study Variables

	N	Mean	Std. Deviation
CAARS_TscoreDSM_Total	27	61.3883	11.24818
EFI_Motivational_Drive	27	14.07	2.973
Diff_RT_SlowFast	27	105.67987	55.784935
Diff_MRT_SlowFast	27	37.69576	50.562093
Diff_ErrorRT_SlowFast	27	-6.6667	20.14371
mRT_fast_corr	27	311.04	25.885
mSD_fast	27	58.57079	13.362780
%_error_fast	27	26.29630	16.617449
%_omissie_fast	27	1.48148	2.109874
mRT_slow_corr	27	416.72	62.870
mSD_slow	27	96.26655	53.217049
%_error_slow	27	19.62963	19.509659
%_omissie_slow	27	2.59259	3.430735

Pearson's correlations are calculated to see whether the variables are (significantly) correlated (see Appendix A, Table 9). DSM-TS and Diff_RT are positively correlated (r = .393, p = .043), indicating a medium significant strength association. The positive association suggests that an increase in ADHD accompanies a bigger difference in the reaction time between the fast and the slow conditions. DSM-TS and MD are positively correlated as well (r = .117, p = 0.331); however, this might require some additional explanation. Since an increase in the motivational drive means better executive functioning and an increase in the DSM-TS means worse symptoms, the scales of the CAARS and EFI are reversed. The positive correlation suggests that more ADHD symptoms accompany a decreased motivational drive. Additionally, the correlation is rather small and non-significant, indicating a weak association between the two variables. The last correlation shows that the difference between the slow and fast conditions in the Go/No-Go task is positively associated with motivational drive (r = .194, p = .331). Again, due to the reverse scale of the EFI, this suggests that decreased motivational drive accompanies an increased difference in reaction time between the two conditions.

Validation task effect mean reaction time

The experimental conditions [mRT_slow_corr] and [mRT_fast_corr] should be tested before the analysis of the hypothesis, to ensure that the stimulus conditions influenced the speed of the student's performance on the Go/No-Go task. This was done by performing a repeated measures ANOVA. The within-subjects effect output shows a significant main effect of the slow and the fast stimulus conditions (F (1) = 103.428, p < .001, η^2 = .805), indicating that the reaction times differ significantly between the fast and the slow condition in the Go/No-Go task, regardless of the ADHD group they are categorized in. However, there is a non-significant effect on the interaction effect of [condition] and [groups_DSM_total] (F (1) = 3.151, p = .088, η^2 = .112). This indicates that there is no significant difference in reaction times between the high and low ADHD symptom groups across both the fast and slow conditions. The between-subjects effect output shows that there is not a significant main effect of the low and high ADHD group based on the self-reported DSM-total score of the EFI (F (1) = .038, p = .847, η^2 = .002). The main effect indicates that the difference in reaction times between the fast and slow conditions does not depend on the ADHD symptoms group. The results are illustrated in Figure 3, and the descriptive statistics are provided in Table 3.

Figure 3:

Mean reaction time of ADHD groups on the stimulus conditions

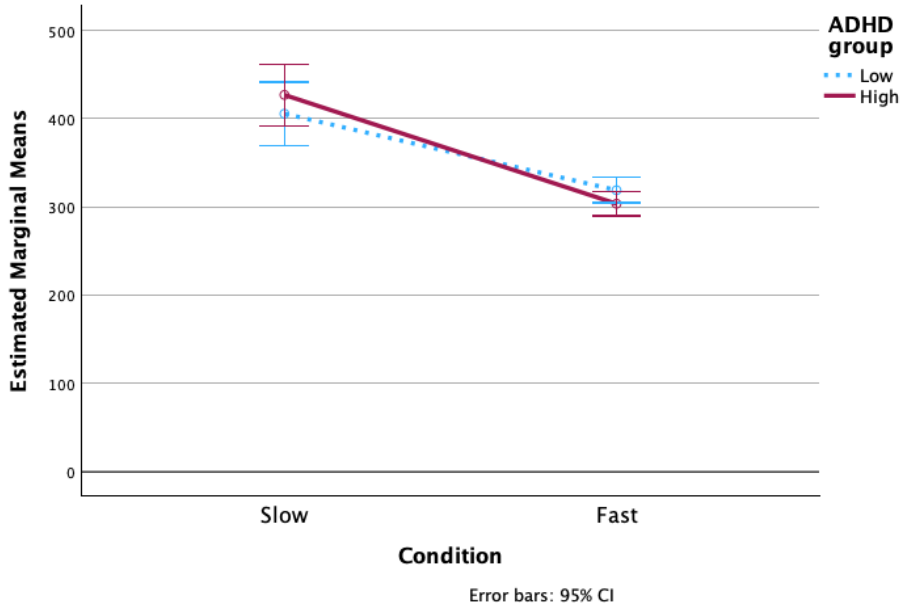


Table 3:

Descriptive statistics

	ADHD groups	Mean	Std. Deviation	N
mRT_slow	Low	405.66	43.773	13
	High	426.99	76.816	14
	Total	416.72	62.870	27
mRT_fast	Low	318.98	20.618	13
	High	303.66	28.739	14
	Total	311.04	25.885	27

Note: mean and standard deviation are in milliseconds (ms)

Validation task effect mean standard deviation

The experimental conditions [mSD_slow] and [mSD_fast] represent the variation in the reaction time in the task in ms. The effect of the conditions should be tested to ensure that the stimulus conditions influenced the variability of the speed of the student's performance on the Go/No-Go task. This was done by performing a repeated measures ANOVA. The within-subjects effect output shows a significant main effect of the slow and the fast stimulus conditions (F (1) = 14.969, $p < .001$, $\eta^2 = .375$), indicating that the reaction times differ significantly with a medium effect size between the fast and the slow condition in the Go/No-Go task, regardless of the ADHD group they are categorized in. However, there is a non-significant effect on the interaction effect of [condition] and [groups_DSM_total] (F (1) = 1.602, $p = .217$, $\eta^2 = .060$). This indicates that there is no significant difference and a small effect size in the variability of reaction times between the high and low ADHD symptom groups across both the fast and slow conditions. The between-subjects effect output shows no significant main effect of the low and high ADHD group based on the self-reported DSM-total score of the EFI (F (1) = 1.891, $p = .181$, $\eta^2 = .070$). The main effect indicates that the variability of reaction times between the fast and slow conditions does not depend on the ADHD symptoms group. The results are illustrated in Figure 4, and the descriptive statistics are provided in Table 4.

