The creative brain

Some insights into the neural dynamics of flexible and persistent creative processes

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Publication date
2018

Document Version
Other version

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Link to publication

CHAPTER 4

Subclinical Symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) are Associated with Specific Creative Processes

This chapter is based on:

Boot, N., Nevicka, B., & Baas, M. (2017). Subclinical symptoms of attention-deficit/hyperactivity disorder (ADHD) are associated with specific creative processes. *Personality and Individual Differences*, *114*, 73–81.

Supplementary material: https://doi.org/10.1016/j.paid.2017.03.050

Abstract

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by distractibility, hyperactivity, and impulsive behavior. Although ADHD generally associates with a range of cognitive impairments, evidence suggests that people with ADHD may be more creative than people without the disorder. However, the exact relationship between specific ADHD symptoms and different creative processes is unclear. In three studies, we investigated the relationship between subclinical symptoms of ADHD and flexible versus persistent creative processes. Although effect sizes were small, we found that ADHD symptoms in general were associated with enhanced self-reported creative behavior and more publically recognized creative achievements in daily life, in line with our hypotheses. Moreover, these symptoms were associated with enhanced divergent thinking and with a more original, but less practical, reconstruction of complex problems. Our results indicate that these relationships were mainly driven by hyperactive–impulsive rather than inattention symptoms of ADHD.

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by distractibility, hyperactivity, and impulsive behavior (American Psychiatric Association [APA], 2013). Approximately 2.5% of the adult population meets the criteria for diagnosis of ADHD (Simon, Czobor, Balint, Meszaros, & Bitter, 2009). Moreover, many people experience subclinical ADHD symptoms. These symptoms do not meet the criteria for diagnosis of the disorder, but are nonetheless associated with negative social and psychological outcomes, such as financial problems and a high comorbidity with other mental disorders (Arcos-Burgos & Acosta, 2007; Das, Cherbuin, Butterworth, Anstey, & Easteal, 2012; Faraone et al., 2006; Overbey, Snell, & Callis, 2011). Despite these difficulties, an often-touted silver lining of ADHD may be enhanced creativity. Symptoms of ADHD, such as distractibility (Baird et al., 2012; Carson et al., 2003; Kasof, 1997; Zabelina et al., 2016b), cognitive arousal and high energy (Baas et al., 2011; Barron & Harrington, 1981; De Dreu et al., 2008), and impulsivity (Batey & Furnham, 2008; Feist, 1998) have all been linked to enhanced creativity. Indeed, compared to people without the disorder, those with ADHD report more publically recognized creative achievements, including receiving a patent for an invention or publishing a book (White & Shah, 2011). However, the underlying process remains unclear, as evidence from laboratory studies on the relation between ADHD symptoms and creative performance is mixed. Some findings indicate that people with ADHD are more creative than people without ADHD (White & Shah, 2006, 2011, 2016), but other studies show the opposite pattern or unaffected creative performance in those with ADHD (Abraham et al., 2006; Barkley et al., 1996; Murphy et al., 2001).

One way to resolve these inconsistencies may be to look at variations in both the degree and quality of subclinical symptoms of ADHD, on the one hand, and the specific creative processes under investigation, on the other. With respect to the degree of symptoms, like other psychopathological disorders, ADHD as a disorder can be seen as the extreme end on a continuum ranging from a low to a high level of symptoms (Levy, Hay, McStephen, Wood, & Waldman, 1997). As is the case for symptoms of other psychopathological disorders, such as schizophrenia and mania, the degree of ADHD symptoms may be related to creativity in a curvilinear rather than a linear way (Acar & Sen, 2013; Baas et al., 2016; Furnham et al., 2008). Moreover, ADHD consists of two symptom dimensions: inattention and hyperactivity–impulsivity (American Psychiatric Association, 2013). These dimensions are associated with specific deficits during performance of cognitive tasks – deficits that may also influence creative performance (Chhabildas, Pennington, & Willcutt, 2001; Sagvolden et al., 2005). Therefore, creativity in ADHD may depend on the specific symptoms that people experience, yet these symptom dimensions have not been taken into account in prior studies. In the present series of studies, we investigated the relationship between (subclinical) symptoms of ADHD and qualitatively different creative processes. In the following, we will first discuss the available evidence pointing to a link between ADHD and creativity. Subsequently, we will present the results of three studies showing that subclinical symptoms of inattention and hyperactivity–impulsivity are related to specific creative processes. Together, these findings advance our understanding of the positive side of ADHD and could help people take advantage of their symptoms in situations that require creativity.

Symptoms of ADHD: Inattention and Hyperactivity–Impulsivity

As a result of their distractibility, hyperactivity, and impulsivity, people with ADHD experience problems with diverse higher-level cognitive abilities, including complex problem solving, planning, response inhibition, and reward processing (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Mitchell, 2010; Murphy et al., 2001; Sagvolden et al., 2005). However, it is important to note that ADHD is not a unidimensional disorder: both the degree and quality of symptoms vary considerably across individuals (Kooij et al., 2005; Mostert et al., 2015) and also within individuals over time (Biederman, Mick, & Faraone, 2000). The Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; APA, 2013) distinguishes three subtypes of ADHD based on people's experience of varying levels of inattention and hyperactivity–impulsivity symptoms (Levy et al., 1997). First, the predominantly inattentive subtype is characterized by impaired attentional processes in the absence of clinically significant levels of hyperactivity and impulsivity. These attentional problems result in distractibility, reduced persistence, slower information processing, and problems with planning (Chhabildas et al., 2001; Dinn, Robbins, & Harris, 2001; Kooij et al., 2005; Sagvolden et al., 2005). Second, the predominantly hyperactive–impulsive subtype does not involve clinical levels of inattention symptoms and is characterized by restlessness, excessive talking, disruptive behavior, and heightened sensitivity to immediate (vs. delayed) rewards (Kooij et al., 2005; Mitchell, 2010; Toplak et al., 2005). These symptoms are expressed as impulsive responding, risky decision making, and a high error rate during cognitive tasks (Sagvolden et al., 2005; Toplak et al., 2005). Third, the combined subtype is associated with symptoms of both inattention and hyperactivity–impulsivity. Although symptoms of ADHD impair performance on a range of cognitive tasks (Castellanos et al., 2006; Chhabildas et al., 2001; Toplak et al., 2005), these symptoms are also associated with positive behavioral and emotional outcomes, such as enthusiasm and an easygoing attitude (Sagvolden et al., 2005). Moreover, people's distractibility, energy, and uninhibited behavior may be associated with specific advantages when tasks require creativity.

