To what Extent do the Different Dimensions of Hyperfocus Predict for risk for Attention-Deficit Hyperactivity Disorder

Bente Leenders

S3992055

Department of Psychology, University of Groningen

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Supervisor: Dr. Miguel Garcia Pimenta

Second evaluator: Dr. Anselm Fuermaier

In collaboration with: Fellow student Emma Snoeren, Sanne Specht, Roberta Vasilev, and Lyan Wellinkvoorde.

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Abstract

Prior research has been mostly consistent in finding a relationship between attention-deficit hyperactivity disorder (ADHD) and hyperfocus. We treated hyperfocus as a multidimensional construct, consisting of the dimensions reduced awareness of the world, time, and self, narrow focus, deep and intense focus, stopping and initiating other things, automatic focus and prolonged concentration. We researched to what extent the different dimensions of hyperfocus predict for risk for ADHD. We hypothesized that the eight dimensions of hyperfocus together would predict a significant proportion of variance in ADHD risk, while being controlled. We also had an exploratory part, where we investigated the relation between the different hyperfocus dimensions and ADHD risk and their predictive ability. We conducted a cross-sectional study (N = 368) with convenience samples. An online questionnaire was administered, measuring ADHD risk, the hyperfocus dimensions, demographic information, personal information and substance use. We performed a hierarchical regression analysis with ADHD risk as dependent variable, age, education, diagnosis last 6 months, diagnosis lifetime, nicotine use, drug use, alcohol use, prescribed medication use and abuse as control variables and the hyperfocus dimensions as predictors. Results showed that the hyperfocus dimensions explain 27.4% variance in ADHD, while being controlled, and this effect is significant. Unexpectedly, a big part of this variance is explained by dimensions which were negatively related to ADHD risk. We expanded the knowledge base on the relations between the different hyperfocus dimensions and ADHD. We recommend a future factor analysis and replication.

Keywords: attention-deficit hyperactivity disorder, hyperfocus, hyperfocus dimensions

To what Extent do the Different Dimensions of Hyperfocus Predict for risk for Attention-Deficit Hyperactivity Disorder

Missing a bus stop because you were reading a book or forgetting to eat because you were playing video games for hours are experiences we might all have now and then. Paradoxically these experiences seem to be especially prevalent in a group of people who normally experience difficulties concentrating. This phenomenon is called hyperfocus: a state of concentration on a task, object, mental representation or activity which is, compared to normal attentional focus, more prolonged and/or more frequent and/or more intense. This is accompanied by diminished attention for non-task related stimuli as the environment and time (Ashinoff & Abu-Akel, 2019). Hyperfocus is present in the normal population (Groen et al., 2020), but is more commonly seen in people with autism, schizophrenia and attention-deficit hyperactivity disorder (ADHD; Ozel-Kizel et al., 2016; Grotewiel et al., 2021; Hupfeld et al., 2018).

In this study we will evaluate hyperfocus in relation to ADHD. ADHD is characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development (American Psychiatric Association, 2013). It is estimated that between 1 and 6% of the adults worldwide have ADHD (Kessler et al., 2005). Hyperfocus is known within clinical practice as both a possible symptom as well as a possible asset of ADHD. Nevertheless, hyperfocus is not included in the diagnostic criteria of ADHD occurring in the Diagnostic and Statistical Manual of Mental Disorders (5^{th} edition.; DSM-5; American Psychiatric Association, 2013).

In this study we will use a new questionnaire which treats hyperfocus as a multidimensional construct, highlighting its diverse nature. Even though previous studies have proposed hyperfocus as a multidimensional construct as well (Hupfeld et al., 2018), they never looked into how these different dimensions uniquely relate to ADHD and thus did not

deliver evidence for the multidimensional nature yet. We think the research line which connects hyperfocus to ADHD will gain a lot of information by looking at how the different dimensions of hyperfocus uniquely relate to ADHD, since some constructs included in the hyperfocus dimensions have been stably found to be positively correlated to ADHD, while others have only shown negative or non-significant correlations so far. With this study we aim to expand the current knowledge on the unique relations between the different hyperfocus dimensions and ADHD, which will result in progress for the empirical base of the hyperfocus construct. Furthermore, almost no research so far went further than looking at correlations. In this study we will perform an analysis with the eight hyperfocus dimensions as predictors for ADHD risk. Doing this will allow us to report on both the relations between the different hyperfocus dimensions and ADHD risk as well as the predictive ability of the different hyperfocus dimensions for ADHD risk. Thus, in this study we will research to what extent the different dimensions of hyperfocus predict for risk for ADHD.