Figure 4:

Mean standard deviation of reaction time of ADHD groups on the stimulus conditions

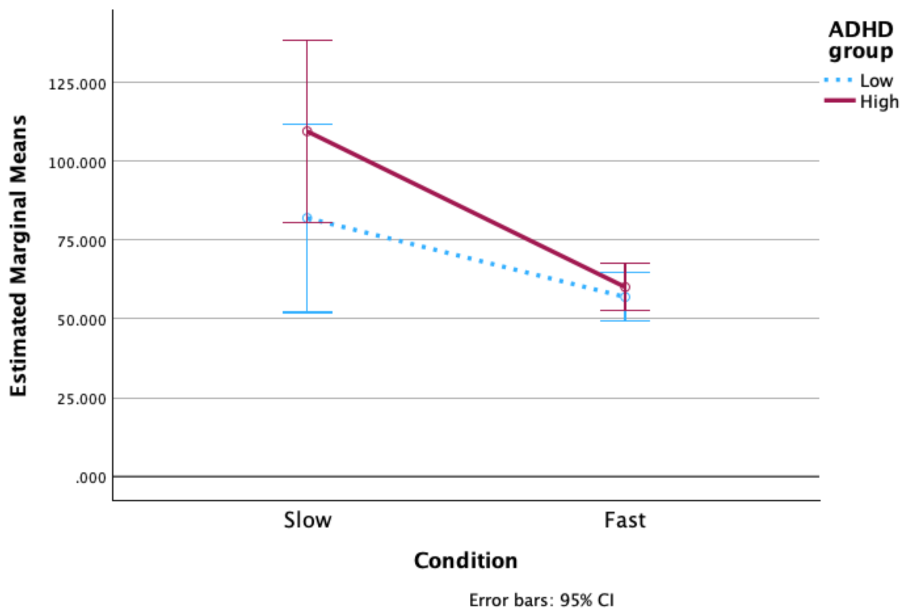


Table 4:

Descriptive statistics

	ADHD groups	Mean	Std. Deviation	N
mSD_slow	Low	82.00042	18.619575	13
	High	109.51367	70.367471	14
	Total	96.26655	53.217049	27
mSD_fast	Low	56.94154	12.020531	13
	High	60.08367	14.786147	14
	Total	58.57079	13.362780	27

Note: mean and standard deviation are in milliseconds (ms)

Validation task effect error

The experimental conditions [%_error_slow] and [%_error_ fast] represent the response accuracy in the task. The effect of the conditions should be tested to ensure that this affects the student's accuracy on the Go/No-Go task. The within-subjects effect output of the repeated measures ANOVA shows a non-significant effect of the slow and the fast stimulus conditions (F (1) = 2.819, p = .106, η^2 = .101), indicating that the accuracy does not differ significantly with a small effect size between the fast and the slow condition in the Go/No-Go task, regardless of the ADHD group. There is a non-significant effect on the interaction effect of [condition] and [groups_DSM_total] (F (1) = .048, p = .828, η^2 = .002). This indicates no significant difference and a small effect size in the accuracy of responses between the high and low ADHD symptom groups across both the fast and slow conditions. The between-subjects effect output shows that there is again no significant main effect of the low and high ADHD group based on the self-reported DSM-total score of the EFI (F (1) = 2.582, p = .121, η^2 = .094). The main effect indicates that the difference in response accuracy between the fast and slow conditions does not depend on the ADHD symptoms group. The results are illustrated in Figure 5, and the descriptive statistics are provided in Table 5.

Figure 5:

Mean accuracy of ADHD groups on the stimulus conditions

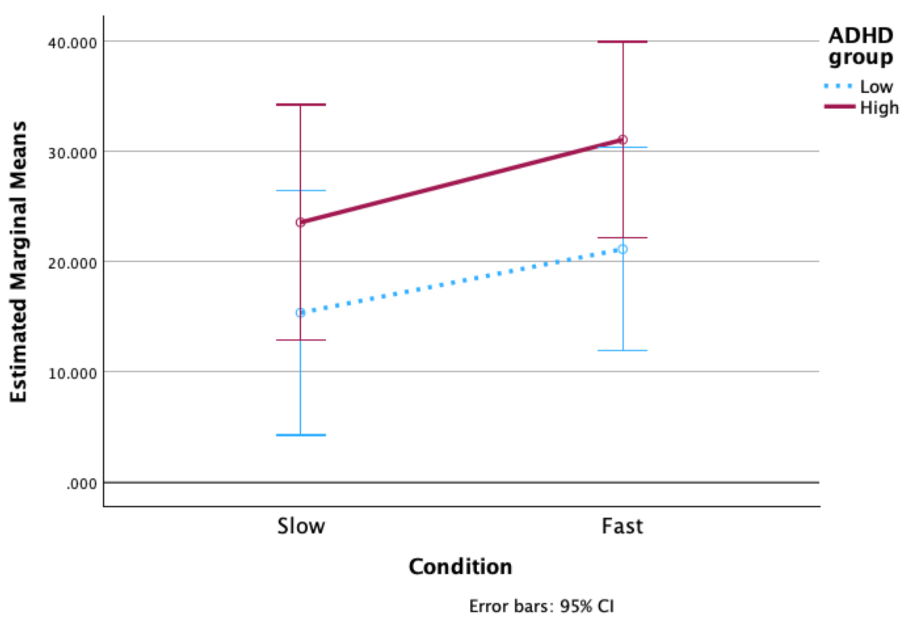


Table 5:

Descriptive statistics

	ADHD groups	Mean	Std. Deviation	N
%_error_slow	Low	15.38462	15.063966	13
	High	23.57143	22.738359	14
	Total	19.62963	19.509659	27
%_error_fast	Low	21.15385	13.867505	13
	High	31.07143	17.993436	14
	Total	26.29630	16.617449	27

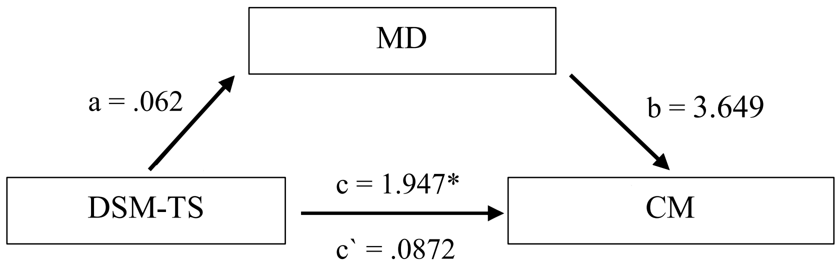
Note: mean and standard deviation are in percentages (%)

Analysis of hypotheses

Several single or multiple regression analyses were performed to study the research questions and their hypotheses. After these analyses, the indirect effect of mediator MD on the relationship between DSM-TS and CM was tested through the bootstrapping method of Hayes' (2013) PROCESS application. The analysis of the three hypotheses is broken down into four steps, which will be illustrated in the next paragraphs and are categorized by research question. The figure below illustrates the conceptual model (see Figure 7).

Figure 7:

Unstandardized regression coefficients for the relationship between ADHD symptoms and cognitive motivation through motivational drive.



Note: *$p < .05$, DSM-TS = ADHD-DSM Total Score, MD = Motivational Drive, CM = Cognitive Motivation.

Research question 1: is there an association between ADHD symptoms and cognitive motivation in students?

