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# Can individual differences in cognitive motivation and hyperfocus predict academic achievement in university students with ADHD?

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## Abstract

**Background:** Attention-deficit/hyperactivity disorder (ADHD) has been consistently associated with difficulties in academic achievement. However, the underlying mechanisms affecting the relationship are not fully understood. As ADHD is tied to motivational impairments, it may be that cognitive motivational constructs (i.e., curiosity and need for cognition) explain these difficulties. Hyperfocus, a state of enhanced attention that insinuates being intrinsically motivated, has also been linked with ADHD. Nonetheless, it is not clear whether it translates into better academic achievement. Thus, the present study aims to investigate whether cognitive motivation and HF mediate the relationship between ADHD and academic achievement. **Methods:** In total, four hundred and eighteen first-year psychology students took part in an online survey, which comprised several questionnaires assessing curiosity, need for cognition, hyperfocus, and ADHD symptoms. **Results**: The parallel mediation analysis could not be performed due to finding a significant interaction effect between inattention symptoms and joyous exploration. Instead, an exploratory multiple linear regression analysis and simple slope analysis were conducted. The results revealed that inattention symptoms were unrelated to academic achievement when students exhibited high levels of joyous exploration. Whereas, at low levels of joyous exploration, inattention symptoms were significantly negatively associated with academic achievement. Further, deprivation sensitivity was positively correlated with academic achievement. **Conclusion:** This study demonstrated that joyous exploration moderates the relationship between inattention symptoms and academic achievement. Further, deprivation sensitivity was found to be a significant predictor of academic achievement. However, future research is needed to investigate whether the present findings also translate for students with ADHD.


*Keywords:* ADHD, inattention symptoms, curiosity, need for cognition, hyperfocus, academic achievement

**Can individual differences in cognitive motivation and hyperfocus predict academic achievement in university students with ADHD?**

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by symptoms of two related dimensions: inattention and/ or impulsivity-hyperactivity (American Psychiatric Association, 2013). Symptoms of inattention include difficulties in sustaining attention (e.g., staying focused during conversations), organizing activities and tasks (e.g., time management), or being easily distracted (APA, 2013). Impulsivity-hyperactivity, on the other hand, comprises feelings of restlessness (e.g., behaving as "driven by a motor"), difficulties with waiting for one's turn or, interrupting others during conversations (APA, 2013). ADHD is regarded as one of the most common neurodevelopmental disorders among children and adolescents, with an approximate prevalence rate between 5.9 % and 7.1 % (Krauss & Schellenberg, 2022; Willcutt, 2012). Furthermore, around two-thirds of children diagnosed with ADHD continue to experience symptoms of ADHD in adulthood (Groen et al., 2020; Kooij et al., 2010).

ADHD and its respective symptoms are of neurocognitive origin and characterized by heterogeneous impairments (Frazier et al., 2007; Shen et al., 2020). Neuropsychological processes associated with ADHD include impairments in executive functioning and working memory, as well as changes in motivational processes (Sonuga-Barke et al., 2010). For example, Coghill et al. (2014) investigated various domains of neuropsychological functioning of a group of children with ADHD (i.e., between 6 and 12 years of age), and they found that in comparison to typically developing children, the ADHD group performed poorer in tasks assessing visual memory, decision-making, inhibition, and timing.

In addition, several models such as the cognitive-energetic model (CEM) and the dual pathway model of ADHD highlight the role of motivational processes in ADHD (Coghill et al., 2014; Morsink et al., 2021). Research indicates that two pathways, namely the cognitive circuit (e.g., impaired attention regulation) and motivational circuit (e.g., delay aversion), may

in part account for the heterogeneity of ADHD (Shen et al., 2020). A commonly reported motivational deficit is altered intrinsic motivation and reward sensitivity (Ceceli et al., 2020). Whereas intrinsic motivation refers to engaging in an activity for the pleasure and gratification one derives from the activity itself (Ryan & Deci, 2000). Further, research suggests that disruptions of the dopamine reward pathway are connected to motivational difficulties in adults with ADHD and that these in turn may influence attentional deficits (Volkow et al., 2010). Yet, it is not clear whether motivation deficits lead to inattention or vice versa (Volkow et al., 2010).

Although ADHD is a heterogeneous disorder, a common finding associated with it is impairments in academic performance and achievement (Arnold et al., 2020). Several studies found associations between ADHD and poorer academic achievement in university students (Daley & Birchwood, 2010; Frazier et al., 2007; Reaser et al., 2007). For example, self-report ratings from students with and without ADHD demonstrated that students with ADHD experience increased difficulties with academic functioning (DuPaul et al., 2009; Lewandowski et al., 2008). Furthermore, research indicates that students with ADHD achieve lower grade point averages (GPAs) and that fewer students will graduate from university, compared to neurotypical students (DuPaul et al., 2009; Frazier et al., 2007; Henning et al., 2021). Studies that investigated specific core symptoms of ADHD (i.e., inattention and/ or hyperactivity-impulsivity) found that in particular inattention symptoms were associated with worse academic achievement (Arnold et al., 2020; Henning et al., 2021; Schwanz et al., 2007).