Research so far is scarce, but it does generally show that hyperfocus is indeed more prevalent for people with ADHD than in the normal population. Ozel-Kizel et al. (2016) were the first to go further than case reports for the research on hyperfocus. They found a higher level of hyperfocus for adults with diagnosed ADHD compared to a control group of students. They applied statistical control for age and education, but still managed to find a significant relationship. Hupfeld et al. (2018) found that hyperfocus tendencies are higher for those with a higher level of ADHD, as based on a questionnaire as well as based on self-reported diagnosis. They found this effect across multiple settings (e.g. school and hobbies) and dimensions (e.g. losing track of time and getting stuck on small details). Lastly, Grotewiel et al. (2021) also found that students with ADHD, according to a questionnaire, reported more experiences of hyperfocus than students without ADHD. Hupfeld et al. (2018) and Grotewiel

et al. (2021) both did not apply any control and thus the association they found might be partly explained by variance in variables like age or education.

However, a significant positive correlation was not always found. Groen et al. (2020) could not find strong support for the claim that hyperfocus has a higher occurrence or frequency in people with ADHD compared to the normal population. They were the first to look at the duration and pervasiveness of hyperfocus, but also found no significant differences here. This might be explained by the fact that Groen et al. were the only ones to make use of matched controls, based on sex, age and level of education. They reported that variables such as age, sex and educational level can play a role in the experience of hyperfocus, although the correlations they found were generally small.

Next to age, sex and educational level there are more variables which could confound the relationship between ADHD and hyperfocus. So are stimulants used as medication for ADHD sometimes mentioned as possible confounders. However, Ozel-Kizel et al. (2016) did not find a different relationship between ADHD and hyperfocus for people using prescribed stimulants or not, delivering evidence against the theory that hyperfocus is a side-effect of stimulants. Other mental disorders can also have an influence. Hupfeld et al. (2018) found that the relationship between hyperfocus and ADHD is independent of anxiety. Depression however, does seem to have an influence. Based on these prior findings we decide to include questions on age, education, current and lifetime diagnosis and questions regarding substance use in our questionnaire and include these variables in a statistical control.

Previous studies on hyperfocus are based on different definitions and measures for hyperfocus. Some of those questionnaires included the consequences of hyperfocus in the measurement of the construct. For example, Ozel-Kizel et al. (2016) included procrastination and impaired time management in the measurement of hyperfocus. These negative consequences of hyperfocus overlap with executive dysfunctions commonly seen in ADHD.

This might explain why studies which did include negative consequences in their measurement of ADHD, namely Ozel-kizel et al. (2016), Hupfeld et al. (2018) and Grotewiel et al. (2021), found a positive association between hyperfocus and ADHD. Meanwhile, Groen et al. (2020) did not include these consequences, and did not find a positive association. The questionnaire developed by Hupfeld et al. (2018), which was also used by Grotewiel et al. (2020) measured hyperfocus by connecting six dimensions to three settings (i.e. school, hobbies and screen time). Since almost every question is connected to a setting, it is quite strongly linked to situational aspects. Within such a narrow setting it might be easier to find an association between hyperfocus and ADHD, this might have contributed to Hupfeld et al. (2018) and Grotewiel et al. (2021) finding a positive association. Groen et al. used a different kind of measure than the other studies. Instead of a questionnaire they made use of four questions, asking about the occurrence, frequency, duration and pervasiveness of the hyperfocus episode. Single items, like they used, are less reliable than scales, so this might have disturbed their findings. This is another possible explanation of the deviant research findings of Groen et al. (2020). In this research a new questionnaire will be used, the core hyperfocus questionnaire. Compared to these previous ones the intention for this questionnaire is to distinguish hyperfocus from its determinants (situational, motivational or task related) and consequences and thus measure core hyperfocus.

Just like Hupfeld et al. (2018), the core hyperfocus questionnaire treats hyperfocus as a multidimensional construct. This way we try to capture the diverse nature of hyperfocus. The different dimensions are based on the prior definitions of hyperfocus. Most of the dimensions find their origin in the definition of hyperfocus as formulated by Hupfeld et al. (2018) and were later confirmed by Grotewiel et al. (2021). This concerns the dimensions reduced awareness of the world, time and self, a narrow focus, a deep and intense focus and the dimension difficulty in stopping and initiating other things. Some of these were also

proposed by Ozel-Kizel et al. (2013), namely the dimensions difficulty stopping and initiating other things and reduced awareness of time. Others were also included in the definition of Groen et al. (2020), namely deep and intense focus, reduced awareness of time and the world. The dimension prolonged concentration is implicit in all of the above mentioned definitions, but will be measured as a separate dimensions for the first time in this questionnaire. The dimension automatic focus is a newly proposed additional dimension of the core hyperfocus questionnaire. This operationalization of hyperfocus and the questionnaire belonging to it is still preliminary.