Path C in the model represents the first research question about the association between the DSM-total symptoms subscale of the CAARS and cognitive motivation (see Figure 7). Cognitive motivation is measured by calculating the difference between the student's reaction times in the slow and the fast conditions. In this study, it is hypothesized that an increase in ADHD symptoms will lead to an increase in the difference between the two conditions. An ANOVA was performed to test the hypothesis, showing that there is a significant effect on the association between DSM-total score and cognitive motivation ($R^2 = 0.154$, $F(1, 25) = 4.557$, $\beta = 1.947$, $p = 0.043$). This suggests that in comparison to the fast condition, the students have a longer reaction time in the slow condition when the student scores high on ADHD symptoms, compared to students who score low on ADHD symptoms. In conclusion, the results provide support for the first hypothesis.

Research question 2: is there an association between ADHD symptoms and the executive function motivational drive?

Path A in the conceptual model represents the research question about the association between the DSM-total score subscale of the CAARS and the motivational drive subscale of the EFI (see Figure 7). It is hypothesized that a higher score on the DSM-total symptoms scale will lead to a lower score on executive functioning. As explained before, a lower score on the EFI indicates more problems with executive functioning, whereas a lower score on the CAARS indicates fewer ADHD symptoms. Therefore, it is hypothesized that ADHD symptoms have a negative effect on the student's motivational drive, indicating a negative association between the two variables.

Like the prior research question, the association is tested using an ANOVA. The results suggest a non-significant small effect on the association between DSM-total score and motivational drive ($R^2 = 0.036$, $F\ (1, 25) = .936$, $\beta = .062$, $p = 0.343$). The positive association indicates that students with more ADHD symptoms have fewer problems with the executive function motivational drive. This is contrary to what was expected in the hypothesis, and the result is not significant. The results do not support our hypothesis.

Research question 3: is the relation between ADHD symptoms and cognitive motivation in students mediated by motivational drive?

Before the indirect effect of the mediating variable motivational drive can be tested, the effect of motivational drive on cognitive motivation must be tested. This association represents path B in the conceptual model (see Figure 7). The ANOVA shows a small non-significant effect of motivational drive on cognitive motivation ($R^2 = 0.038$, $F\ (1, 25) = .983$, $\beta = 3.649$, $p = 0.331$). This suggests that lower motivational drive in students results in decreased cognitive motivation.

Now that all the required paths of the conceptual model have been researched, the indirect effect of the mediating variable motivational drive on the relation between DSM-total score and cognitive motivation is tested. This research question corresponds to path C` in the model (see Figure 7). The indirect effect is tested through Hayes' bootstrapping method (2013). The results indicate a small non-significant indirect effect ($\eta^2 = 0.0872$, 95% $CI = -0.5189, 0.7275$). This does not provide evidence for the hypothesis that motivational drive (partly) explains the effect of ADHD symptoms on student's cognitive motivation.

Discussion

This research studied the effect of ADHD symptoms on cognitive motivation in university students. It specifically tested whether the executive function motivational drive has a mediating effect on the relationship between ADHD symptoms and cognitive motivation in the Go/No-Go task. This research contributes to the complex understanding of the association between ADHD symptoms, motivational drive, and cognitive motivation. The results reveal insightful information about the association between these variables. However, the expected mediation effect of motivational drive was not supported, highlighting the complexity of motivational processes in individuals with ADHD. More detailed information about these results and their implications is explained in the sections below.

ADHD-total symptoms and cognitive motivation

The first hypothesis is that students with more ADHD symptoms have worse cognitive motivation. The statistical analysis indicates support for this hypothesis. More ADHD symptoms lead to a bigger difference between the students' reaction times in the slow and fast conditions, representing cognitive motivation. This finding suggests, as expected, that an increase in ADHD symptoms leads to a decrease in the student's cognitive motivation, which increases the difficulty of staying motivated to pursue long-term goals. In our experiment, students experience more problems staying focused on the slower stimulus manipulation, resulting in a longer reaction time. The relatively large gap in the reaction times of students with more ADHD symptoms in the fast and slow conditions of the Go/No-Go task suggests that higher ADHD symptomatology is linked to increased cognitive difficulties in task engagement. In conclusion, the first hypothesis is supported.

ADHD-total symptoms and motivational drive

The second hypothesis is that increased ADHD symptoms lead to a lower score on the EFI motivational drive subscale, indicating more problems with an individual's motivational drive. The analysis does not indicate enough support for this hypothesis. The correlation suggests, as expected, that an increase in ADHD symptoms leads to a decrease in the students' motivational drive, leading to a possible decreased ability to initiate and sustain goal-directed actions, maintain motivation, or regulate behaviour to achieve desired outcomes. However, there is not enough evidence to support the hypothesis.

Researching executive functions is complex since there is no universal definition, and involves numerous cognitive processes (Barkley, 1997). The prefrontal and thalamic-reticular regions of the brain are linked to various processes that constitute the executive system (Roselló, 2020). Given that these brain regions are also implicated in ADHD, it is not surprising that there is some overlap between executive function deficits and ADHD symptoms. It is known that inhibition problems play a role in ADHD symptomatology (Barkley, 1997), but less is known about the effect of other executive functions. That the hypothesis is not fully supported, might be due to the sample of university students. University students have good levels of executive functioning generally. A possible explanation for the result could be that the students with ADHD have managed to make it to university despite their attention and impulsivity/hyperactivity difficulties. The students might have developed coping mechanisms to overcompensate for their problems with proper motivation and dedication, which might have affected the relationship between self-reported motivational drive and ADHD symptoms.

The mediating role of motivational drive in ADHD-total symptoms and cognitive motivation

The third and last hypothesis is that motivational drive mediates the relationship between ADHD symptoms and cognitive motivation. It was tested through a bootstrapping method, in which the results did not completely support our hypothesis. There is not enough support to state that motivational drive explains the relationship between ADHD symptoms and cognitive motivation in our sample of students.

The concept of delay aversion could help to explain why students with high ADHD symptoms had a shorter reaction time in the fast condition and a longer reaction time in the slow condition, compared to students with low ADHD symptoms. Aversion to delay can lead to impulsiveness when individuals get overstimulated in childhood, indicating worse cognitive motivation (Sonuga-Barke, 2005). However, brain development continues into adulthood, which can affect the presentation of ADHD symptoms. As the brain matures, some individuals may experience a reduction in symptoms. Similarly, the context in which individuals operate changes over time. Initially, caregivers provide structure externally, but as individuals grow older, they must create structure independently (Barkely, 1997). In line with the possible explanation of the insignificant result in the association between ADHD symptoms and motivational drive, it might be possible that the development of coping strategies as individuals with ADHD grow older also plays a role in the third analysis. It could be that this is the case in our sample of university students; the students have created coping strategies to mask the impact of their ADHD symptoms. Therefore, our sample might not generalize to the population based on their executive functioning levels, which might have influenced the outcome of the data analysis.

Implications

The goal of my research is to gain a deeper understanding of how ADHD symptoms manifest in adults, with a focus on motivation. Misdiagnosis and underdiagnosis of the disorder are known to impact individuals in their daily lives and hinder them in their occupational and social functioning. There has been critique about the diagnostic process of ADHD in adults, but before this can be improved the full expression of the disorder in older age should be understood. This research helps to gain more knowledge about the expression of the symptoms in adulthood so that underdiagnosis and misdiagnosis can be reduced in the future.