While ADHD symptomatology and poor academic achievement are correlated, several other factors are known to influence academic achievement as well. Individual differences in intelligence and personality traits have often been the focus to explain academic achievement (von Stumm et al., 2011). Furthermore, previous research on cognitive motivational and related personality/ temperament constructs found that curiosity (Mussel, 2022; von Stumm et

al., 2011) and need for cognition (Grass et al., 2017; Richardson et al., 2012) can significantly predict academic achievement in healthy students. Thus, implying that cognitive motivation may play an important role within academic contexts. Although ADHD is associated with academic and motivational impairments, the underlying mechanisms are not fully understood (Wu & Gau, 2013). To our knowledge, no prior studies examined cognitive motivational constructs as underlying mechanisms through which inattention symptoms affect academic achievement. Therefore, the present study tries to fill in this knowledge gap and aims to investigate whether curiosity and need for cognition mediate the relationship between inattention symptoms and academic achievement.

**Curiosity: Joyous Exploration, Deprivation Sensitivity, Stress Tolerance**

The first cognitive motivational construct that we are interested in is epistemic curiosity since it is thought to be closely related to academic achievement (Tang & Salmela-Aro, 2021). Although curiosity has attracted a vast amount of research, there is no universally agreed-upon definition of the term (Kashdan et al., 2018; Kidd & Hayden, 2015). Nevertheless, there is a consensus that curiosity is a multidimensional construct that is more complex than previously conceptualized and that it is closely related to intrinsic motivation (Kashdan et al., 2018).

According to the information gap theory by Loewenstein (1994), epistemic curiosity can be defined as one's desire to learn specific information. Further, Loewenstein (1994) proposes that epistemic curiosity is the result of a perceived discrepancy between acquired knowledge and knowledge that an individual would like to obtain. Epistemic curiosity comprises two dimensions: joyous exploration and deprivation sensitivity (Tang & Salmela-Aro, 2021). Joyous exploration, on the one hand, reflects pleasurable experiences of learning or being fascinated by activities (Kashdan et al., 2018). Within university, it can be understood as enjoying learning new topics and being curious to explore these topics further (e.g., studying for exams, or writing essays about novel topics) (Kashdan et al., 2020).

Deprivation sensitivity, on the other hand, reflects experiences of frustration and anxiety due to an individual being aware of a certain information gap (Kashdan et al., 2018; Loewenstein, 1994). Hence, if students perceive a discrepancy between what they know and what they need to know for an exam, it is thought that this gap motivates them to learn and resolve this discrepancy.

Besides epistemic curiosity, we are also interested in the curiosity dimension of stress tolerance. Stress tolerance refers to an individual's propensity to cope with the anxiety that may result from exploring something new (Kashdan et al., 2020). Within the context of a university, stress tolerance can be understood as a capacity and approach to cope with academic challenges, such as coursework or exams (Kashdan et al., 2020).

Research that examined curiosity (i.e., according to Loewenstein's definition) within academic settings found that curiosity is thought to be a crucial component of academic achievement (Day, 1982; Loewenstein, 1994; Tang et al., 2022). As it is associated with motivation (Tang et al., 2022; Tang & Salmela-Aro, 2021), learning (Kang et al., 2009; Tang et al., 2022) as well as cognitive development (Malanchini et al., 2019; Tang et al., 2022). Moreover, von Stumm et al. (2011) found that intellectual curiosity (i.e., typical intellectual engagement) is a core determinant of individual variations in academic achievement. Intellectual curiosity refers to epistemic curiosity, need for cognition, and typical intellectual engagement and insinuates intellectual investment (von Stumm et al., 2011).

However, the relationship between epistemic curiosity, stress tolerance, and ADHD in the context of academic achievement has not been empirically investigated. Nonetheless, research suggests that academic activities may be less intrinsically rewarding for students with ADHD due to altered anticipatory dopamine responses (Oudeyer et al., 2007; Sibley et al., 2019). These altered anticipatory dopamine responses, in turn, are thought to be associated with lower levels of curiosity and enjoyment (Sibley et al., 2019). Further, research indicates that long-term academic activities with delayed rewards, such as exam preparation, may lead

to mental discomfort (Sibley et al., 2019; Sonuga-Barke et al., 2008). Insinuating that individuals with ADHD may have difficulties maintaining interest and commitment throughout academic activities that do not provide an immediate reward (Sibley et al., 2019). Thus, we want to examine whether low levels of curiosity impact the relationship between inattention symptoms and academic achievement.

**Need for Cognition**

The second cognitive motivational construct of interest is need for cognition (NFC). NFC refers to a personality trait and is commonly defined as the propensity of an individual to engage in thinking as well as to enjoy thinking (Cacioppo & Petty, 1982; Colling et al., 2022; Strobel et al., 2019).

Research investigating NFC found that it is related to academic and cognitive outcomes such as academic interest (Feist, 2012; Keller et al., 2019), academic achievement (Grass et al., 2017; Richardson et al., 2012), and different types of intelligence, such as crystallized and fluid intelligence (Fleischhauer et al., 2009; Hill et al., 2013). Although NFC is related to different types of intelligence, it is not considered to be an intellectual capacity, but a cognitive motivational construct (Liu & Nesbit, 2023). Cognitive motivation implies that individuals invest cognitive resources to achieve a higher level of cognition as a result of intrinsic motivation (Liu & Nesbit, 2023). Furthermore, it is thought that individuals with high levels of NFC are more intrinsically motivated to engage in demanding cognitive processing (e.g., cognitive effort) (Richardson et al., 2012). Whereas individuals with low levels of NFC are more likely to avoid or minimize cognitive effort (Cacioppo et al., 1996; Enge et al., 2008). Thus, if students exhibit low levels of NFC, it is likely that it negatively affects their academic achievement.

Regarding ADHD, studies found that individuals with ADHD are more likely to avoid tasks that involve cognitively challenging (Morsink et al., 2019), which may be related to low levels of NFC. Even though NFC is regarded as an essential part of cognitive motivation

(Strobel et al., 2021) and a significant predictor of academic achievement (Grass et al., 2017; Richardson et al., 2012), less is known about its potential effects on GPA in students with ADHD. Therefore, we want to examine whether differences in NFC may explain academic difficulties of students with inattention symptoms.