Considering significant correlations between ADHD and hyperfocus have been found quite consistently (Ozel-Kizel et al., 2016; Grotewiel et al., 2021; Hupfeld et al., 2018), only not when matched controls were used (Groen et al., 2020), we do expect the hyperfocus dimensions can be used as predictors of ADHD risk and that they will, altogether, explain a significant proportion of variance in the risk for ADHD. We do not expect applying control will completely outrule the predictive power of the hyperfocus dimensions. Thus we formulate *H*: the eight dimensions of hyperfocus together will predict a significant proportion of variance in ADHD risk, even when control is applied.

Unfortunately, most of the relations between the different hyperfocus dimensions and ADHD have not been researched in much detail yet. So, as the prior research is not extensive enough to make a specific hypothesis for every dimensions relation to ADHD risk, and their predictive power of ADHD risk, we will research this in an exploratory manner.

Methods

Participants

Participants are obtained through convenience samples via the SONA first-year pool of the University of Groningen (n = 249), the paid participant pool (PPP; n = 84), and through social media (n = 35). This yields a total sample size of N = 368 before exclusion. Participants

are excluded if they report insufficient language abilities (*n* = 1), if they report to not have answered the questions seriously (*n* = 5), if they fail one of the three validity control questions (*n* = 20), if they do not complete the questionnaire (*n* = 32) or if they do not consent to participation (*n* = 22). The final sample size is *N* = 322, with 240 female, 79 male and 3 participants who identified as 'other'. The age ranges from 18 to 54 with a mean of 21.44 (*SD* = 3.69). The level of education was coded by a bachelor thesis group and a master student separately via the International Standard Classification of Education System (ISCED; ISCED, 2011). The Cohen's kappa is .939, which is considered as excellent inter-rater reliability. Level of education ranges from the levels 3 ("upper secondary education") to 7 ("master or equivalent"), with mode education level being 5 ("short-cycle tertiary education"). 152 participants reported Dutch as their first language (47.2%), 68 reported German (21.1%), and 22 reported English (6.8%). Additionally, various reported other languages (e.g. Frisian, Romanian, Greek, Hebrew), which are categorized as "other" (24.8%). The participants also reported if they were ever diagnosed (*n* = 98), and/or currently have a diagnosis or received treatment for psychological, mental or brain disorders by a mental health professional (*n* = 46) and/or used prescribed medication (*n* = 29). Several diagnoses are reported that were then categorized, e.g. ADHD (*n* = 16), anxiety disorder (*n* = 39) and mood disorders (n = 38). Next to this, they reported on the use of various substances, namely alcohol (*M* = 2.81, *SD* = 1.24), nicotine (*M* = 2.19, *SD* = 1.51), drugs (*M* = 1.82, *SD* = 1.10), and abuse of prescription medication (*M* = 1.23, *SD* = 0.77).

Measures

Demographic information

Via open questions in English, participants are instructed to self-report demographic data such as age, nationality, first language, highest level of education attained and in which country they attained this education. Furthermore, participants are asked to categorize their

sex as either “female”, “male” or “other”. Lastly, they are instructed to categorize their current occupational status based on nine answer options, including an “other” option, where they could fill it in themselves if theirs is different from the options provided.

Core Hyperfocus questionnaire

For assessing the various dimensions of hyperfocus among participants, an experimental version of the Core Hyperfocus questionnaire is applied. Participants are instructed to indicate the frequency of specific hyperfocus experiences in the past six months, on a 6-point Likert scale (1 = never, 6 = very frequently/always). This questionnaire incorporates eight dimensions of hyperfocus: ‘reduced awareness of the world’ (6 items, α = .85), ‘reduced awareness of time’ (6 items, α = .82), ‘reduced awareness of the self’ (6 items, α = .76), ‘narrow focus’ (6 items, α = .78), ‘deep and intense focus’ (4 items, α = .75), ‘stopping and initiating other things’ (6 items, α = .34), ‘automatic focus’ (6 items, α = .86) and ‘prolonged concentration’ (6 items, α = .72), with a total of 46 items (α = .95). Examples of items are; “I can be so focused on something that I do not notice the world around me’’ (world awareness) and “There are times when I feel trapped or locked in a state of deep concentration’’ (stopping and initiating other things). Two validity control questions are included, which instruct participants to choose the answers “rarely” and “sometimes” in order to indicate attentive responding. Item order is randomized to reduce the probability of order and fatigue effects. To summarize the scores for these hyperfocus dimensions, the scores of each question are summed up, and divided by the amount of questions per dimension.