AHDH Symptoms Benefit (Flexible) Creativity

Creativity, the generation of ideas that are both original and useful (Amabile, 1996), is a complex cognitive process that involves different problem solving stages, including problem construction, idea generation, and evaluation of generated ideas (Montag, Maertz, & Baer, 2012; Mumford, Baughman, Threlfall, Supinski, & Costanza, 1996) – stages that, in turn, involve lower-level cognitive processes, such as the inhibition of unoriginal ideas, retrieval of information from long-term memory, and recombination of this information into novel ideas (Allen & Thomas, 2011; Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; Cropley, 2006; Dietrich, 2004). These processes can be roughly divided into those that require cognitive flexibility and those that require cognitive persistence (De Dreu et al., 2008; Hommel, 2012; Nijstad et al., 2010). Flexible creative processes include effortless switching between perspectives, having a broad attentional scope, divergent thinking (the ability to generate many different answers in response to a single question; Guilford, 1967), and seeing associations between concepts that are not obviously related to each other (Chermahini & Hommel, 2010; Nijstad et al., 2010). These flexible processes are generally measured using open-ended idea generation tasks in which people are asked to come up with alternative solutions for a certain problem. For example, in the Alternate Uses Task (Guilford, 1967), people are asked to write down as many uses for a common object (e.g., a brick) as they can think of. People's ideas can subsequently be scored in terms of *fluency* (the number of generated ideas), *flexibility* (the number of conceptual categories the ideas belong to) and *originality* (the extent to which an idea is novel). As generating many ideas increases the chance of generating highly original ideas (Nijstad et al., 2010; Simonton, 2003), performance benefits from high productivity and free association without immediate evaluation of ideas. Moreover, performance on idea generation tasks improves when inhibitory control is reduced, so that seemingly irrelevant information can enter working memory during idea generation (Radel, Davranche, Fournier, & Dietrich, 2015).

Persistent creative processes, on the other hand, rely on systematic problem analysis, sustained goal-directed effort, deep exploration of a certain line of ideas, and convergent thinking – the combination of existing information into novel solutions according to certain rules and constraints (Cropley, 2006; De Dreu et al., 2012; Lucas & Nordgren, 2015; Roskes et al., 2012). Persistent creative processes can be measured with convergent thinking tasks, which require people to restructure and reapply existing information about a presented problem, and to engage in constrained and confirmatory search processes to identify the correct solution (Cropley, 2006; Hommel, 2012). For instance, in the Remote Associates Test (Mednick, 1962), participants are presented with series of three words that are only remotely related to each other (e.g., *black*, *bean*, *break*) and are instructed to generate a word that relates to all of these three words (i.e., *coffee*). To find the correct solution, people first generate potential relations between the three words and evaluate the correctness of possible solutions through convergent thinking.

Creative processes, particularly those requiring cognitive flexibility, are associated with cognitive processes and personality traits that also play a role in ADHD. For example, cognitive arousal and high energy are associated with increased flexibility and originality in idea generation (Barron & Harrington, 1981; De Dreu et al., 2008, 2011). People with (symptoms of) ADHD score higher on aspects of extraversion and openness to experience – personality traits that are associated with flexible creative processes (Baas et al., 2016, 2013; Chavez-Eakle, Del Carmen Lara, & Cruz-Fuentes, 2006; Feist, 1998; Galang, Castelo, Santos, Perlas, & Angeles, 2016): they are impulsive, highly sensitive to positive, rewarding stimuli, and engage in novelty seeking and risky behavior more often than people without such symptoms (Anckarsäter et al., 2006; Barkley & Murphy, 2011; Faraone et al., 2006; Mitchell, 2010; Toplak et al., 2005). Moreover, a certain degree of distractibility seems to improve flexibility in the generation of ideas and problem solutions (Baird et al., 2012; Carson et al., 2003; Dijksterhuis & Meurs, 2006; Sio & Ormerod, 2009). When people take a break from thinking about a creative problem and perform a relatively easy, unrelated task, they subsequently generate more original ideas and solve more problems than people who keep focusing on the creative problem for extended periods of time (Baird et al., 2012; Sio & Ormerod, 2009). Presumably, the (unconscious) processing of task-unrelated information during creative problem solving expands the associative network so that uncommon associations are activated, resulting in original combinations of information. Thus, being easily distracted by irrelevant information during tasks that require flexible creative processes could be an advantage rather than an obstacle (but see Zabelina et al., 2016b, for a different perspective). Conversely, because more persistent processes in creativity rely on sustained, goal-directed focus and sufficient working memory capacity (De Dreu et al., 2012; Roskes et al., 2012), these creative processes would most likely be impaired by disinhibition, novelty seeking, and distractibility.

This suggests that symptoms of ADHD could be associated with enhanced (flexible) creativity, but reduced creativity through persistence. Indeed, some studies show that, compared to healthy controls, people with ADHD perform better on divergent thinking tasks, but worse on convergent thinking tasks (White & Shah, 2006, 2011, 2016). However, a number of other studies did not observe any differences in divergent thinking between people with ADHD and healthy controls (Barkley et al., 1996; Murphy et al., 2001) or found only some specific aspects of creativity to be enhanced (Abraham et al., 2006).