**Hyperfocus**

Besides cognitive motivational constructs (i.e., curiosity and NFC), we are also interested in a commonly reported experience of individuals with ADHD, namely hyperfocus (Hupfeld et al., 2019). The term hyperfocus (HF), can be defined as a state of increased focused attention, in which individuals experience difficulties shifting attention away from the task at hand, lose the sense of time, and fail to attend to themselves as well as to their environment (Groen et al., 2020; Hupfeld et al., 2019). HF is frequently reported when an individual is engaged in an activity that is perceived as interesting (Ashinoff & Abu-Akel, 2019), insinuating a link to intrinsic motivation. Despite being often reported anecdotally by individuals with ADHD or by clinicians, as well as issued in popular media, HF is not a diagnostic criterion of ADHD (APA, 2013; Hupfeld et al., 2019).

To date, only a few studies have empirically investigated HF in ADHD (Groen et al., 2020; Hupfeld et al., 2019; Ozel-Kizil et al., 2013, 2016). In 2019, Hupfeld et al. developed the Adult Hyperfocus Questionnaire (AHQ) to assess HF in individuals with ADHD and those without. Hupfeld et al. (2019) found that individuals with ADHD experienced HF more frequently in educational activities than individuals without ADHD. Nonetheless, the correlation between ADHD and HF was moderate ($r = 0.39$). In contrast, Groen et al. (2020) could not corroborate this finding. In their study, fewer participants with ADHD experienced HF in educational activities, than healthy matched controls ($\varphi = 0.19$). Thus, there is inconsistent evidence regarding a higher incidence of HF in educational activities for individuals with ADHD, compared to neurotypical individuals (Groen et al., 2020; Hupfeld et al., 2019). Further, a previous study speculated a relation between HF and heightened

performance (Groen et al., 2020), however, it is not clear whether HF in educational settings translates into better academic achievement. Hence, we aim to examine whether HF experiences may influence academic achievement of university students with inattention symptoms.

**Hypotheses**

To answer the research question of whether individual differences in cognitive motivation and HF can predict the GPA of university students with inattention symptoms of ADHD and test the parallel mediation model (see Figure 1), the following hypotheses were formulated.

H 1: Inattention symptoms are negatively associated with GPA (i.e., higher levels of inattention symptoms are associated with a lower GPA) while accounting for the indirect effects of inattention symptoms through the mediators on GPA (i.e., the direct effect of X on Y).

H 2: High levels of inattention symptoms are associated with low levels of joyous exploration. H 2.1: High levels of joyous exploration are associated with a higher GPA. H 2.2: Joyous exploration mediates the relationship between inattention symptoms of ADHD and GPA (i.e., higher levels of inattention symptoms are associated with a lower GPA via low levels of joyous exploration).

H 3: High levels of inattention symptoms are associated with low levels of deprivation sensitivity. H 3.1: High levels of deprivation sensitivity are associated with a higher GPA. H 3.2: Deprivation sensitivity mediates the relationship between inattention symptoms of ADHD and GPA (i.e., higher levels of inattention symptoms are associated with a lower GPA via low levels of deprivation sensitivity).

H 4: High levels of inattention symptoms are associated with low levels of stress tolerance. H 4.1: High levels of stress tolerance are associated with a higher GPA. H 4.2: Stress tolerance mediates the relationship between inattention symptoms of ADHD and GPA

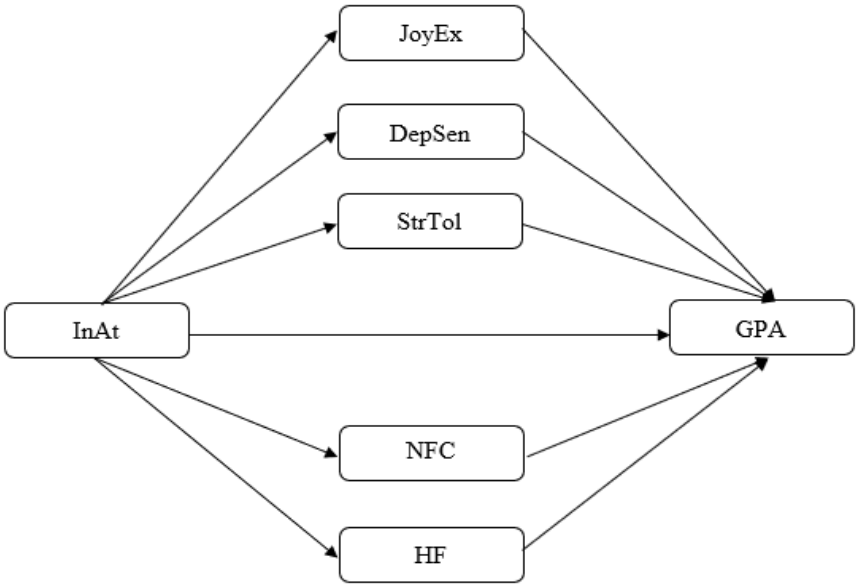
(i.e., higher levels of inattention symptoms are associated with a lower GPA via low levels of stress tolerance).

H 5: High levels of inattention symptoms are associated with low levels of NFC. H 5.1: High levels of NFC are associated with a higher GPA. H 5.2: NFC mediates the relationship between inattention symptoms of ADHD and GPA (i.e., higher levels of inattention symptoms are associated with a lower GPA via low levels of NFC).