Adult ADHD self-report scale screener (ASRS-S)

To measure the risk for ADHD of the participants we use The World Health Organization ASRS-S (Kessler et al., 2005). This is a shortened version consisting of six items from the full ASRS, which contains 18 items. The ASRS assesses the prevalence of common symptoms of ADHD and therefore the potential risk for an ADHD diagnosis. The

items are based on the criteria for ADHD as described in the DSM-IV (American Psychiatric Association, 1994) and input from clinical experts. The items are measured on a 6-point Likert scale (1 = never, 6 = very often). Participants are asked to self-report these symptoms over the last six months. Examples of items included are: “How often do you have difficulty getting things in order when you have to do a task that requires organization?” and “How often do you feel overly active and compelled to do things, like you were driven by a motor?”. A validity control question was included which instructed participants to choose the answer “often” to indicate that their responses were attentive. The ASRS-S summary score consists of the sum of these six individual item scores. Validity research by Kessler et al. (2007) showed Cronbach's alpha ranged from 0.63 to 0.72. This research identifies a Cronbach's alpha of 0.66.

Personal information questionnaire

The questionnaire includes items regarding personal information. Participants are instructed to self-report whether they have ever been diagnosed or received treatment for a psychological, mental or brain disorder, and whether this diagnosis was obtained in the last six months. If the response is yes, they are asked to specify which disorder(s). In addition to that, an inquiry is done regarding the use of prescribed medication, and the specific type of medication which was prescribed. Considering the sensitive nature of these questions, participants are given the option to skip any questions they did not feel comfortable answering.

The Tobacco, Alcohol, Prescription medication, and other Substance use (TAPS) tool

Furthermore, four questions of the TAPS screening tool (Adam et al, 2019) are used to examine the frequency of substance use, including tobacco/other forms of nicotine, alcohol, drugs or the abuse of prescribed medication in the last six months. An example of an item is “In the past 6 months, how often have you used tobacco or any other nicotine delivery product

(i.e., e-cigarette, vaping or chewing tobacco)?" These are assessed by a 5-point Likert scale (1 = never, 5 = daily or almost daily). Considering the sensitive nature of these questions, participants were able to leave any of these questions open if they did not feel comfortable answering.

Procedure

The full survey is administered online, and takes approximately fifteen minutes to complete. Participants gain access to the online Qualtrics (https://www.qualtrics.com) questionnaire through a link and complete it unsupervised. Participants gaining access through SONA receive mandatory study credits as compensation. Participants gaining access through the PPP received €2.00 as compensation. Lastly, other participants are approached via social media (e.g. Facebook, Whatsapp), but not compensated. All relevant aspects of the study were approved by the Ethics Committee of the Faculty of Behavioral and Social Sciences of the University of Groningen.

The questionnaire starts with information of the study, after which participants give informed consent to participation and to collection of personal data (e.g. IP address). First, participants answer questions regarding demographic information. Then, the core hyperfocus questionnaire is presented. In addition to the core hyperfocus questionnaire, participants are instructed to estimate the average duration of a single hyperfocus experience in hours and minutes. Then the ASRS-S is administered, followed by additional personal information questions and the TAPS screening tool. In addition to the validity control questions, two final quality control questions are included at the end of the questionnaire to control for attentive responding. Participants are instructed to report whether they responded seriously and if their English language skills were sufficient to reliably fill in the questionnaire. The final phase is a debriefing in which participants are informed about the research's purpose.

Data-analysis

The data set is analyzed using the program SPSS, version 26 and the power analysis was calculated using the program G*power (Faul et al., 2007). The research started with 368 participants, after exclusion 322 remain. There are seven participants who left one or more of the questions which were optional to answer open. These participants are also excluded from the analysis, after which 315 remain.

In order to make sure that a hierarchical regression analysis is appropriate we are first going to take a look at the assumptions for hierarchical regression analyses. Due to our research design we can assume independence of the residuals, thus this assumption is met. Outliers are checked for using casewise diagnostics. Cases with an ASRS-S summary score with a standard deviation > ±3 are marked as outliers. From this criterion two outliers come forward in our participant pool: case number 117 and 302. These outliers show to influence the results of the hierarchical regression analysis to such an extent that we decide to remove them, after which 313 participants remain. Linearity and homoscedasticity are evaluated by looking at the residuals vs predicted plot. The assumptions of linearity and homoscedasticity are met. The assumption of normality is checked by looking at the frequency distribution histogram and a QQ-plot, of the residuals and of all the hyperfocus dimensions separately. We conclude that the assumption of normality is met. Lastly, to check for multicollinearity, we make a correlation matrix plotting the hyperfocus dimensions against each other. There are some signs of multicollinearity. The Pearson correlations between the hyperfocus dimensions reduced awareness of the world and deep and intense focus and the dimensions reduced awareness of the world and reduced awareness of time are higher than .7. However, when we look at the tolerance and VIF values, we see that all the tolerance values are higher than .1 and the VIF values are all lower than 10, as they should be. Considering this, we can assume that the multicollinearity assumption is slightly violated, but not problematic. Thus, all assumptions are met and a hierarchical regression analysis is appropriate.