To resolve these inconsistencies, one could investigate the relationship between creativity and the *degree* of ADHD symptoms. In most studies on creativity in ADHD, creative performance of a clinical group is compared to the performance of a control group, while individual variability in ADHD symptoms within groups is ignored (e.g., Murphy et al., 2001; White & Shah, 2011, 2016). By also taking subclinical ADHD symptoms into account, we can investigate the possibility that the relationship between ADHD and creativity depends on the severity of these symptoms. One study showed that subclinical symptoms of ADHD were related to publically recognized creative achievements, but not divergent thinking (Zabelina et al., 2014), but the authors did not test the possibility that the relationship between ADHD symptoms and creativity is curvilinear rather than linear, similar to the inverted-U-shaped relationship of symptoms of other psychopathological disorders, such as schizophrenia and bipolar disorder, with creativity. For example, intermediate levels of schizotypal symptoms (e.g., overinclusive thinking, eccentric behavior) in healthy people are associated with improved creativity (Acar & Sen, 2013; Baas et al., 2016; Polner et al., 2015), but as symptoms increase in severity and develop into full-blown schizophrenia, cognitive functioning in general declines and creativity is impaired (Abraham et al., 2007). A similar inverted-U-shaped relationship may exist for other psychiatric disorders that are associated with deficits in executive functioning, such as ADHD. Thus, while moderate symptoms of ADHD may facilitate creativity, more severe symptoms may impair creative performance. In the current series of studies, we set out to test this possibility.

As a second explanation of the inconsistent findings in prior laboratory studies, we propose that the relationship between creativity and ADHD may also depend on the specific *types* of symptoms that people experience and on the particular creative processes under investigation. To date, studies on creativity in ADHD did not take the different symptom dimensions of ADHD into account, nor the distinction between flexible and persistent creative processes. The impulsive and disinhibited responding, risky decision-making, extraversion, and increased behavioral activation that characterize hyperactive–impulsive symptoms could be associated with increased output and flexibility during idea generation, resulting in more original ideas (Baas et al., 2013; Barkley & Murphy, 2011; De Dreu et al., 2011; Galang et al., 2016; Parker, Majeski, & Collin, 2004; Radel et al., 2015; Toplak et al., 2005). For inattention symptoms, the direction of a possible relationship with creativity is unclear. On the one hand, distractibility and disinhibition has been associated with facilitated divergent thinking and more creative achievements in everyday life (Baird et al., 2012; Carson et al., 2003; Radel et al., 2015; Zabelina et al., 2016b). On the other hand, evidence indicates that divergent thinking requires some level of selective attention and cognitive control and benefits from fast information processing (Benedek, Franz, Heene, & Neubauer, 2012; Sagvolden et al., 2005; Zabelina, O'Leary, Pornpattananangkul, Nusslock, & Beeman, 2015; Zabelina et al., 2016b). This suggests that inattention symptoms of ADHD and the reduced processing speed that characterizes these symptoms would actually associate with impaired divergent thinking. Moreover, because inattention symptoms are related to reduced persistence (Chhabildas et al., 2001; Kooij et al., 2005), people who experience inattention symptoms may also be impaired on more persistent creative measures.

The Present Studies

In the present series of studies, we aimed to clarify the relationship between ADHD and creativity by investigating how subclinical symptoms of ADHD are associated with creative outcomes and specific creative processes. In line with previous findings (White & Shah, 2006, 2011, 2016), we expected that subclinical ADHD symptoms in general would be associated with enhanced performance on creativity tasks that require cognitive flexibility and with more publically recognized creative achievements and behavior in daily life, but with impairments on more persistent and convergent aspects of creativity. Moreover, we hypothesized that the hyperactivity–impulsivity and inattention symptom dimensions of ADHD would relate to flexible and persistent creative processes in different ways. We expected that hyperactive–impulsive symptoms would positively predict flexibility in creative idea generation, due to the disinhibited, impulsive responding, and increased novelty seeking that are associated with these symptoms. Our expectations regarding inattention symptoms were less straightforward, as the deficits in sustained attention that characterize these symptoms could either be positively or negatively associated with creativity (Baird et al., 2012; Carson et al., 2003; Zabelina et al., 2016b). On the one hand, increased processing of task-irrelevant information may activate uncommon associations, resulting in original ideas. On the other hand, idea generation may require flexible but sustained attention to rapidly switch from one idea to another without distraction. As reduced persistence is one of the diagnostic criteria for the predominantly inattentive, but not the hyperactive–impulsive ADHD subtype (Kooij et al., 2005), we expected that inattention (but not hyperactive–impulsive) symptoms would be negatively associated with persistent creative processes. Finally, we tested the possibility that ADHD symptoms would be associated with creativity in an inverted-U-shaped fashion, so that moderate (but not low and high) symptom levels would be associated with enhanced (flexible) creative performance. Because the three cross-sectional studies (Study 4.1-4.3) were highly similar in set-up, the method and result sections of the three studies with independent samples will be described jointly.

Method

Design, Participants, and Procedure

Both Study 4.1 and 4.2 were conducted as part of several mass testing sessions, with the ADHD and creativity scales and tasks administered weeks apart in different sessions. In Study 4.1, 419 undergraduate students (67% female) with a mean age of 20.15 years (*SD* = 2.61) participated for partial fulfillment of a course requirement. In Study 4.2, an independent sample of 316 undergraduate students (71% female) with a mean age of 20.05 years (*SD* = 3.04) participated. Participants were seated in large lecture halls behind a personal computer, which displayed all materials and recorded all responses. Experimenters supervised testing sessions in which participants were not allowed to talk and were required to work individually, at their own pace, and without consulting others. In both studies, participation was voluntary and participants provided informed consent. In Study 4.1, participants completed two self-report creativity measures, a problem construction task, a creative ideation task, and a convergent thinking task; in Study 4.2, participants completed two self-report creativity measures, a problem construction task, and a (different) creative ideation task. Because variables were measured across several weeks in different sessions, in a number of cases participants did not complete all questionnaires and tasks. When data from the testing sessions were combined, 4 cases were missing for creativity indicators and 11 were missing for the ADHD scale in Study 4.1. In Study 4.2, 60 cases were missing for the creativity indicators and 60 were missing for the ADHD scale.