H 6: High levels of inattention symptoms are associated with high levels of HF. H 6.1: High levels of HF are associated with a higher GPA. H 6.2: HF mediates the relationship between inattention symptoms of ADHD and GPA (i.e., higher levels of inattention symptoms are associated with a high GPA via high levels of HF).

**Figure 1**

*Conceptual Parallel Mediation Model*




*Note.* InAt = inattention symptoms of ADHD, JoyEx = joyous exploration, DepSen = deprivation sensitivity, StrTol = stress tolerance, NFC = need for cognition, HF= hyperfocus, GPA = grade point average

## Method

**Participants**

This Master thesis study was approved by the Ethics Committee of the Faculty of Behavioural and Social Sciences. The data collection started in October 2022 and ended in February 2023. A convenience sample of first-, second-, and third-year psychology students was recruited via SONA (i.e., a practicum pool for first-year psychology students), flyers, and social networks of student research assistants. The sample of the present study comprised solely first-year psychology students. Nonetheless, being a first-, second, or third-year psychology student at the University of Groningen was used as an inclusionary criterion for participation in the study. Participants that were younger than 18 years of age and who answered at least one instructed response item wrong were excluded from the analysis. Further, participants who did not permit to access and process their grades, and did not complete the survey were excluded as well.

In total, 532 participants took part in the study. After merging the datasets for the analysis 488 participants remained. Out of the 488 participants, 11 cases were deleted because they were younger than 18 years. In addition, 34 cases were excluded due to not having grades (i.e., a GPA) or not having completed the survey (i.e., no progress). While inspecting univariate and multivariate outliers further 16 cases were deleted. In addition, 9 cases were deleted due to spending too little or too much time completing the survey (i.e., falling below or above two standard deviations of the mean). Hence, the current sample comprised 418 participants.

Out of the 488 participants, 296 (70.8%) identified as women, 121 (28.9%) as men, and 1(0.2%) preferred not to say. The reported age of the sample ranged from 18 to 31 years of age ($M$ = 19.88, $SD$ = 2.01). In addition, out of 418 participants, 220 (52.6%) had a Dutch nationality, 93 (22.2%) had a German nationality, and 105 (25.1%) had another nationality. Regarding the educational level of our sample, 363 (86.8%) obtained upper secondary education (i.e., level from 9th to 12th grade – high school), 5 (1.2%) post-secondary

vocational education (i.e., preparing for labor market entry), 6 (1.4%) short-cycle higher education (vocational or specialized technical), 21 (5.0%) Bachelor's degree, 2 (0.5%) Master's degree, and 21 (5.0%) selected "not sure".

## Materials

### *Five-dimensional curiosity scale*

To examine participants' curiosity, we implemented the Five-Dimensional Curiosity Scale (5DC) (Kashdan et al., 2018). The 5DC scale consists of 25 items that measure joyous exploration (e.g., "I find it fascinating to learn new information."), deprivation sensitivity (e.g., "I can spend hours on a single problem because I just can't rest without knowing the answer."), stress tolerance (e.g., "It is difficult to concentrate when there is a possibility that I will be taken by surprise."), social curiosity (e.g., "I like to learn about the habits of others."), and thrill-seeking (e.g., "Creating an adventure as I go is much more appealing than a planned adventure."). Participants were instructed to indicate on a 7-point Likert scale, ranging from (1) "Does not describe me at all" to (7) "Completely describes me", the extent to which the items (i.e., statements) describe themselves. Regarding the stress tolerance subscale, scores were reversed. As we were interested in joyous exploration, deprivation sensitivity, and stress tolerance, the mean average of items assessing the respective dimension was calculated (i.e., separately). The reliabilities for the subscales joyous exploration, deprivation sensitivity, and stress tolerance were $\alpha = .765$; $\alpha = .828$; $\alpha = .810$, respectively, indicating moderate to good internal consistencies.

### *Need for cognition scale*

To assess participants' tendencies to engage and enjoy thinking, we applied the six-item version of the Need for Cognition Scale (NCS-6) (Coelho et al., 2020). The NCS-6 is a short version of the Need for Cognition Scale, which was originally developed by Cacioppo and Petty (1982). According to Coelho and colleagues, the NCS-6 has strong convergent and discriminant validity and is highly correlated with the eighteen-item version of the Need for

Cognition Scale (NCS-18) (Cacioppo et al., 1984; Coelho et al., 2020). Participants were asked to indicate on a 6-point Likert scale ranging from (1) “extremely uncharacteristic of me” to (5) “extremely characteristic of me”, to which extent they agree or disagree that a statement is characteristic of them. Items of the NCS-6 include statements such as “I would prefer complex to simple problems.” or “I really enjoy a task that involves coming up with new solutions to problems.”. Two items are negatively phrased (e.g., “Thinking is not my idea of fun”), therefore the respective scores were reversed. The internal consistency in the present sample was moderate (α =.735).

***School hyperfocus scale of AHQ***

To assess participants’ HF, we implemented a subscale of the Adult Hyperfocus Questionnaire (AHQ). The AHQ contains three settings in which HF is likely to occur (i.e., school, hobbies, and screen time) (Hupfeld et al., 2019). The AHQ comprises five quantitative subscales (e.g., (1) dispositional HF, (2) HF during school-related activities, (3) during hobbies, etc.) As we aim to investigate HF in the context of a university, we applied the School HF subscale. The following modifications of the School HF subscale were implemented: we changed the answer option “daily” of the 6-point Likert scale to “always/ daily” and added a frequency rating to each answer option (e.g. “rarely/ 1-2 times every 6 months”, “sometimes/ 1-2 times per month”, “often/ once a week”, “very often/ 2-3 times a week”). Participants were requested to indicate on a 6-point Likert scale ranging from (1) “never” to (6) “always/ daily” how often they had the described feelings or experiences within the last year when they were studying or completing homework. Additionally, the instruction to relate the answers to the person's favorite course was not included. Sample items of the School HF subscale are: “Not attending to distractions (e.g., not hearing someone talking to you) when you’re doing homework or studying”, and “Feeling completely engrossed or fixated with your schoolwork or studying”. The reliability was α = .860, indicating good internal consistency.