Due to the heterogeneity of the disorder, it is difficult to form a complete and coherent understanding of the problems individuals experience in their daily lives. This variability is considered by not focusing on a formal diagnosis, but rather on self-reported problems with events that represent symptoms of inattention and hyperactivity/impulsivity in the CAARS. Using the self-report questionnaire EFI and an experimental design of the Go/No-Task, allows us to measure motivation on both a cognitive and behavioral level. This is not often done in studies, increasing our understanding of the topic.

Limitations

The primary limitation of this study concerns the sample used for the experiment, which limits the reliability of the results. Initially, participants were to be recruited based on their CAARS scores, with the highest and lowest 25% invited to facilitate a clear comparison between low and high ADHD groups. However, only a few students initially signed up. Consequently, the decision was to invite all students who had completed both questionnaires to increase the sample size. While this approach effectively recruited more participants, we still had a relatively small sample of 30 participants (n = 30). A possible reason for the low participation rate is that students were participating to earn course credits. By the last block of the year, many had likely already earned the necessary credits and did not sign up for the study. After applying exclusion criteria, the final sample size was 27 participants (*n* = 27), which is too small to obtain reliable outcomes. Generally, recruiting a sample of at least 71 participants is advised to get reliable outcomes in a mediation analysis (Fritz & MacKinnon, 2007).

Secondly, the sample used in this research was a convenience sample, which may limit the generalizability of the findings. Convenience samples can introduce biases and may not accurately represent the population. Due to the student sample, we cannot translate the results directly to the adult population. Although university students are a relevant sample due to their typically high executive functioning, future research should strive to use more representative samples to enhance the validity and reliability of the results, such as through random sampling. Additionally, examining gender differences is crucial. The majority of the current sample consists of women (73.2%). A balanced sample with an equal number of men and women could generate different results, as research by Saleh et al. (2021) suggests that gender may play a role in how ADHD symptoms and executive function deficits are expressed.

Additionally, cultural differences could impact the expression of ADHD symptoms and the effectiveness of various interventions. ADHD is a context-dependent disorder, and cultural factors may influence both symptom manifestation and treatment outcomes (McFadden, 2023). Future research should investigate cultural variations to provide valuable insights into how ADHD manifests across different populations and to inform more culturally sensitive diagnostic and treatment approaches.

The Go/No-Go task used in this study measures motivation by manipulating the time the stimuli are presented. Originally, the task measures pure inhibition, raising questions about its specificity and validity for this research. Future studies should consider using tasks that specifically measure cognitive motivation, such as delay tasks, to study the mediating effect of motivational drive on the association between ADHD symptoms and cognitive motivation better. Exploring more nuanced motivation tasks (i.e. delay aversion task) will allow for a deeper investigation into the topic.

Another critical aspect to consider for the validity of the research is the relationship between cognitive motivation and motivational drive. It remains uncertain which variable mediates the other—whether cognitive motivation influences motivational drive or vice versa. Future studies should aim to disentangle the complex direction of the association to understand the roles of cognitive and behavioural motivation in ADHD better.

A notable limitation of this study is the inability to monitor students while completing the CAARS and EFI questionnaires. As a result, it cannot be ensured that participants filled out these measures with proper motivation, which decreases the reliability of the data since motivation is a key variable in this study. However, it is important to note that there were no disruptions in the task measurements, and the experiments took place in a controlled laboratory setting with proper instructions provided beforehand. Future studies should consider implementing strategies to monitor and enhance participant motivation during questionnaire completion to improve the finding's reliability.

As been told previously, it is known that ADHD symptoms impact executive functioning and the other way around, as explained in the inhibition theory by Barkley (1997). The main focus of current research about ADHD and executive functioning is on inhibition, and little attention is paid to the other executive functions. Measuring motivation on both a cognitive and behavioural level is a new way of approaching the daily difficulties adults with ADHD encounter daily. The main strength of this research is that it goes beyond what is already known and focuses on new possibilities to improve our understanding of the expression of ADHD symptomology in adulthood.

Conclusion

The primary aim of my research was to gain a deeper understanding of how ADHD symptoms manifest in adults, with a particular focus on their impact on motivation. Although the expected mediating role of the executive function motivational drive in the relationship between ADHD symptoms and cognitive motivation was not supported, the findings still shed light on the factors involved in adult ADHD symptomatology. This research underscores the complex relationship between ADHD and executive functions, emphasizing the need for further exploration of cultural and gender differences, more specific measures of motivation, and a better understanding of motivational factors. Addressing these limitations and considerations in future studies will contribute to a more comprehensive understanding of ADHD in adults.

References

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

American Psychiatric Association. (2022). Neurodevelopmental Disorders. *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.). https://doi.org/10.1176/appi.books.9780890425787.x01_Neurodevelopmental_Disorders

Arellano-Virto, P. T., Seubert-Ravelo, A. N., Prieto-Corona, B., Witt-González, A., & Yáñez-Téllez, G. (2021). Association between psychiatric symptoms and executive function in adults with attention deficit hyperactivity disorder. *Psychology & Neuroscience*, *14*(4), 438.

Ayano, G., Tsegay, L., Gizachew, Y., Necho, M., Yohannes, K., Abraha, M., Demelash, S., Anbesaw, T., & Alati, R. (2023). Prevalence of attention deficit hyperactivity disorder in adults: Umbrella review of evidence generated across the globe. *Psychiatry Research*, *328*, 115449. https://doi.org/10.1016/j.psychres.2023.115449

Barkley, R. A. (1997). ADHD and the nature of self-control. *Guilford Press.*

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological bulletin*, *121*(1), 65.

Brown, T. E. (2006). Attention deficit disorder: The unfocused mind in children and adults. Yale University Press.

Cardinal, R. N., Pennicott, D. R., Lakmali, C., Sugathapala, Robbins, T. W., & Everitt, B. J. (2001). Impulsive choice induced in rats by lesions of the nucleus accumbens core. *Science*, *292*(5526), 2499-2501.

Christiansen, H., Kis, B., Hirsch, O., Matthies, S., Hebebrand, J., Uekermann, J., ... & Colla, M. (2012). German validation of the Conners Adult ADHD Rating Scales (CAARS) II:

Reliability, validity, diagnostic sensitivity and specificity. European Psychiatry, 27(5), 321-328.

Deci, E. L., & Ryan, R. M. (1985). Intrinsic Motivation and Self-Determination in Human Behavior. New York: Plenum.

Dillo, W., Göke, A., Prox-Vagedes, V., Szycik, G. R., Roy, M., Donnerstag, F., Emrich, H. M., & Ohlmeier, M. D. (2010). Neuronal correlates of ADHD in adults with evidence for compensation strategies--a functional MRI study with a Go/No-Go paradigm. *German medical science : GMS e-journal*, *8*, Doc09. https://doi.org/10.3205/000098

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science, 18*(3), 233-239.