Because the testing conditions in Study 4.1 and 4.2 may be suboptimal for people who experience a relatively strong degree of ADHD symptoms, we replicated these studies in a laboratory setting in Study 4.3. An independent sample of 205 undergraduate students (72% female) with a mean age of 22.5 years (SD = 5.96) volunteered to participate in this study for money or course credit. Sample size was determined based on a power analysis in G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) for multiple regression with two predictors, an alpha of 0.05, and a power of 0.95. This power analysis indicated that a sample of at least 158 participants would be required to detect the small to moderate effects ($f^2 = 0.10$) that characterize the association between creativity and subclinical symptoms of mental disorders (Acar & Sen, 2013; Baas et al., 2016). Participants were seated in individual cubicles behind a personal computer, which displayed all materials and recorded all responses. In this study, participants first completed an ADHD symptom checklist, followed by two self-report creativity measures, a creative ideation task, and a creative insight task. These tasks and questionnaires took approximately 25 minutes to complete and were administered as part of a larger study.

ADHD Symptoms

Current inattention and hyperactivity–impulsivity symptoms were measured with the 23-item ADHD DSM-IV rating scale for adults (Kooij et al., 2005). For each ADHD symptom, participants rated its frequency in the past 6 months using a scale from 1 (*never or rarely*) to 5 (*very often*). Sample items of the inattention subscale are “fail to give close attention to details in work” and “make careless mistakes in work”. Sample items of the hyperactivity–impulsivity subscale are “feel restless”, and “get bored quickly”. Reliability of the aggregated scale ($\alpha > .89$) and subscales was good ($\alpha_{inattention} > .82$; $\alpha_{hyperactivity-impulsivity} > .81$) in all three studies. The inattention and hyperactivity–impulsivity scales were strongly correlated in all three studies (all *r*s > .65, all *p*s < .001). Table 4.1 displays the means, standard deviations, and the range of scores for the total ADHD scale and both subscales. Across studies, 163 participants (17%) reported a level of symptoms that reached the threshold for a clinical diagnosis of one of the ADHD subtypes according to the diagnostic criteria of Kooij and colleagues (2005): 86 participants qualified for a diagnosis of the predominantly inattentive subtype, 39 qualified for a diagnosis of the predominantly hyperactive–impulsive subtype, and another 38 participants qualified for a diagnosis of the combined ADHD subtype.

Table 4.1. Means, SDs, and range of ADHD symptoms for the total scale and the two subscales in all three studies

	Mean	*SD*	*range*
Study 4.1			
Total ADHD scale	2.58	0.60	1.00 – 4.78
Hyperactivity–impulsivity	2.67	0.70	1.00 – 4.91
Inattention	2.49	0.62	1.00 – 4.67
Study 4.2			
Total ADHD scale	2.60	0.58	1.30 – 4.35
Hyperactivity–impulsivity	2.74	0.67	1.18 – 4.82
Inattention	2.47	0.61	1.17 – 4.00
Study 4.3			
Total ADHD scale	2.48	0.59	1.22 – 4.65
Hyperactivity–impulsivity	2.58	0.63	1.25 – 4.67
Inattention	2.37	0.65	1.09 – 4.64

Creative Behavior and Outcomes

Creative behavior

In Study 4.1 and 4.2, self-reported creative behavior was assessed with the Janssen creative behavior scale (Janssen, 2001). Participants rated how often they engaged in the creative behaviors described in eight items; e.g., “I often come up with original solutions for problems” (1 = *never* to 7 = *always*; α = .88). In Study

4.1, the mean self-rated creativity score was 4.48 (*SD* = 0.98, range = 1 – 7). In Study 4.2, the mean score was 4.30 (*SD* = 0.97, range = 1 – 7).

Creative achievements

Creative achievements were measured with the Creative Achievement Questionnaire (Carson et al., 2005), a self-report assessment of recognized and concrete creative achievements in ten domains (e.g., visual arts, sciences, music) that has good test-retest reliability. For each domain, eight rank-ordered statements were presented ranging from 0 ("I have no training or recognized talent in this area") to 7 ("I have won a national prize in this area"). Across the three studies, the mean creative achievement score was 8.86 (*SD* = 8.04, range = 0 – 70). The marked ranks for each domain were summed together, and log-transformed to yield a creative achievement score (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012).

Problem construction

In all three studies, we measured participants' ability to effectively restructure complex, ill-defined problems, a first step in the creative problem solving process and a predictor of creative achievement (Mumford et al., 1996). During this problem construction task, participants read a short description of four problematic situations such as "You are the principal of an elementary school. One of the students has brought in a snake, but now it is missing". After reading each description, participants were asked to redefine the problem in terms of i) diagnostic information, ii) alternative goals, iii) alternative procedures, and iv) constraints. For each of these aspects, participants could choose from four problem definitions that varied in usefulness (high vs. low) and originality (high vs. low). In the above example situation, an alternative goal high in both usefulness and originality would be: "How can I turn this into a learning experience for the students?", whereas an alternative goal of low usefulness and low originality would be: "How can I keep from being held directly accountable?". We subsequently counted the number of high-usefulness and high-originality options that participants selected. Across studies, participants obtained a mean usefulness score of 12.33 (*SD* = 2.00, range = 0 – 16) and a mean originality score of 6.84 (*SD* = 2.41, range = 0 – 15).

Convergent and Divergent Thinking

Pasta task

In Study 4.1, we measured convergent and divergent creative ideation using the Pasta task (De Dreu et al., 2014; Dijksterhuis & Meurs, 2006; Marsh et al., 1999). Participants were given five primes of non-existing pasta names all ending with an "i" (e.g., maloveni, paragoni), and then generated as many new pasta names as possible within two minutes. From their responses, we created indices for convergent thinking (number of items ending with an 'i,' the cue given in the instructions), category repetitions (number of times in which participants consecutively generated pasta names with the same ending), divergent thinking (number of items not ending with an 'i'), category switches (number of times in which participants switched from one ending, e.g. 'i,' to another ending, e.g. 'a'), and the number non-redundant endings (De Dreu et al., 2014). Because these variables were strongly skewed, they were log-transformed to approach a normal distribution. Category repetitions associated positively with convergent thinking ($r(416) = .80$, $p < .001$), and both were z-transformed and aggregated as a measure of convergent ideation. Divergent thinking, category switches, and the number of non-redundant endings were z-transformed and formed a reliable index of divergent ideation ($\alpha = .92$).