### *Adult ADHD self-report scale v 1.1.*

The Adult ADHD Self-Report Scale (ASRS-v 1.1) was applied to examine dimensional ADHD (Kessler et al., 2005). The ASRS-v 1.1 comprises 18 items assessing inattention and hyperactivity-impulsivity symptoms of ADHD. The questions are in accordance with DSM-IV criteria. Nine items assess inattention symptoms (e.g. “How often do you have difficulty keeping your attention when you are doing boring or repetitive work?”) and the remaining nine items assess hyperactivity-impulsivity symptoms (e.g., “How often do you feel restless or fidgety?”). Participants were instructed to rate themselves on a 5-point Likert scale on the presented criteria over the past six months. Response options ranged from (1) never to (5) always. For seven items the answer options (3) sometimes, (4) often, and (5) very often, indicated clinically significant impairment. Whereas, for the remaining eleven items the answer options (4) often, and (5) very often suggested clinically significant impairment. The internal consistency in the present sample was moderate ($\alpha$ =.735).

## Procedure

Preceding the online survey, the procedure was explained to all participants. Information on how the participants’ data are being handled and that participation in the study is voluntary was provided. Participants were then asked to provide online informed consent. In addition, participants were asked for permission to access and process their grades for the study. The survey was composed of several questionnaires and programmed in Qualtrics. First, participants were instructed to provide information regarding their demographic characteristics. The questions included participants' sex, age, nationality, and professional status (e.g., student, working student, other). Furthermore, all participants were asked to indicate their level of education (i.e., the highest currently obtained level). Subsequently, participants were instructed to complete the online survey, which included questionnaires assessing their curiosity, need for cognition, academic motivation, work engagement, HF experiences, dispositional flow, and self-reported dimensional ADHD. Each participant

received the same order of questionnaire blocks but the order of items within the blocks was randomized. The first questionnaire block included the following scales: the Five-Dimensional Curiosity Scale, Need for Cognition, and Academic Motivation. Whereas the second block included the School Hyperfocus Subscale, the Utrecht Work-Engagement Scale, and the Dispositional Flow Scale. The randomizations were implemented to control for order effects and to reduce biases. Further, participants were asked about their current mental health as well as their current medication intake. The total duration of the survey was approximately 15 to 20 minutes. At the end of the survey, participants were asked about the quality of their responses (e.g., "Did you try to answer all questions in this survey seriously and honestly so that we can use your data in our research?"). Subsequently, participants could write comments regarding the survey. Information regarding the GPA of participants was collected from the administrative services of the faculty of Social and Behavioral Sciences of the University of Groningen. Solely participants who completed the survey, fulfilled the inclusion criteria, and gave us permission to access and process their grades were included in the data analysis.

**Statistical analyses**

To investigate whether cognitive motivational constructs (i.e., curiosity and need for cognition) and HF are related to academic achievement of university students with ADHD, a parallel mediation analysis was carried out. All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS), Version 28, and PROCESS macro tool (Hayes, 2013). In our analyses, the independent variable (IV) was inattention symptoms, the dependent variable (DV) was academic achievement (i.e., GPA), and the mediators (M) were joyous exploration (M1), deprivation sensitivity (M2), stress tolerance (M3), need for cognition (M4), and HF (M5). Before the main analysis, assumptions of parallel mediation (e.g., linearity, homoscedasticity, normality of estimation error, independence of observations) were checked. To assess whether joyous exploration (M1), deprivation sensitivity (M2), stress tolerance (M3), NFC (M4), and HF (M5) mediate the relationship

between inattention symptoms (IV) and GPA (DV), the following analyses were carried out: Analysis 1: Linear regression of inattention symptoms (IV) on academic achievement (DV). Analysis 2: Linear regressions of inattention symptoms (IV) on joyous exploration (M1), deprivation sensitivity (M2), stress tolerance (M3), NFC (M4), and HF (M5). Analysis 3: Linear regressions of joyous exploration (M1), deprivation sensitivity (M2), stress tolerance (M3), NFC (M4), and HF (M5) on GPA (DV). Analysis 4: Linear regression of joyous exploration (M1), deprivation sensitivity (M2), stress tolerance (M3), NFC (M4), HF (M5), and inattention symptoms (IV) on GPA (DV). In addition, indirect and direct effects were examined, using a significance level of 0.5 for all analyses.

## Results

### Assumptions Check

Before the assumption checks were conducted, the data was checked for univariate and multivariate outliers. The median absolute deviation (MAD) method was implemented to assess univariate outliers. First, the median of each scale was calculated, and then the absolute deviation of each data point from the median. Subsequently, the median of the absolute deviations was calculated and multiplied by 3 (i.e., a conservative value) to obtain a threshold value. Data points outside the threshold values were considered univariate outliers and excluded from the analysis. By obtaining the Mahalanobis distances multivariate outliers were assessed. In total, 16 univariate and no multivariate outliers were detected.