First, we calculate the descriptive statistics of hyperfocus dimension scores and the ASRS-S summary score, from now on called the ASRS-S score. We also make a correlation matrix for the ASRS-S score and hyperfocus dimension scores. All the reported *p*-values in this study are two-tailed. Statistical analysis of the education variable is done through the process of dummy coding, using four dummy variables. We start the main analysis with making a correlation matrix between the ASRS-S score, hyperfocus dimensions scores, demographic information, personal information and substance use. Variables correlating significantly with the ASRS-S score or hyperfocus dimension score are marked as control variables. We then run a hierarchical regression analysis using the enter method, while controlling for the variables age, education, diagnosis last 6 months, diagnosis lifetime, prescribed medication-, nicotine-, drug-, and alcohol use and prescribed medication abuse. The ASRS-S score is entered as the dependent variable, the control variables are entered in the first block and the hyperfocus dimensions in the second block. We find a power of 0.99, calculated based on a multiple regression with 8 predictors, with a sample size of N = 313, $\alpha = 0.05$ and a calculated medium effect size ($f^2 = .23$).

Results

Descriptive statistics and correlations

Table 1 shows the descriptive statistics for the ASRS-S score and the hyperfocus dimension scores. The means of the hyperfocus dimensions all fall between 3 and 4 and are thus similar. Table 2 shows the Pearson correlations between the ASRS-S score and the hyperfocus dimension scores. The results show that the hyperfocus dimension reduced awareness of the self is the only dimension which is significantly positively correlated to the ASRS-S score. The dimensions automatic focus and prolonged concentration are significantly negatively correlated with the ASRS-S score. For all the other dimensions there is no

significant relation found. Furthermore, every hyperfocus dimension is significantly positively correlated with all the other hyperfocus dimensions.

Table 1

Means and standard deviations of the ASRS-S score and hyperfocus dimension scores.

	Mean	*SD*
ASRS-S score	12.57	3.83
Reduced awareness of the world	3.31	0.86
Reduced awareness of time	3.53	0.81
Reduced awareness of the self	3.01	0.83
Narrow focus	3.36	0.76
Deep and intense focus	3.96	0.72
Stopping and initiating other things	3.34	0.55
Automatic focus	3.65	0.69
Prolonged concentration	3.32	0.85

Table 2

Pearson correlations of the ASRS-S score and hyperfocus dimension scores.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. ASRS-S score	-								
2. Reduced awareness of the world	0.002	-							
3. Reduced awareness of time	0.077	0.717**	-						
4. Reduced awareness of the self	0.153**	0.682**	0.613**	-					
5. Narrow focus	-0.085	0.587**	0.497**	0.481**	-				
6. Deep and intense focus	-0.046	0.721**	0.624**	0.568**	0.607**	-			
7. Stopping and initiating other things	0.081	0.517**	0.529**	0.532**	0.442**	0.496**	-		
8. Automatic focus	-0.395**	0.478**	0.402**	0.426**	0.525**	0.545**	0.391**	-	
9. Prolonged concentration	-0.146**	0.651**	0.600**	0.576**	0.634**	0.674**	0.550**	0.594**	-

Note. ** $p < .01$.

Hierarchical regression analysis

To test *H*: the eight dimensions of hyperfocus together will predict a significant proportion of variance in ADHD risk, even when control is applied, we first consider table 3,

which shows the correlations between the ASRS-S score, hyperfocus dimensions scores, demographic information, personal information and substance use. Age, education, prescribed medication use, nicotine use, drug use and alcohol use correlate significantly with the ASRS-S score. Diagnosis lifetime, diagnosis last 6 months and prescribed medication abuse correlate significantly with one or more of the hyperfocus dimensions. Therefore, all these variables have been entered as control variables.