Gaillard, A. W. (2002). Stress, workload and fatigue as three bio-behavioural states: a general overview. In P. A. Hancock & P. A. Desmond (Eds.), *Stress, Workload and Fatigue* (pp. 623-640). Mahwah, NJ: Lawrence Erlbaum Associates.

Ginsberg, Y., Quintero, J., Anand, E., Casillas, M., & Upadhyaya, H. P. (2014). Underdiagnosis of Attention-Deficit/Hyperactivity Disorder in Adult Patients. *Primary Care Companion To CNS Disorders/The Primary Care Companion For CNS Disorders*. https://doi.org/10.4088/pcc.13r01600

Hayes, A. F. (2013). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. *Guilford Press.*

Hegerl, U., & Hensch, T. (2014). The vigilance regulation model of affective disorders and ADHD. *Neuroscience & Biobehavioral Reviews*, *44*, 45-57.

Hockey, G. R. (1997). Compensatory control in the regulation of human performance under stress and high workload: a cognitive-energetical framework. *Biological Psychology, 45*(1-3), 73-93.

Huang, J., Sander, C., Jawinski, P., Ulke, C., Spada, J., Hegerl, U., & Hensch, T. (2015). Test-retest reliability of brain arousal regulation as assessed with VIGALL 2.0. *Neuropsychiatric Electrophysiology*, *1*, 1-13.

Lasky, A. K., Weisner, T. S., Jensen, P. S., Hinshaw, S. P., Hechtman, L., Arnold, L. E., W Murray, D., & Swanson, J. M. (2016). ADHD in context: Young adults' reports of the impact of occupational environment on the manifestation of ADHD. *Social science & medicine (1982)*, *161*, 160–168. https://doi.org/10.1016/j.socscimed.2016.06.003

Macey, K. (2003). Conners' Adult ADHD Rating Scales (CAARS). By C.K. Conners, D. Erhardt, M.A. Sparrow. New York: Multihealth Systems, Inc., 1999. *Archives Of Clinical Neuropsychology*, *18*(4), 431–437. https://doi.org/10.1016/s0887-6177(03)00021-0

McFadden, Oliver G., "Reconceptualizing the Interaction Between ADHD Symptoms and Environmental Context" (2023). *University Honors Theses.* Paper 1369. https://doi.org/10.15760/honors.1398

Miranda, A., Colomer, C., Fernández, I., & Presentación, M. J. (2012). Executive functioning and motivation of children with attention deficit hyperactivity disorder (ADHD) on problem solving and calculation tasks. *Revista de psicodidáctica*, *17*(1), 51-71.

Moaz, H., Aviram, S., Nitzan, U., Segev, A., & Bloch, Y. (2018). Association between continuous performance and response inhibition tests in adults wiht ADHD. *Journal of Attention Disorders,* 22(3), 293-299. http://doi.org/10.1188/1087054715584056

Robbins, T. W., & Everitt, B. J. (1996). Neurobehavioural mechanisms of reward and motivation. *Current opinion in neurobiology*, *6*(2), 228-236.

Roselló, B., Berenguer, C., Baixauli, I., Mira, Á., Martinez-Raga, J., & Miranda, A. (2020). Empirical examination of executive functioning, ADHD associated behaviors, and functional impairments in adults with persistent ADHD, remittent ADHD, and without ADHD. *BMC Psychiatry*, *20*(1). https://doi.org/10.1186/s12888-020-02542-y

Sagvolden, T., Johansen, E. B., Aase, H., & Russell, V. A. (2005). A dynamic developmental theory of attention-deficit/hyperactivity disorder (ADHD) predominantly hyperactive/impulsive and combined subtypes. *Behavioral and Brain Sciences, 28*(3), 397-419. https://doi.org/10.1017/S0140525X05000075

Salari, N., Ghasemi, H., Abdoli, N., Rahmani, A., Shiri, M. H., Hashemian, A. H., Akbari, H., & Mohammadi, M. (2023). The global prevalence of ADHD in children and adolescents: a systematic review and meta-analysis. *Italian Journal Of Pediatrics*, *49*(1). https://doi.org/10.1186/s13052-023-01456-1

Saleh, M. H., Börger, N. A., & van der Meere, J. J. (2021). Executive and Daily Life Functioning Influence the Relationship Between ADHD and Mood Symptoms in University Students. *Journal of attention disorders*, *25*(12), 1731–1742. https://doi.org/10.1177/1087054719900251

Salomone, S., Fleming, G. R., Bramham, J., O'Connell, R. G., & Robertson, I. H. (2020). Neuropsychological deficits in adult ADHD: Evidence for differential attentional impairments, deficient executive functions, and high self-reported functional impairments. Journal of Attention Disorders, 24(10), 1413–1424. https://doi.org/10.1177/1087054715623045

Sanders, A. F. (1998). Elements of human performance: Reaction time processes and attention in human skills. Mahwah, NJ: Lawrence Erlbaum Associates.

Solanto, M. V. (2001). *Cognitive-behavioral therapy for adult ADHD: Targeting executive dysfunction*. Guilford Press.

Sonuga-Barke E. J. (2005). Causal models of attention-deficit/hyperactivity disorder: from common simple deficits to multiple developmental pathways. *Biological psychiatry*, *57*(11), 1231–1238. https://doi.org/10.1016/j.biopsych.2004.09.008

Sonuga-Barke, E. J., Sergeant, J. A., Nigg, J., & Willcutt, E. (2008). Executive dysfunction and delay aversion in attention deficit hyperactivity disorder: nosologic and diagnostic implications. *Child and adolescent psychiatric clinics of North America*, *17*(2), 367–ix. https://doi.org/10.1016/j.chc.2007.11.008

Sonuga-Barke, E. (2002). Interval length and time-use by children with AD/HD: a comparison of four models. *Journal Of Abnormal Child Psychology*, *30*(3), 257–264. https://doi.org/10.1023/a:1015154829796

Sonuga-Barke, E. (2002). Psychological heterogeneity in AD/HD—a dual pathway model of behaviour and cognition. *Behavioural Brain Research*, *130*(1–2), 29–36. https://doi.org/10.1016/s0166-4328(01)00432-6

Spinella M. (2005). Self-rated executive function: development of the executive function index. *The International journal of neuroscience*, *115*(5), 649–667. https://doi.org/10.1080/00207450590524304

Valera, E. M., Brown, A., Biederman, J., Faraone, S. V., Makris, N., Monuteaux, M. C., Whitfield-Gabrieli, S., Vitulano, M., Schiller, M., & Seidman, L. J. (2010). Sex differences in the functional neuroanatomy of working memory in adults with ADHD. The American Journal of Psychiatry, 167(1), 86–94. https://doi.org/10.1176/appi.ajp.2009.09020249

Van Der Meere, J. (2005). State Regulation and Attention Deficit Hyperactivity Disorder. In *Contemporary clinical neuroscience* (pp. 413–433). https://doi.org/10.1385/1-59259-891-9:413

Van der Meere, J. J., Börger, N. A., & Wiersema, J. R. (2010). ADHD: State Regulation and Motivation. *Current Medical Literature. Psychiatry,* 21(1), 14-20.