(1) To assess whether the independent variables (i.e., inattention symptoms, joyous exploration, deprivation sensitivity, stress tolerance, NFC, and HF) and the dependent variable (i.e., GPA) are linearly related, eleven scatter plots were created. By visually inspecting the scatterplots no major linearity violations were detected. However, there was only a weak linear relationship between the variables. (2) Next, to check whether the residuals are normally distributed, twelve P-P plots were created. All twelve P-P plots displayed no violation of normality as the dots were centered around the plot line. (3) In addition, no major

violations of homoscedasticity were observed when inspecting the scatterplots. (4) The assumption of independence of observations was not violated as our sample comprises undergraduate students (i.e., SONA participants) of the University of Groningen, thus the chance of common underlying characteristics affecting the independence assumption is unlikely. (5) A correlation matrix was created to assess multicollinearity between the predictor variables. The highest variance inflation factor (VIF) was 1.91 (for NFC), thus indicating no multicollinearity between the predictor variables.

Next, the PROCESS macro tool (Hayes, 2013) was used to check whether there are significant interaction effects. The results revealed a significant interaction effect between inattention symptoms (*X*) and joyous exploration (*M1*) ($F$ (1, 410) = 4.77, $p$ = .029). Since this violates the assumption of parallel mediation, the analysis could not be performed. Hence the parallel mediation did not adequately model the data. Conceivably, all proposed hypotheses could not be tested, and instead, an exploratory analysis was conducted.

Prior to the exploratory analysis, the variables' zero-order correlations (i.e., Pearson correlation coefficients) were calculated. To account for multiple comparisons, the Bonferroni correction was applied, thus the new significance level was set to .002. The results revealed a significantly weak negative correlation between inattention symptoms (IV) and stress tolerance (M3) ($r$ = -.325, $p$ < .001), inattention symptoms (IV) and NFC (M4) ($r$ = -.169, $p$ < .001), and inattention symptoms (IV) and GPA (DV) ($r$ = -.167, $p$ < .001). Further, inattention symptoms (IV) demonstrated a significantly weak positive relationship with HF (M5) ($r$ = .170, $p$ < .001). No significant correlations between GPA (DV) and joyous exploration (M1), GPA (DV) and deprivation sensitivity (M2), GPA (DV) and stress tolerance (M3), GPA (DV) and NFC (M4), and GPA (DV) and HF (M5) were found. The zero-order correlations are reported in Table 1.

**Table 1**

*Means, Standard Deviations, and Correlations*

| | | | Pearson Correlation (r) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. InaAt | 2.13 | .54 | | | | | | | |
| 2. JoyEx | 5.11 | .88 | -.096 | | | | | | |
| 3. DepSen | 4.32 | 1.24 | .075 | .346* | | | | | |
| 4. StrTol | 4.36 | 1.25 | -.324* | .305* | -.114* | | | | |
| 5. NFC | 3.62 | .65 | -.162* | .625* | .426* | .292* | | | |
| 6. HF | 3.08 | .80 | .172* | .151* | .399* | -.198* | .173* | | |
| 7. GPA | 6.67 | 1.28 | -.168* | .110 | .118 | .046 | .130 | -.019 | |

*Note.* The mean, standard deviation (SD), and Pearson correlation coefficient are represented for the following variables: InAt = inattention symptoms of ADHD, JoyEx = joyous exploration, DepSen = deprivation sensitivity, StrTol = stress tolerance, NFC = need for cognition, HF= hyperfocus, GPA = grade point average. N = 418.

* Correlation is significant at the .05 level (first accepted at .002).

**Exploratory Analyses**

To investigate the relationship between the variables as well as the interaction effect a multiple linear regression analysis including all variables as well as the interaction effect between inattention symptoms and joyous exploration (i.e., as another predictor) was conducted. Subsequently, to further examine the nature of the interaction effect, a simple slope analysis was carried out.

Since no major assumption violations were detected the planned multiple regression analysis was carried out. However, as we included the interaction effect as an additional predictor, we centered the variables of inattention symptoms and joyous exploration to avoid problems of multicollinearity. Conceivably, the interaction term was created by multiplying the centered variables of inattention symptoms and joyous exploration.

The results of the multiple linear regression analysis revealed that inattention symptoms, joyous exploration, deprivation sensitivity, stress tolerance, NFC, HF, and the interaction of inattention symptoms and joyous exploration significantly predicted GPA ($F$ (7, 410) = 4.155, $p < .001$, $R^2 = .05$). However, the overall model explained 5 % (i.e., adjusted $R^2$) of GPA, which is comparatively small. As shown in Table 2, solely inattention symptoms, deprivation sensitivity, and the interaction between inattention symptoms and joyous exploration exhibited a significant effect.

**Table 2**

*Results of the Multiple Linear Regression Analysis*

| Variable | ß | SE | T | p | 95% CI [LL, UL] |
|---|---|---|---|---|---|
| Constant | | .548 | 11.295 | <.001 | [5.113, 7.267] |
| InAtC | -.170 | .122 | -3.318 | <.001 | [-.645, -.165] |
| JoyExC | .029 | .091 | .463 | .644 | [-.137, .222] |
| DepSen | .116 | .060 | 1.991 | .047 | [.002, .239] |
| StrTol | -.018 | .057 | -.314 | .754 | [-.130, .094] |
| NFC | .045 | .131 | .688 | .492 | [-.167, .347] |
| HF | -.055 | .085 | -1.032 | .303 | [-.255, .080] |
| InAt x JoxExC | .129 | .131 | 2.688 | .007 | [.095, .611] |

*Note.* InAtC = centered inattention symptoms of ADHD, JoyExC = centered joyous exploration, InAt x JoyExC = centered interaction between inattention symptoms of ADHD and joyous exploration; Dependent variable = GPA;ß = standardized regression coefficient; SE = standard error; t = t- value; p = p-value; CI = 95% confidence interval for unstandardized regression coefficient B; LL = lower level of 95% CI; UL = upper level of 95% CI. N = 418.