Table 3

Pearson correlations of the ASRS-S score, hyperfocus dimensions scores and possible control variables.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Age	-0.016*	0.014	0.055	0.060	0.063	0.002	-0.060	0.066	0.095
Education[a]	-0.152**	-0.040	-0.078	0.000	-0.031	-0.003	-0.075	0.013	-0.020
Diagnosis lifetime	0.101	0.061	0.074	0.130*	0.115*	0.070	0.077	-0.037	0.109
Diagnosis last 6 months	0.106	0.045	0.080	0.125*	0.084	0.057	0.056	-0.038	0.072
Prescribed medication use	0.112*	0.021	0.061	0.061	0.080	0.015	0.021	-0.074	0.042
Nicotine use	0.168**	0.007	-0.024	0.030	0.014	0.006	-0.074	-0.059	-0.059
Drug use	0.190**	-0.012	-0.049	0.005	-0.073	-0.041	-0.085	-0.108	-0.082
Prescribed medication abuse	0.078	-0.070	-0.059	-0.010	-0.011	-0.059	-0.125*	-0.189**	-0.062
Alcohol use	0.174**	-0.010	-0.053	0.029	-0.024	-0.026	-0.017	-0.080	-0.078

Note. 1. ASRS-S score; 2. Reduced awareness of the world; 3. Reduced awareness of time; 4. Reduced awareness of the self; 5. Narrow focus; 6. Deep and intense focus; 7. Stopping and initiating other things; 8. Automatic focus; 9. Prolonged concentration.

[a] For the education variable Spearman's rho is reported.

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

For the results of the hierarchical regression analysis see table 4. When we look at model 1, including only the control variables, we find that they explain a significant amount of the variance in the value of the ASRS-S score ($F(12, 300) = 2.731$, $p = .002$, $R^2 = .098$, $R^2 Adjusted = .062$). Model 2 which includes both the control variables and all the hyperfocus

dimensions also explains a significant amount of the variance in the value of the ASRS-S score ($F(20, 292) = 8.677$, $p < .001$, $R^2 = .373$, $R^2Adjusted = .330$). The $R^2change$ between model 1 and 2 is .274 and is significant at $p < .001$ level, which means that the hyperfocus dimensions explain 27.4% of the variance in the ASRS-S score above and beyond the variance already explained by the control variables and this effect is significant. So, our hypothesis is supported.

Table 4

Result of the hierarchical regression analysis for the ASRS-S score with control variables and hyperfocus dimensions as predictors.

	ASRS-S score	
Predictors	R^2	$R^2change$
Step 1		
Control variables[a]	0.098	
Step 2		
Hyperfocus dimensions[b]	0.373	0.274***

Note. [a]control variables (age, diagnosis lifetime, prescribed medication use, prescribed medication abuse, nicotine use, alcohol use and drug use). [b]hyperfocus dimensions (reduced awareness of the world, reduced awareness of time, reduced awareness of the self, narrow focus, deep and intense focus, stopping and initiating other things, automatic focus and prolonged concentration).

*** $p < .001$.

To evaluate the exploratory part of this analysis we will consider table 5, which shows the unstandardized coefficients and significance levels of the predictors and their squared semipartial correlation coefficients, after applying control. The results show that most hyperfocus dimensions have a positive coefficient, however the hyperfocus dimensions

automatic focus, prolonged concentration and reduced awareness of the world have a negative coefficient. A positive coefficient tells us that as the value of the predictor increases, the mean of the ASRS-S score also tends to increase. However, with an increase in a predictor with a negative coefficient the mean of the ASRS-S score tends to decrease. Using a $p < .05$ significance level, the dimensions automatic focus, reduced awareness of the self, prolonged concentration and stopping and initiating other things come forward as significant predictors. The squared semipartial correlation coefficients tell us how much the total proportion explained variance increases when you add a predictor to the model, already including the other predictors. Table 5 is ordered from highest to lowest squared semipartial correlation coefficient. Thus, the hyperfocus dimension on top of the table uniquely adds the most variance in the ASRS-S score explained and the dimension at the bottom the least. The explained variance increases with 15,5% when the hyperfocus dimension automatic focus is added to the model and with 4,9% when reduced awareness of the self is added. So, these two have the largest contribution to the total proportion of variance explained. The other dimensions add only 1,1% or less explained variance when they are added to the model and thus only make a minor contribution to the total proportion of explained variance.

Table 5

Unstandardized coefficients, significance levels and squared semipartial correlation coefficients of the hyperfocus dimensions.

	B	*p*	sr^2
Automatic focus	-2.397	0.000	0.155
Reduced awareness of the self	1.548	0.000	0.049
Prolonged concentration	-1.002	0.021	0.011
Stopping and initiating other things	0.879	0.043	0.009
Reduced awareness of time	0.621	0.075	0.007
Reduced awareness of the world	-0.492	0.191	0.004
Deep and intense focus	0.492	0.231	0.003
Narrow focus	0.113	0.738	0.000

Discussion

In this study we researched to what extent the different dimensions of hyperfocus predict for risk for ADHD. Prior research has been mostly consistent in finding a significant relationship between hyperfocus and ADHD and this effect does not seem to be solely due to confounding variables (Ozel-Kizel et al., 2016; Grotewiel et al., 2021; Hupfeld et al., 2018), although disputable (Groen et al., 2020). Therefore, we stated a hypothesis claiming that the eight dimensions of hyperfocus together would predict a significant proportion of variance in ADHD risk, even when control is applied. We also included an exploratory part in the analysis, researching the unique relations of the different hyperfocus dimensions to ADHD risk and their predictive power.