Alternate Uses Task

In Study 4.2 and 4.3, we assessed divergent thinking using the Alternate Uses Task (AUT; Guilford, 1967), in which we asked participants to generate as many new, original ways to use a tin can and a chord as they could think of. For each topic, they had two minutes for idea generation. An independent and trained coder subsequently counted the number of non-redundant ideas (fluency) and the number of categories the ideas belonged to (flexibility). To obtain a measure of flexibility, ideas were categorized into different conceptual categories. For instance, for the tin can topic, the idea "put pencils in" is coded in the category 'as a container,' whereas the idea "as a drum kit" is coded in the category 'as a musical instrument.' To obtain a measure of originality, each idea was scored for the extent to which it was novel and uncommon (1 = *not original at* *all*, 5 = *very original*). We averaged originality ratings across all ideas per individual to correct for differences in fluency. A second coder rated 120 ideas to assess interrater reliability. Interrater reliability for both flexibility (Cohen's $\kappa_{tin\ can}$= .80, p < .001; Cohen's κ_{chord}= .93, p < .001) and originality ($ICC_{tin\ can}$ = .73, p < .001; ICC_{chord} = .72, p < .001) was good. Across studies, participants generated an average of 6.87 ideas (*SD* = 2.93, range = 1.00 – 17.50), with a mean flexibility score of 4.71 (*SD* = 1.66, range = 1 – 10) and a mean originality of 1.84 (SD = 0.33, range = 1 – 3.61).

Remote associates

In Study 4.1 and 4.3, we used the Remote Associates Test (RAT), a measure of convergent thinking that requires participants to identify associations among words that are not normally connected (De Dreu et al., 2012; Hommel, 2012; Mednick, 1962). Participants received 10 items in which they were given three words (e.g., *car*, *swimming*, *cue*) and had to generate a word that associates with all of them (i.e., *pool*). The number of correctly solved items was our measure of convergent thinking. In Study 4.1, people solved a mean of 4.21 items (*SD* = 2.04, range = 0 – 9). In Study 4.3, people solved a mean of 5.58 items (*SD* = 2.25, range = 1 – 10).

Results

Correlations between Creativity Indicators

Table 4.2 shows means and standard deviations, along with zero-order correlations for the creativity indicators in all three studies. Although these correlations varied somewhat across studies, self-reported creative behavior and creative achievements were generally positively correlated with flexible divergent thinking and the originality of problem construction. More convergent and systematic measures of creativity, such as RAT performance and the usefulness of problem construction, neither consistently correlated with each other, nor with indices of flexible creativity.

Table 4.2. Means and SDs, and correlations between creativity measures in all three studies

	M	*SD*	1.	2.	3.	4.	5.	6.
Study 4.1								
1. Divergent thinking	0.00	0.97						
2. Convergent thinking	0.00	0.95	−.45**					
3. Creative behavior	4.48	0.99	.12*	−.02				
4. Creative achievements	1.97	0.77	.06	.04	.33**			
5. Problem usefulness	12.14	1.97	.03	.01	−.01	−.10*		
6. Problem originality	6.93	2.41	.09	.01	.18**	.08	.06	
7. Remote associates	4.21	2.04	−.03	.10	−.04	−.01	.08	−.08
Study 4.2								
1. AUT fluency	6.32	2.60						
2. AUT flexibility	4.38	1.60	.89**					
3. AUT originality	1.93	0.29	.27**	.27**				
4. Creative behavior	4.30	0.97	.19**	.18**	.17**			
5. Creative achievements	1.86	0.85	.20**	.23**	.14*	.32**		
6. Problem usefulness	12.62	1.94	−.03	−.08	−.08	.12	−.02	
7. Problem originality	6.93	2.37	.14*	.15*	.17**	.27**	.03	.19**
Study 4.3								
1. AUT fluency	7.65	3.18						
2. AUT flexibility	5.17	1.65	.84**					
3. AUT originality	1.70	0.34	.35**	.37**				
2. Creative achievements	2.11	0.75	.26**	.21**	.20**			
3. Problem usefulness	12.35	2.08	−.01	−.10	−.11	−.04		
4. Problem originality	6.54	2.46	.10	.12	.04	.01	.05	
5. Remote associates	5.58	2.25	.13	.12	.01	−.12	.13	−.01

Note. $^*p < .05$, $^{**}p < .01$, $N_{Study4.1} = 415$, $N_{Study4.2} = 256$, $N_{Study4.3} = 205$

Table 4.3. Meta-analytic results of the correlations between ADHD symptom scales and creativity indicators across all three studies

			Total scale		Inattention		Hyperactivity–impulsivity	
	N	*k*	*r*	95% *CI*	*r*	95% *CI*	*r*	95% *CI*
Creative performance								
Creative achievements	838	3	.09	.01; .17	.04	–.04; .11	.13	.05; .20
Creative behavior	649	2	.07	.02; .13	–.02	–.10; .07	.16	.15; .17
Problem usefulness	835	3	–.13	–.17; –.08	–.15	–.20; –.09	–.09	–.12; –.06
Problem originality	835	3	.06	.02; .10	.02	–.02; .05	.09	.04; .15
Divergent thinking								
Pasta task	409	1	.07	–.03; .16	.02	–.08; .11	.11	.01; .20
AUT fluency	415	2	.13	.10; .16	.21	.07; .34	.17	.15; .19
AUT flexibility	415	2	.21	.20; .21	.15	.08; .22	.23	.18; .28
AUT originality	415	2	.16	.10; .23	.13	.09; .17	.16	.08; .24
Convergent thinking								
Pasta task	409	1	–.04	–.14; .06	.01	–.09; .10	–.08	–.18; .01
Remote Associates Test	611	2	–.03	–.04; –.02	.00	–.07; .07	–.07	–.11; –.03

Note. N = number of participants; *k* = number of independent studies, *CI* = Confidence Interval

Meta-Analysis of Correlational Data

We conducted a meta-analysis of the correlations between ADHD symptoms and creativity indicators across all three studies using Meta-Essentials (Van Rhee, Suurmond, & Hak, 2015). We used a random effects model (Hedges & Olkin, 2014).