Vizgaitis, A. L., Bottini, S., Polizzi, C. P., Barden, E., & Krantweiss, A. R. (2023). Self-Reported Adult ADHD Symptoms: Evidence Supporting Cautious Use in an Assessment-Seeking Sample. Journal of Attention Disorders, 108705472311727. https://doi.org/10.1177/10870547231172764

Volkow, N. D., Wang, G. J., Kollins, S. H., Wigal, T. L., Newcorn, J. H., Telang, F., Fowler, J. S., Goldstein, R. Z., Klein, N., Logan, J., Wong, C., & Swanson, J. M. (2009). Evaluating dopamine reward pathway in ADHD: Clinical implications. *JAMA, 302*(10), 1084-1091. https://doi.org/10.1001/jama.2009.1308

Wade, T. R., de Wit, H., & Richards, J. B. (2000). Effects of dopaminergic drugs on delayed reward as a measure of impulsive behavior in rats. *Psychopharmacology*, *150*, 90-101.

Appendix A

Table 1:

What is your current gender identity?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Man	125	23.2	23.2	23.2
	Woman	394	73.2	73.2	96.5
	Nonbinary/Genderqueer	12	2.2	2.2	98.7
	Trans man	4	.7	.7	99.4
	Not listed: please state	1	.2	.2	99.6
	Decline to answer	2	.4	.4	100.0
	Total	538	100.0	100.0	

Table 2:

Descriptive Statistics of total sample

	N	Minimum	Maximum	Mean	Std. Deviation
What is your age (how many years old)?	538	16	35	19.87	2.204

Table 3:

Descriptive Statistics of final sample

	N	Minimum	Maximum	Mean	Std. Deviation
What is your age (how many years old)?	515	16	35	19.82	2.150

Table 4:

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
CAARS_TscoreDSM_Total	.973	498	<.001***
Motivational drive	.982	498	<.001***

Note: *p = 0.05 indicates a significant deviation from normal distribution.

Table 5:

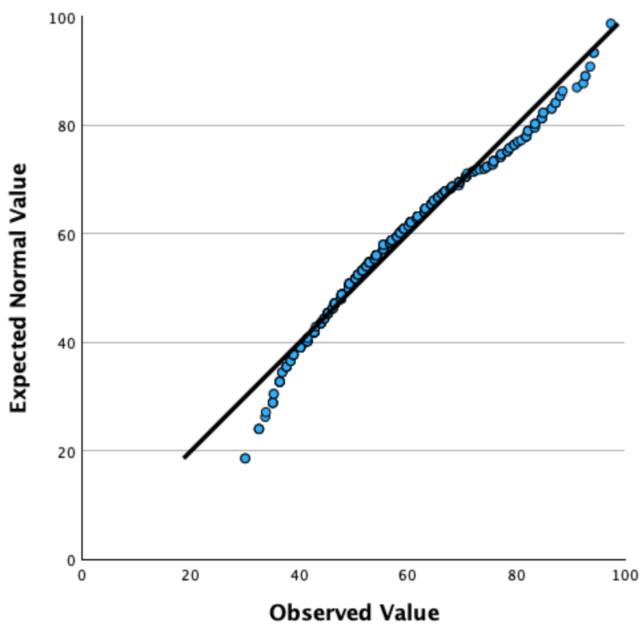
Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
mRT_fast_corr	.960	27	.363
mRT_slow_corr	.894	27	.010**
mSD_fast	.951	27	.225
mSD_slow	.750	27	<.001***
%_error_fast	.912	27	.025*
%_error_slow	.862	27	.002**
%_omissie_fast	.717	27	<.001***
%_omissie_slow	.735	27	<.001***

Note: *p = 0.05 indicates a significant deviation from normal distribution.

Figure 1:

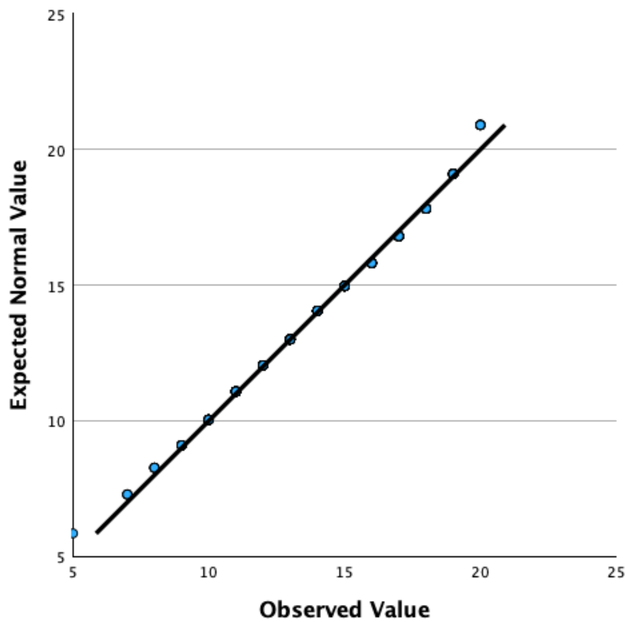
Normal Q-Q Plot of CAARS T-score DSM-Total



Note: Based on the total sample (*N* = 515) for EFI and CAARS

Figure 2:

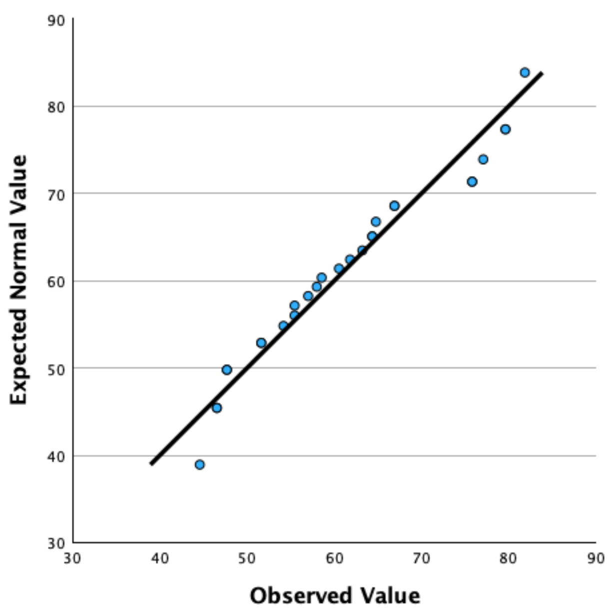
Normal Q-Q Plot of Motivational drive



Note: Based on the total sample (*N* = 515) for EFI and CAARS

Figure 3:

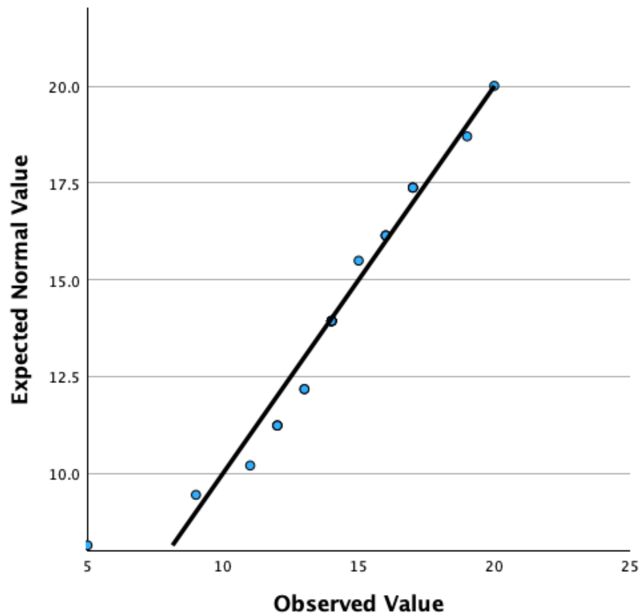
Normal Q-Q Plot of CAARS T-score DSM-Total



Note: Based on the experimental sample (*N* = 27)

Figure 4:

Normal Q-Q Plot of Motivational drive



Note: Based on the experimental sample ($N = 27$)

Figure 5:

Normal Q-Q Plot of mean reaction time fast condition

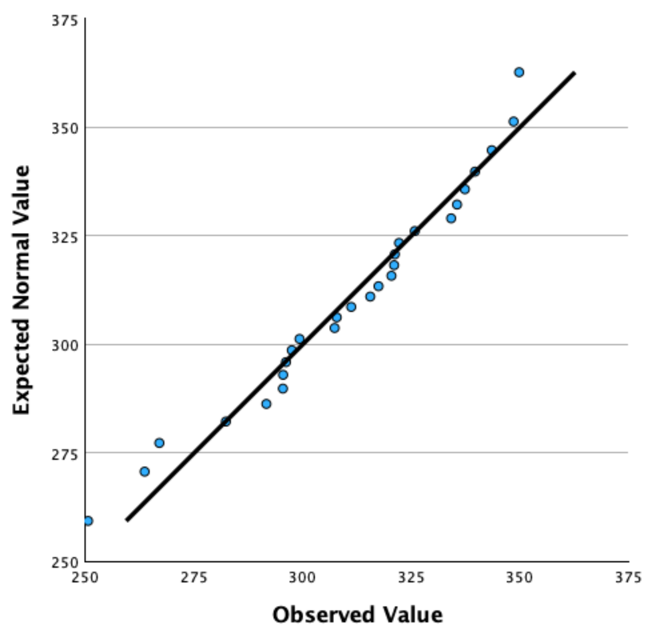


Figure 6:

Normal Q-Q Plot of mean standard deviation fast condition

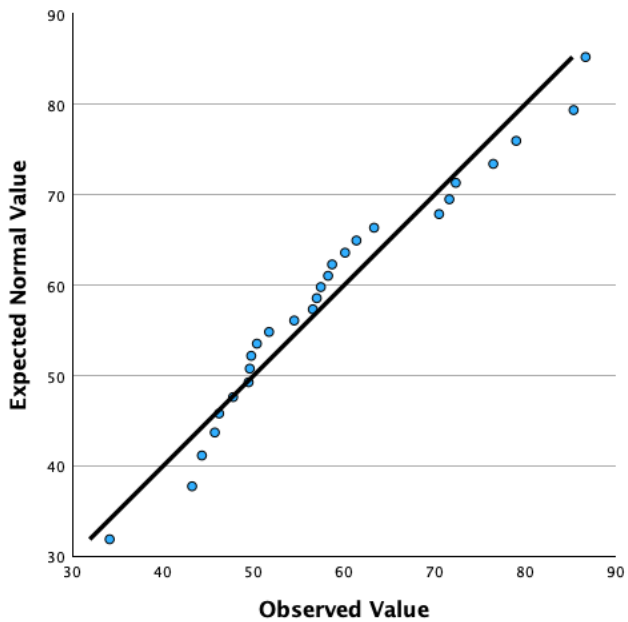


Figure 7:

Normal Q-Q Plot of percentage error fast condition

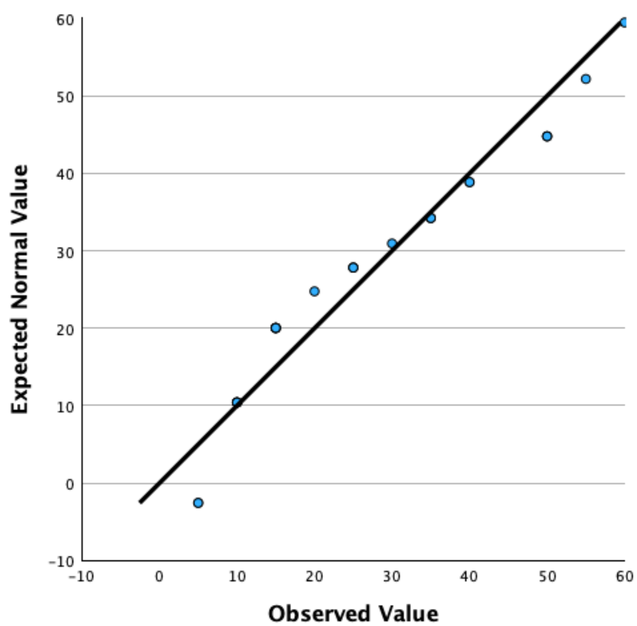


Figure 8:

Normal Q-Q Plot of percentage omission fast condition

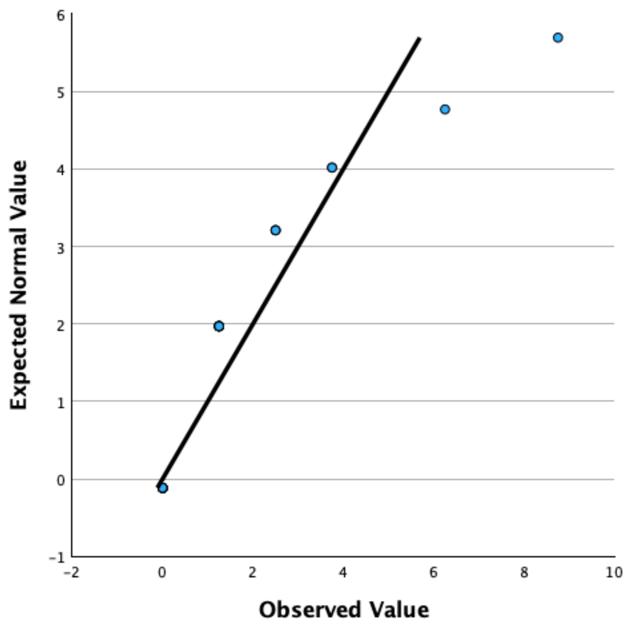


Figure 9:

Normal Q-Q Plot of mean reaction time slow condition

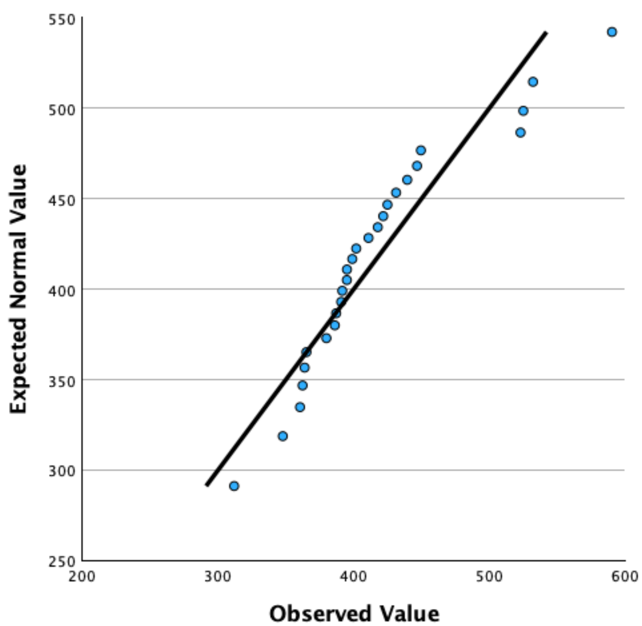


Figure 10:

Normal Q-Q Plot of mean standard deviation slow condition

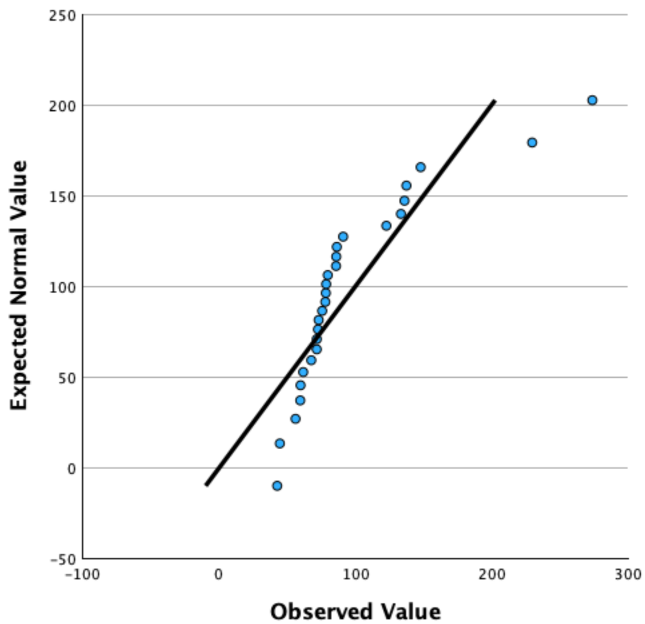


Figure 11:

Normal Q-Q Plot of percentage error slow condition

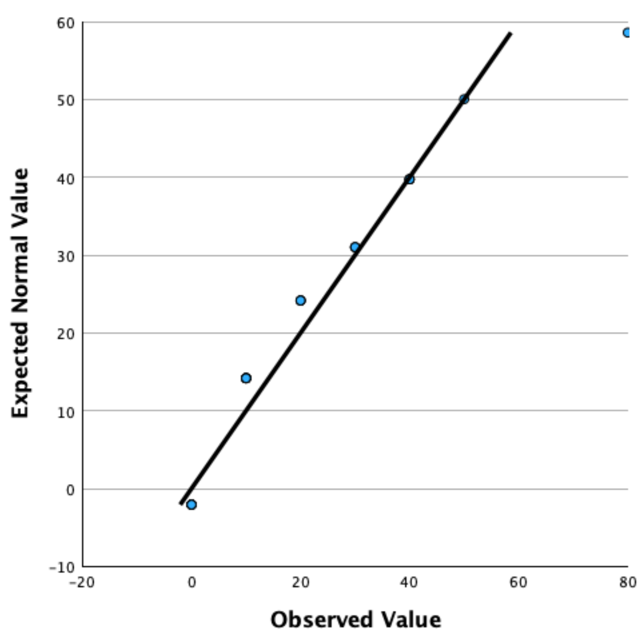


Figure 12:

Normal Q-Q Plot of percentage omission slow condition

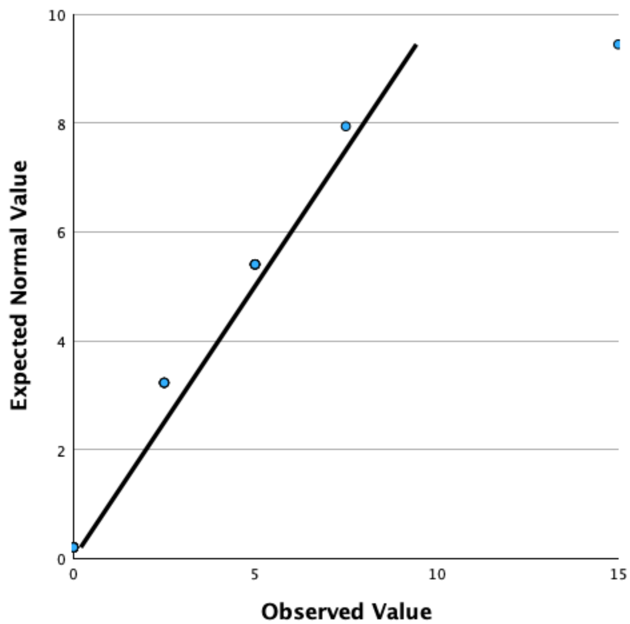


Table 6:

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
%_error_fast	Based on Mean	1.719	1	25	.202
	Based on Median	1.601	1	25	.217
	Based on Median and with adjusted df	1.601	1	23.975	.218
	Based on trimmed mean	1.799	1	25	.192
%_error_slow	Based on Mean	1.201	1	25	.284
	Based on Median	.897	1	25	.353
	Based on Median and with adjusted df	.897	1	22.265	.354
	Based on trimmed mean	.902	1	25	.351

Table 7:

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
%_omissie_fast	Based on Mean	5.658	1	25	.025
	Based on Median	1.552	1	25	.224
	Based on Median and with adjusted df	1.552	1	18.464	.228
	Based on trimmed mean	3.859	1	25	.061
%_omissie_slow	Based on Mean	2.007	1	25	.169
	Based on Median	1.628	1	25	.214
	Based on Median and with adjusted df	1.628	1	22.548	.215
	Based on trimmed mean	1.722	1	25	.201

Table 8:

Check for Multicollinearity

		Collinearity Statistics	
Model		Tolerance	VIF
1	CAARS_TscoreDSM_Total	1.000	1.000

Note: VIF represents the Variation Inflation Factor; Dependent Variable is motivational drive

Table 9:

Pearson's Correlations for Study Variables

		Diff_RT_SlowFast	Motivational drive
CAARS_TscoreDSM_Total	Pearson Correlation	.393*	.117
	Sig. (2-tailed)	.043	.562
	N	27	27
Diff_RT_SlowFast	Pearson Correlation		.194
	Sig. (2-tailed)		.331
	N		27

Note: * Correlation is significant at the 0.05 level (2-tailed).