The simple slope analysis of the interaction effect revealed a significant negative relationship between inattention symptoms and GPA at low levels of joyous exploration ($\beta$ = -.298, $SE$ = .169, $t$ (417) = -4.201, $p$ < .001). Whereas the relationship between inattention symptoms and GPA was insignificant at high levels of joyous exploration ($\beta$ = -.036, $SE$ = .157, $t$ (417) = -.550, $p$ = .582). Thus, if individuals exhibit low levels of joyous exploration, inattention symptoms significantly negatively affect their GPA. If individuals exhibit high levels of joyous exploration, on the other hand, inattention symptoms seem to have no significant impact on their GPA. The results of the simple slope analysis are reported in Tables 3 and 4.

**Table 3**

*Results of the Multiple Linear Regression Analysis*

| Variable | ß | SE | T | P |
|---|---|---|---|---|
| (Constant) | | .087 | 75.425 | <.001 |
| InAtC | -.298 | .169 | -4.201 | <.001 |
| LowJoyExC | .084 | .070 | 1.743 | .082 |
| InAt x LowJoxExC | .191 | .131 | 2.695 | .007 |

*Note.* InAtC = centered inattention symptoms, LowJoyExC = centered low levels of joyous exploration, InAt x LowJoyExC = centered interaction effect of inattention symptoms and low levels of joyous exploration. N = 418.

**Table 4**

*Results of the Multiple Linear Regression Analysis*

| Variable | ß | SE | T | p |
|---|---|---|---|---|
| (Constant) | | .087 | 78.190 | <.001 |
| InAtC | -.036 | .157 | -.550 | .582 |
| HighJoyExC | .084 | .070 | 1.743 | .082 |

| | | | | |
|---|---|---|---|---|
| InAt x HighJoxExC | .177 | .131 | 2.695 | .007 |

*Note.* InAtC = centered inattention symptoms, HighJoyExC = centered high levels of joyous exploration, InAt x HighJoyExC = centered interaction effect of inattention symptoms and high levels of joyous exploration. N = 418.

## Discussion

The present study aimed to investigate whether individual differences in cognitive motivation and HF can explain academic difficulties that are associated with inattention symptoms. To our knowledge, this is the first study to assess whether curiosity (i.e., joyous exploration, deprivation sensitivity, and stress tolerance), NFC, and HF mediate the relationship between inattention symptoms of ADHD and academic achievement (i.e., GPA). We hypothesized that inattention symptoms are associated with a lower GPA. Furthermore, we predicted that individuals with high levels of inattention symptoms exhibit lower levels of joyous exploration, deprivation sensitivity, stress tolerance, and NFC, and thus obtain a lower GPA. Lastly, we hypothesized that individuals with high levels of inattention symptoms exhibit high levels of HF, and in turn, obtain a higher GPA.

However, as we found a major assumption violation of the parallel mediation analysis (i.e., a significant interaction effect between inattention symptoms and joyous exploration), we could not test our hypotheses. Consequently, we conducted an exploratory multiple linear regression analysis and a simple slope analysis to further explore the relationship between inattention symptoms, the cognitive motivational constructs, HF, and GPA as well as the interaction effect (i.e., moderating effect).

The results of the multiple linear regression analysis revealed that the predictors (i.e., inattention symptoms, joyous exploration, inattention symptoms x joyous exploration, deprivation sensitivity, stress tolerance, NFC, and HF) only explained 5% (i.e., adjusted $R^2$) of the variation in GPA. Indicating that the predictors have limited explanatory power. Solely inattention symptoms, the interaction effect of inattention symptoms and joyous exploration,

and deprivation sensitivity significantly predicted GPA. Further, the simple slope analysis revealed that inattention symptoms are significantly negatively associated with GPA when individuals exhibit low levels of joyous exploration. Whereas when individuals exhibit high levels of joyous exploration, inattention symptoms were unrelated to GPA.

Finding that inattention symptoms in a non-clinical population of university students are negatively associated with GPA, is in line with previous research that found a significant relationship between inattention symptoms and academic achievement (Arnold et al., 2020; Henning et al., 2021; Schwanz et al., 2007). Although inattention symptoms in a non-clinical population may be different from those experienced by individuals with ADHD, the present findings highlight the importance of attention within an academic context.

Additionally, finding evidence that the negative relationship between inattention symptoms and GPA is only significant at low levels of joyous exploration was novel. This finding implies that less pleasurable experiences of learning or not being fascinated by academic activities strengthen the negative relationship between inattention symptoms and GPA. However, when individuals enjoy learning and are fascinated by academic activities, the negative relationship between inattention symptoms and GPA is insignificant. Thus, this finding suggests that interventions that promote curiosity (i.e., joyous exploration) may enable individuals to compensate for the negative impact of inattention symptoms on academic achievement. Since curiosity is considered to be amenable to change (Singh & Manjaly, 2022), modifying academic activities to induce higher levels of joyous exploration may lead to better academic outcomes.

Further, the finding that deprivation sensitivity significantly predicted GPA aligns with previous research (Tang et al., 2022; von Stumm et al., 2011). Although these studies examined different curiosity constructs (e.g., epistemic curiosity, intellectual curiosity), the present finding suggests that individuals who exhibit experiences of frustration or anxiety due

to a perceived knowledge gap are motivated to reduce this discrepancy, which in turn, positively affects GPA.