The results of this meta-analysis are displayed in Table 4.3. Although effect sizes were small, across the three studies, the total scale correlated positively with creative achievements, self-reported creative behavior, the originality of problem construction, and divergent thinking on the AUT (but not on the Pasta task), but negatively with the usefulness of problem construction and convergent thinking on the RAT (but not on the Pasta task). Importantly, the 95% confidence intervals for problem originality, creative achievements, and creative behavior did not overlap with the 95% confidence interval for problem usefulness. In addition, the 95% confidence interval for divergent thinking on the AUT did not overlap with the 95% confidence intervals for convergent thinking on the pasta task and RAT. This suggests that, indeed, the relationship between ADHD symptoms and creativity depends on the creativity indicator that is assessed.

Effect sizes across the three studies were similarly small for the hyperactivity–impulsivity and inattention subscale and the 95% confidence intervals for both subtypes overlapped for most of the creativity indicators, except for self-reported creative behavior. Both the hyperactivity–impulsivity and inattention subscale correlated positively with divergent thinking on the AUT, negatively with the usefulness of problem construction, and did not correlate with convergent thinking on the Pasta task. However, whereas the inattention subscale did not correlate with any of the other creativity indicators, the hyperactivity–impulsivity subscale correlated positively with creative achievements, self-reported creative behavior, the originality of problem construction, and divergent thinking on the Pasta task, but negatively with the usefulness of problem construction and convergent thinking as assessed with the RAT. The heterogeneity statistic Q was non-significant in all cases (all Qs < 3.14, all *p*s > .077), indicating that findings did not differ across studies and different testing environments.

Regressions on ADHD subscales

Although the meta-analytic findings benefit from an increased power to detect associations between ADHD symptoms and creativity, these do not control for the strong comorbidity of inattention and hyperactivity–impulsivity symptoms. Therefore, for each study, we also conducted a series of regression analyses in which we regressed creativity indicators on the ADHD subscales inattention and hyperactivity–impulsivity. We corrected for multiple comparisons using the stepwise Bonferroni method proposed by Holm (1979), which has the advantage that it controls for multiple testing without a loss of power. In this procedure, the observed p-values (starting with the smallest value, then moving to the second smallest, etcetera) are checked against statistical significance values adjusted for the number of tested predictions (.05/(number of hypotheses [k] – the number of tested predictions for which the null-hypothesis was rejected [x]). The null hypothesis is rejected for a comparison if the observed p-value is smaller than .05/(k – x).

Study 4.1

In line with our hypothesis, hyperactive–impulsive symptoms positively predicted self-reported creative behavior (β = .34, $t(409)$ = 5.31, p < .001) and divergent thinking in the pasta task (β = .17, $t(406)$ = 2.59, p = .010). Hyperactivity–impulsivity was negatively associated with RAT performance (β = -.18, $t(409)$ = -2.83, p = .005). Hyperactivity–impulsivity symptoms did not significantly predict convergent thinking (β = -.15, $t(406)$ = -2.33, p = .020), creative achievements (β = .14, $t(409)$ = 2.22, p = .027), and the usefulness (β = -.04, $t(409)$ = -0.57, p = .567) and originality of problem construction (β = .06, $t(409)$ = 0.93, p = .351). Inattention, on the other hand, was negatively associated with self-reported creativity (β = -.28, $t(409)$ = -4.39, p < .001), but did not predict any of the other creativity indicators (all *t*s < 2.38, all *p*s > .019). It should be noted that given the strong correlation between the two symptoms dimensions (r = .65, p < .001) and the negative relationship between inattention and self-reported creativity, the much larger beta-weight of hyperactivity-impulsivity on self-reported creativity in Study 4.1, in comparison to the correlation coefficient from the meta-analysis (*r* = .16, Table 4.3), could be a reflection of the suppressing effect of inattention (MacKinnon, Krull, & Lockwood, 2000).

Study 4.2

In this study, the degree of hyperactivity–impulsivity symptoms positively predicted self-reported creative behavior (β = .24, $t(234) = 2.84$, $p = .005$) and the originality of problem construction (β = .20, $t(221) = 2.30$, $p = .022$). Moreover, hyperactivity-impulsivity predicted fluency (β = .28, t(232) = 3.31, p = .001) and flexibility (β = .32, $t(232) = 3.82$, $p < .001$), but not originality (β = .08, t(232) = 0.95, $p = .344$) of idea generation. Hyperactivity–impulsivity did not predict creative achievements (β = .17, $t(224) = 1.93$, $p = .055$) or the usefulness of problem construction (β = .02, $t(211) = .27$, $p = .789$). Inattention symptoms negatively predicted the usefulness of problem construction (β = –.23, $t(211) = -2.71$, $p = .007$), but did not predict any of the other indicators (all *t*s < 1.83, all *p*s > .068)

Study 4.3

Hyperactivity–impulsivity symptoms positively predicted creative achievements (β = .27, $t(196) = 2.77$, $p = .006$) and originality of problem construction (β = .26, $t(196) = 2.63$, $p = .009$), but did not predict fluency (β = .15, $t(188) = 1.53$, $p = .127$), flexibility (β = .12, $t(188) = 1.20$, $p = .230$), and originality (β = .19, $t(188) = 1.95$, $p = .053$) of idea generation, RAT performance (β = .02, $t(196) = .16$, $p = .870$), or the usefulness of problem construction (β = .08, $t(196) = .81$, $p = .422$). Inattention did not predict any of the creativity indicators (all *t*s < 1.97, all *p*s > .050).