To answer our research question, the hyperfocus dimensions explain 27.4% variance in the ASRS-S score above and beyond the variance already explained by the control variables and this effect is significant. This is in line with our hypothesis. However, our exploratory part of the analysis showed that a big proportion of this variance is explained by two hyperfocus dimensions which are negatively related to ADHD. These negative relations are not in line with what you would expect based on prior research. Furthermore, the

dimensions automatic focus and reduced awareness of the self have shown to be the best predictors. Four of the eight predictors have shown to be non-significant and these all explained only 0.7% or less of the total variance. Thus, the dimensions all uniquely relate to ADHD risk, showing different directions in their coefficients and varying predictive abilities.

This study comes with some interesting theoretical implications. This study was one of the first to look at hyperfocus as a predictor for ADHD risk instead of merely looking at correlations. This comes with the advantage of better understanding of the association of each individual hyperfocus dimension with ADHD, while also accounting for the effect of the other dimensions. Since almost no studies used hyperfocus as a predictor for ADHD before, we can only compare these results to correlational studies. Hupfeld et al. (2018) and Grotewiel et al. (2021) both found a significant positive correlation between ADHD and hyperfocus experiences. Furthermore Ozel-Kizel et al. (2016), also applied statistical control and still found a significant positive correlation between ADHD and hyperfocus. So, our finding that the hyperfocus dimensions together predict a significant amount of variance in risk for ADHD, while applying statistical control, is in line with what would be expected based on these previous significant positive correlations. It however contradicts Groen et al. (2020), since when they made use of matched controls they could not find a significant correlation between hyperfocus and ADHD. So, our findings contradict the idea that the relation between hyperfocus and ADHD can fully be explained by the effect of control variables. However, the studies which found a significant correlation always found a positive one, while if we look at our hyperfocus dimensions separately, we find some positive and some negative correlations. Two of the negative correlating dimensions were the newly added ones, prolonged concentration and automatic focus. Since these were not included in previous research it explains why they only found positive correlations, while we did not. We will now expand on the effects found for the different dimensions.

During our exploratory analysis we found that some hyperfocus dimensions formed better predictors of the ASRS-S score than others. If we look at the different predictors, we see that the dimension reduced awareness of the self has a significant positive coefficient and explains a big proportion of variance. This is contrary to the findings of Grotewiel et al. (2021), who found no significant difference for loss of self-consciousness between people with or without ADHD. The dimension stopping and initiating other things also has a significant positive coefficient, although it did not explain a big proportion of variance. This exact relation has not been researched yet, but similar concepts had already been positively linked to ADHD before. For example, Ayers-Glassey & Maclntyre (2021) found that people with ADHD scored higher on perseveration than a control group. Thus, our findings are in line with this prior research. The newly added dimensions automatic focus and prolonged concentration both have a significant negative coefficient. Automatic focus was previously found to not be significantly correlated to ADHD (Grotewiel et al. 2021). So the fact that we found a significant negative coefficient and that it is the best predictor of our model, is surprising. Prolonged concentration is one of the core features of hyperfocus, which as we know has shown to be positively correlated to ADHD multiple times (Ozel-Kizel et al., 2016; Grotewiel et al., 2021; Hupfeld et al., 2018). So, the negative coefficient that we found, now that it is added as a separate dimension, is contrary to what had been expected. One possible explanation of these surprising findings can be found in the formulation of the hyperfocus questionnaire. The hyperfocus questionnaire started with the statement “Please read the following statements and indicate how often you had the following experiences while concentrating or focusing on something in the last 6 months”. In combination with a question like “I can be completely focused without making an effort to pay attention” from the automatic focus dimension. It is likely that participants answered these questions with not only hyperfocus experiences, but also general attention experiences in mind, during which

prolonged concentration and automatic focus can indeed be disturbed for people with ADHD. This might also explain why the dimensions deep and intense focus and narrow focus did not show up as significant predictors. Future research should consider reformulating the questions in order to make sure the questions get answered concerning hyperfocus experiences. The direction of the non-significant coefficients was sometimes as expected, such as the positive coefficient of narrow focus (Ozel-Kizel et al., 2016) and reduced awareness of time (Grotewiel et al., 2021; Ozel-Kizel et al., 2016). However deep and intense focus had a positive coefficient, while this was not expected (Grotewiel et al., 2021) and neither was the negative coefficient of reduced awareness of the world expected (Moneta, 2012). Above all since these last four dimensions had all been linked to ADHD before, it is unexpected that they all turned out to be non-significant as predictors and explain only such a small proportion of variance.