While previous research found that NFC is related to academic achievement in university students (i.e., small-moderate correlations) (Richardson et al., 2012; von Stumm & Ackerman, 2013), the present study did not find evidence that NFC is related to GPA. However, a recent meta-analysis revealed that grade levels (i.e., educational level) act as a significant moderator within the relationship between NFC and academic achievement (Liu & Nesbit, 2023). Liu and Nesbit (2023) found that older individuals seemed to be more influenced by NFC than younger individuals (i.e., school children). Thus, the findings suggest that the relationship between NFC and academic achievement varies across time (i.e., the age of an individual). Since only first-year students were included in the study (i.e., mean age = 18 years), it may be that these individuals display lower levels of NFC (in comparison to older individuals) and hence no significant association between NFC and GPA was found. Further, the GPA was computed from the grades obtained within the first semester and not from the whole academic year. It could be that students who are further in their studies may exhibit higher levels of NFC, which in turn may be positively associated with academic achievement.

Even though studies found that individuals with ADHD and neurotypical individuals report experiences of HF in educational settings (Hupfeld et al., 2019; Ozel-Kizil et al., 2016), in the present study we could not corroborate these findings, as we did not find a significant relationship between HF and GPA. Nonetheless, it is worth mentioning that previous studies did not focus on academic achievement and solely examined whether HF occurred in educational settings but without considering objective academic outcome measures such as GPAs. Further, the finding that HF was not related to academic achievement may be due to the demographic characteristics of the current sample. In a previous study by Groen et al. (2020) it was found that in the healthy control sample, higher age and level of education were

associated with experiences of HF in a reduced number of activities and with shorter durations of HF experiences. Hence, indicating that age and level of education can impact HF.

The present study had several strengths. To our knowledge, it is the first study investigating cognitive motivational constructs among university students with inattention symptoms. Limited but new insights were gathered. First, we implemented validated scales to assess the cognitive motivational constructs, HF, and dimensional ADHD (Coelho et al., 2020; Hupfeld et al., 2019; Kashdan et al., 2018; Kessler et al., 2005). Additionally, all scales had a moderate to good internal consistency (i.e., reliability). Second, we included four instructed response items to check the quality of the responses as well as to enhance their reliability. Last, the present study has some potential clinical implications. Since inattention symptoms are associated with worse academic achievement, understanding which potential factors may contribute to the negative relationship between ADHD and academic achievement can be beneficial regarding assessments and interventions promoting academic achievement.

Notwithstanding, this study also had some limitations. First, we used convenience sampling, which may limit the generalizability of our findings. Since solely first-year psychology students constituted the sample, conceivably, the sample's heterogeneity was compromised. Second, the data relied on self-reports and thus questions the reliability of the present findings as retrospective self-reports are susceptible to measurement errors, including limited insights and memory-related biases (Althubaiti, 2016). Third, we implemented a correlational design, hence no causal claims can be made. Fourth, we considered values below or above the predetermined threshold as univariate outliers and excluded them from the analyses, which may lead to biased results. Although we excluded outliers to avoid extreme values that may impact our assumptions and results, they could still contain valuable information about the constructs under investigation. Last, we did not include age as a covariate, which is thought to influence some variables of interest (i.e., NFC and HF).

Based on the current findings and limitations, the following recommendations for future research are provided. First, it would be interesting to conduct a follow-up study with a heterogenous representative sample of university students with ADHD to compare the findings. Second, including age and level of education as a covariate may lead to more accurate results as both are thought to influence NFC and HF (Groen et al., 2020; Liu & Nesbit, 2023). Third, future studies should implement a more complex model (i.e., moderated mediation model) to assess whether curiosity and other cognitive motivational constructs, such as academic motivation or novelty seeking, may mediate the relationship between inattention symptoms and GPA, as we could not test this. Last, another aspect worth considering would be to investigate whether the time when the survey was completed within the academic year (i.e., at the beginning of the academic year, when there are no exams, or close to the end of a block during the exam period) may influence the cognitive motivation of university students. Since, previous research established that some of the constructs are influenced by factors such as age or level of education, time pressure, and stress which are commonly associated with exam periods may in turn also influence individual differences in cognitive motivation. In addition, Kool et al. (2018) found that intellectual curiosity, measured by openness to experience, fluctuates during the academic year. It may be that during exam periods students demonstrate higher levels of cognitive motivation, compared to non-exam periods.

In conclusion, this study was the first to specifically examine whether cognitive motivational constructs and HF influence the relationship between inattention symptoms and GPA. Although we could not test the hypothesized parallel mediation model, exploratory analyses revealed a moderating effect of joyous exploration on the relationship between inattention symptoms and GPA. If individuals display low levels of joyous exploration, inattention symptoms negatively affected their GPA. Whereas at high levels of joyous exploration,

inattention symptoms were not related to a lower GPA, indicating that high levels of joyous exploration may compensate for the negative impact of inattention on academic achievement. Additionally, if individuals experience feelings of anxiety or frustration due to a knowledge gap, they appear to be motivated to reduce this discrepancy. Hence deprivation sensitivity was found to be positively associated with GPA. Nonetheless, future studies should test whether the same effects are found in a representative sample of students with ADHD. Investigating if and how cognitive motivational factors affect academic achievement of students with ADHD, can help to understand the heterogeneity of impairments associated with ADHD. Moreover, understanding the potential underlying mechanisms can aid in developing interventions that promote academic achievement.

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