Curvilinear Relationships between ADHD Symptoms and Creativity Indicators

To assess whether ADHD symptoms were related to creativity in a curvilinear rather than linear way, we conducted a number of hierarchical regression analyses in which we regressed the different creativity indicators on the ADHD symptom scales. To increase power, we aggregated the data across the three studies.[1] In the first step of the analyses, we entered the ADHD score as a predictor. In the second step, we added the squared term for this variable. Again, we applied Holm's (1979) stepwise Bonferroni correction for multiple comparisons.

For the sake of brevity, Table 4.4 only displays the results of the second step of these analyses, in which the squared ADHD scores were added as predictors of the different creativity indicators. For the total ADHD scale, none of the squared terms significantly predicted the creativity indicators after correction for multiple comparisons (all ts < 2.02, all ps > .044; scatterplots of the relationship between total ADHD scores and the creativity indicators are displayed in Supplementary Figure S4.1, available online). When regressing the creativity indicators on the separate inattention and hyperactivity–impulsivity symptom scales, none of the squared terms predicted the creative indicators after correction for multiple comparisons (all ts < -2.40, all ps > .016). Running these analyses on the female subsample only did not change the outcome of these analyses, indicating that potential curvilinear relationships were not masked by gender differences.

Discussion

The aim of the present series of studies was to assess whether and how the degree and quality of ADHD symptoms relate to different facets of creativity. Although effect sizes were small, we uncovered that ADHD symptoms in general were associated with enhanced self-reported creative behavior and more publically recognized creative achievements in daily life, in line with our hypotheses. Moreover, these symptoms were associated with enhanced divergent, but not convergent thinking, and with more original, but less practical reconstruction of complex problems. Our results furthermore indicate that these relationships were mainly driven by the hyperactive–impulsive symptom dimension of ADHD. Although results varied somewhat across the three studies, hyperactivity–impulsivity generally predicted enhanced self-reported creative behavior, creative achievements, and originality of problem construction.

Table 4.4. Results of regression analyses with squared ADHD symptom scales as predictors of creativity indicators across all three studies

		Total scale			Inattention			Hyperactivity–impulsivity		
	N	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Creative performance										
Creative achievements	838	−0.03	0.79	.430	0.02	0.52	.602	0.03	0.93	.355
Creative behavior	649	0.08	2.02	.044	0.05	1. 26	.207	0.07	1.77	.077
Problem usefulness	835	−0.05	−1.37	.170	−0.08	−2.40	.016	−0.02	−0.43	.665
Problem originality	835	0.04	1.13	.257	0.00	−0.01	.995	0.06	1.58	.114
Divergent thinking										
Pasta task	409	0.06	1.22	.224	0.06	1.28	.200	0.04	0.80	.423
AUT fluency	415	−0.03	−0.65	.519	−0.02	−0.33	.739	−0.03	−0.63	.527
AUT flexibility	415	−0.06	−1.22	.224	−0.04	−0.89	.374	−0.05	−1.07	.288
AUT originality	415	−0.08	−1.66	.097	−0.02	−0.39	.698	−0.11	−2.26	.024
Convergent thinking										
Pasta task	409	−0.02	−0.32	.748	−0.02	−0.38	.703	0.01	0.24	.808
Remote Associates Test	611	0.02	0.53	.595	0.03	0.79	.429	0.01	0.09	.932

In addition, these symptoms were associated with improved divergent thinking performance during two different creative ideation tasks. ADHD symptoms in general, and symptoms of hyperactivity–impulsivity in particular, negatively predicted RAT performance, a task that measures more convergent aspects of creativity. Inattention symptoms, on the other hand, were less consistently associated with creativity. We found that these symptoms predicted enhanced divergent thinking on one of the creative ideation tasks, but reduced usefulness of problem construction. Moreover, inattention symptoms predicted reduced self-reported creative behavior in one of the studies, but none of the other creativity indicators. We also hypothesized that ADHD symptoms could be associated with (flexible) creativity in a curvilinear rather than a linear manner. We did not find such a relationship between ADHD symptoms and creativity indicators across the three studies.

Theoretical Implications

Our results are in line with previous studies which showed that people with ADHD report more real-world creative achievements and are more flexible in generating ideas than healthy controls (Abraham et al., 2006; White & Shah, 2006, 2011, 2016). One of these studies also showed that people with ADHD (vs. healthy controls) performed worse on the RAT and that this relationship was mediated by impaired inhibitory control (White & Shah, 2006). Indeed, our findings indicate that ADHD symptoms are associated with reduced RAT performance and crucially, that this effect is driven by symptoms of hyperactivity–impulsivity. Inattention symptoms, on the other hand, do not seem to decrease RAT performance. In fact, a recent study shows that RAT performance may even benefit from some degree of inattention, presumably because a lack of focus allows for the activation of more remote associations in semantic memory (Zedelius & Schooler, 2015). Thus, hyperactivity–impulsivity symptoms, including disinhibition, seem to impair RAT performance, whereas inattention symptoms do not and may actually facilitate performance. Supporting findings by Abraham and colleagues (2006), who showed that adolescents with ADHD generated ideas that were less practical than a control group, we found that both hyperactive–impulsive and inattention symptoms were associated with reduced usefulness of problem construction. This suggests that ADHD symptoms in general result in problems with goal-directed planning of behavior (Sagvolden et al., 2005; Tucha et al., 2011).