Deviant findings can partly be explained by the limitations and strengths of this study. The biggest limitation is the fact that we used a questionnaire which is still in development for the measurement of hyperfocus, namely the Core hyperfocus questionnaire. Basing our study on this questionnaire advanced its development. However, it degraded the validity of our study. We assumed that the eight hyperfocus dimensions are part of the hyperfocus construct even though this has not been validated yet. It is therefore not possible to say how well we actually measured hyperfocus. Thus, since our results are based on a non-validated measure, this makes their validity questionable as well.

Moreover, the core hyperfocus questionnaire consists of 46 items of which some are similar in phrasing. During the pilot phase we received feedback concerning the fact that the questionnaire was experienced as repetitive. We did try to minimize the effects of questionnaire fatigue by randomizing the questions and including control questions for attentive answering. Still, we cannot deny some answers might have been rushed and thus less

accurate. This might have undermined the validity of our results. As the questionnaire is still in development, in this phase it was important to include all of these items. However, executing a factor analysis to investigate the possibilities of shortening the questionnaire or rephrasing items to make them less similar is desired.

Furthermore, the choice of our sample comes with some limitations as well. Since it mostly consists of university students this results in a sample with a narrow range in age and educational level. Age and education have both shown to be significantly positively correlated to hyperfocus occurrence, but negatively to hyperfocus duration and pervasiveness (Groen et al., 2020). It is therefore conceivable that the relations between the hyperfocus dimensions and ADHD also vary with these variables. This might explain why our results of some of these relations were not in line with prior research. Moreover, we cannot generalize these results to populations of lower educational level and/or higher age. Therefore, this study should be replicated with a sample representative for a bigger population.

Moreover, we measured a diverse range of possible control variables and also included all of these as control in our analysis. These control variables together explained 9.8% of the variance. If we had not filtered out their effect, part of it would have been included in the proportion of variance explained by the hyperfocus dimensions, resulting in an overestimation. However, since this control was also partly based on the narrow range in age and educational level, it should be kept in mind that this control is of lesser quality than desired.

A strength of this research concerns how broadly the hyperfocus construct has been measured. Eight different dimensions of hyperfocus were included, allowing us to measure the diverse nature of hyperfocus. Compared to previous hyperfocus questionnaires this questionnaire distinguishes hyperfocus from its determinants (situational, motivational or task related) and consequences. Some previous questionnaires measured experiences of

hyperfocus while connected to certain settings or tasks. Hyperfocus has shown to be more strongly correlated to some settings than others (Hupfeld et al., 2018). Since we did not include any situational aspects it is conceivable that this partly explains why our findings are somewhat deviant from prior research. Other hyperfocus definitions and questionnaires also often included the possible negative consequences of a hyperfocus experience, such as difficulty switching tasks and failure to attend to personal needs. As mentioned before, there is overlap between these operationalizations of hyperfocus used in other studies and executive dysfunctions commonly seen in ADHD (Groen et al., 2020). This might explain why other studies did observe a positive association between ADHD and hyperfocus, but not all of our hyperfocus dimensions showed to be positively connected to ADHD risk and/or had a high predictive power.

When we consider the implications of this study, we see that even though the hyperfocus dimensions explained 27.4% variance in the ASRS-score while being controlled, a big proportion of this variance is explained by hyperfocus dimensions which are negatively related to ADHD. A future factor analysis should show whether the newly added dimensions which were negatively related to ADHD actually belong in the hyperfocus construct or not. In general, this factor analysis will provide information about the existence of the eight hyperfocus dimensions. A future replication which tackles the limitations of this study should show whether the findings which were deviant from prior research were due to methodological and conceptual differences or whether the relation between hyperfocus and ADHD is actually less stably positive than previously thought. Furthermore, with this study we have expanded the knowledge base on the unique relations between the different hyperfocus dimensions and ADHD. As both the direction of the relation with ADHD and the predictive abilities of the hyperfocus dimensions varied, we encourage continuing considering the unique relations between ADHD and the different hyperfocus dimensions.

In this study we researched to what extent the different dimensions of hyperfocus predict for risk for ADHD. We found that all the hyperfocus dimensions together predict ADHD risk significantly, even when control is applied. However, unexpectedly, a big part of this variance is explained by dimensions which are negatively related to ADHD risk. We expanded the knowledge base on the unique relations between the different hyperfocus dimensions and ADHD. A factor analysis and replication should give clarity on the reason for the deviant findings.

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