Overall, our results show that the high energy, impulsivity, behavioral activation, and novelty seeking that characterize the hyperactivity–impulsivity symptom dimension of ADHD are indeed beneficial to flexible (but not persistent) processes in creativity, supporting previous findings regarding the role of these traits and processes in creativity (Baas et al., 2016, 2013; De Dreu et al., 2008; Feist, 1998). However, the distractibility that is characteristic of the inattention dimension of ADHD does not seem to benefit flexibility in idea generation. This is in line with studies showing that divergent thinking requires not only flexible, but also sustained attention and cognitive control which is impaired by distraction (Benedek et al., 2012; Zabelina et al., 2015, 2016b). Although our meta-analytic results showed that inattention symptoms were associated with enhanced divergent thinking on one of the creative ideation tasks, these results do not control for the strong comorbidity between inattention and hyperactivity–impulsivity symptoms. Regression analyses in which levels of both symptom dimensions were entered as predictors consistently showed that inattention symptoms did not predict any of the (flexible) creativity indicators, whereas hyperactivity-impulsivity symptoms predicted enhanced self-reported creative behavior and achievements, as well as divergent thinking performance and the originality of problem construction. Thus, our findings do not seem to support studies showing that mind wandering and the processing of task-irrelevant information facilitates divergent thinking (Baird et al., 2012; Carson et al., 2003; Dijksterhuis & Meurs, 2006). However, it is important to note that we did not directly assess attentional processes or other aspects of executive control in the present studies, but merely inferred the quality of these processes from self-reported ADHD symptoms. Future studies should directly assess the role that these cognitive processes play in enhanced or impaired creativity in ADHD.

Contrary to our expectations, we did not find any curvilinear relationships between ADHD symptoms and measures of creativity. Although we looked at subclinical symptoms in a sample of university students without clinical ADHD, the range of ADHD symptoms in our sample seemed to be sufficient to cover the extreme symptoms that would be associated with the strongest decline in cognitive performance, as a substantial number of participants in our studies reported a degree of symptoms that would qualify for a clinical diagnosis (Kooij et al., 2005). Possibly, the students in our sample had additional cognitive resources at their disposal to compensate for the impairments that usually accompany strong ADHD symptoms. This would be much in line with findings by Carson and colleagues (2003) who showed that reduced latent inhibition, a decreased ability to ignore irrelevant information in the environment, was associated with enhanced divergent thinking and creative achievements, especially in people with a high IQ. It would be interesting to assess the interaction between ADHD symptoms and intelligence in predicting creativity in both subclinical and clinical samples in future studies.

Although adults with ADHD often experience one of the symptom dimensions but not the other (Simon et al., 2009), prior studies on creativity in clinical ADHD did not take the different subtypes of ADHD into account (Abraham et al., 2006; White & Shah, 2011, 2016). Our findings imply that it is important to differentiate between different subtypes of ADHD and also between flexible and persistent creative processes. Although evidence indicates that inattention symptoms underlie most of the cognitive deficits in ADHD (Chhabildas et al., 2001), our results suggest that especially people with the combined and predominantly hyperactive–impulsive subtypes of ADHD will show enhanced flexibility and, to some extent, reduced persistence when cognitive tasks require creativity. Directing people with such symptoms to jobs or tasks that require creativity could help them benefit from the positive aspects of ADHD, thereby increasing motivation and job satisfaction (Verheul et al., 2015). However, it is unclear to what extent we can generalize the findings in subclinical samples to clinical groups. Previous studies suggested that the occupational and academic problems that people with clinical ADHD experience could lead to reduced self-esteem, anxiety, pessimism, and social inhibition (Biederman et al., 2006, 2008; Faraone, Kunwar, Adamson, & Biederman, 2009) – factors which may actually impair creative performance (Baas et al., 2008, 2016, 2013). Although subclinical symptoms have also been associated with such negative outcomes, these effects seem to be milder than for full-blown ADHD

(Faraone et al., 2009). Therefore, findings in subclinical samples may overestimate creative performance in clinical ADHD.

When interpreting the present findings, it is important to note that the ADHD scores obtained in our studies may overestimate the degree of actual ADHD symptoms that our participants experienced. In our study, 17% of participants reported a degree of ADHD symptoms that would qualify for a diagnosis of the disorder – a much larger percentage than the estimated 2.5% of people in the general population that are diagnosed with the disorder (Simon et al., 2009). It is important to note that these 'diagnoses' were only based on the degree of self-reported ADHD symptoms, whereas clinical diagnoses are usually based on a more elaborate assessment of symptoms by a clinical psychologist or psychiatrist. Moreover, the criteria for ADHD diagnosis in adults include additional requirements that we did not consider here, such as the presence of inattention and hyperactivity-impulsivity symptoms before the age of 12 (American Psychiatric Association, 2013). Thus, the large percentage of potential diagnoses in our study may not reflect the actual prevalence of ADHD as a disorder, but, to some degree, common feelings of boredom and restlessness in our student sample.

Similarly, the use of self-report scales to assess creativity in our study may overestimate creative abilities and behavior in our sample. The creative behavior scale (Janssen, 2001) and the Creative Achievement Questionnaire (Carson et al., 2005) may reflect people's beliefs about their own creativity rather than actual creative activities and accomplishments. Arguably, such self-enhancement may be less likely for the Creative Achievement Questionnaire, in which participants are asked to report publically recognized and concrete creative achievements, than for other self-report scales where ratings are based solely on participants' subjective judgment. Creative achievement scores are often strongly skewed, with many scores at the lower end of the scale, indicating that participants have no problem reporting a lack of outstanding creative achievements (Silvia et al., 2012). In the present series of studies we observed similarly skewed scores, which suggests that overestimation is probably not a large issue here. Moreover, participants' scores on both self-report scales were reliably correlated with their performance on measures of flexible creativity in our studies. Nonetheless, we acknowledge that it is difficult to definitively rule out the possibility of overestimation in self-reported creativity. Future studies could consider including a social desirability scale and controlling for this in the analyses.

Conclusion

In sum, the present research provides converging evidence for a relationship between symptoms of ADHD and enhanced (flexible) creativity. These relationships seem to be driven mainly by symptoms of hyperactivity–impulsivity, such as high energy, impulsivity, reward sensitivity, and novelty seeking. Although, at present, it is unclear how these findings extend to clinical groups, our findings show that a certain degree of ADHD symptoms does not necessarily lead to problems in all cognitive domains, but can have specific benefits when problems ask for novel solutions.

Footnote

[1] Analyzing the data for the three studies separately did not notably change the results of these analyses, nor did a different analytic strategy to test for possible curvilinear relationships in which we broke down our sample into ten different groups based on participants' total ADHD scores and compared creativity across these groups using one-way ANOVAs.