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ORIGINAL ARTICLE

Individual differences in tendencies to attention-deficit/hyperactivity disorder and emotionality: empirical evidence in young healthy adults from Germany and China

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Abstract

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder that is characterized by inattention, hyperactivity, and impulsivity but also by negative emotionality. The aim of the present study was to investigate whether subclinical ADHD tendencies are associated with negative emotionality in healthy adult samples. The present study is of special interest since it investigated negative emotionality with a questionnaire anchored in Neuroscience Theory—the Affective Neuroscience Personality Scales (ANPS). Furthermore, through the investigation of samples in two countries, namely Germany and China, the study aims to replicate the results across different cultures. German ($n = 377$; age: $M = 23.25$, $SD = 8.47$; 117 males) and Chinese ($n = 389$; age: $M = 20.74$, $SD = 2.47$; 279 males) subjects completed ANPS (primary emotional traits) and ASRS (ADHD tendencies) questionnaires in an online survey. Principal component analysis of the ANPS revealed one factor for negative emotionality and one factor for positive emotionality. Partial correlations between ANPS and ASRS (controlled for age) were conducted separately for nation and gender. The same correlation patterns between ADHD tendencies and negative emotionality could be found in male and female German/Chinese participants (range $r = .189$ to $r = .352$). Higher negative emotionality was always significantly associated with more inattentive, hyperactive/impulsive, or combined tendencies. However, significant negative correlations between ADHD tendencies and positive emotionality could only be observed in Chinese males (range $r = -.264$ to $r = -.296$). The results are in line with former findings in children and show that also in healthy adults, associations between negative emotionality and ADHD tendencies are robustly visible. The results were independent of the cultural background, indicating a general association between ADHD tendencies and negative emotionality, even in healthy adults.

Keywords ADHD · Emotionality · Primary emotional traits · Replication · Germany · China

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder with an onset during childhood that persists into adulthood in many cases (American Psychiatry Association (APA); APA 2013). The disorder is

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characterized by three main symptoms: inattention, hyperactivity, and impulsivity (APA 2013). Due to the fact that not all main symptoms need to occur together the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5; APA 2013), distinguishes three subtypes of ADHD based on the predominant symptoms, namely the inattentive subtype, the hyperactive/impulsive subtype, and the combined subtype, which includes inattentive as well as hyperactive/impulsive symptoms (APA 2013). Based on DSM-5, for the diagnosis of ADHD onset of symptoms must occur before the age of 12 years (APA 2013).

The point prevalence of childhood ADHD is estimated between 5 and 7.2% worldwide (APA 2013; Polanczyk et al. 2007; Thomas et al. 2015), with only slight divergences between different countries. Thus, a specific point prevalence of 5.91% is reported in Chinese children (boys: 8.75%, girls: 3.0%; Huang et al. 2017) and a lifetime prevalence of 4.8% in German children (boys: 7.7%, girls: 1.8%; Huss et al. 2008). ADHD has more often been reported in males than in females, whereby estimates for sex ratio vary between 2:1 and 4.3:1 (APA 2013; Huang et al. 2017; Huss et al. 2008).

Over the years, a growing number of research studies have been conducted on adult ADHD which have shown that ADHD is a lifespan disorder that persists into adulthood although with some slight changes in its symptomatic manifestation over time (e.g. Caye et al. 2016). In up to 60–70% of all individuals with ADHD, inattentive and/or hyperactive and impulsive symptoms persist into adulthood (e.g. Biederman et al. 2000, 2006; Faraone et al. 2006) even though the symptoms decline to some extent until the age of 20 years (e.g. Biederman et al. 2000; Buitelaar et al. 2011). Although inattentive symptoms decline with increasing age, they tend to dominate the clinical picture in affected adults (Buitelaar et al. 2011). Estimates of the point prevalence of ADHD in adulthood range from 2.5 to 4.4%, whereas prevalence rates vary between countries (APA 2013; Buitelaar et al. 2011; de Zwaan et al. 2012; Fayyad et al. 2017; Kessler et al. 2006; Polanczyk and Rohde 2007).

The main symptoms of ADHD are accompanied by executive dysfunctions, problems with motivation and emotion regulation as well as negative emotionality (APA 2013; Bonvicini et al. 2016; Buitelaar et al. 2011; Graziano and Garcia 2016). Mood instability due to emotional dysregulation is reflected in behavioural, cognitive and neuroanatomical measures of ADHD (Skirrow et al. 2009). Executive functions impact on emotion regulation strategies (Green et al. 2007). This could be one reason why people with ADHD often suffer from problems with the top-down regulation of emotions, which is often considered as an executive function (Buitelaar et al. 2011). Issues with emotional dysregulation—especially of negative emotions (Bunford et al. 2015)—are of special interest as these problems are prevalent in ADHD across lifetime (Shaw et al. 2014). For example, boys with an ADHD diagnosis in childhood showed more negative emotions in terms of sadness, anger, and guilt compared to boys without ADHD, whereas no difference in positive emotionality could be observed between both groups (Braaten and Rosén 2000). Extending such associations to the females, individuals who were diagnosed with ADHD during adulthood were reported to be more anxious and stressed, showing more depressive symptoms, and having a more external locus of control (Rucklidge and Kaplan 1997). In addition, even in adulthood persons afflicted with an ADHD still had higher levels of state and trait anger and expressed significantly more anger compared to adults without an ADHD (Ramirez et al. 1997). Furthermore, a recent meta-analysis by Graziano and Garcia (2016) showed that children and adolescents diagnosed with ADHD have more intense negative as well as positive emotions and are more sensitive to stressful and frustrating situations compared to healthy individuals. This meta-analysis further showed that cognitive functioning, broadly defined as executive functioning by the authors, moderates the connection between ADHD and emotional reactivity and negativity (Graziano and Garcia 2016). These meta-analytic results indicate that executive functions play an important role in emotional dysregulation in ADHD.

Moreover, ADHD often has psychopathological comorbidities related to emotional problems such as oppositional defiant disorder (ODD; characterized by anger, irritability, deviance), bipolar disorder (BPD, among others: irritability, hyperactivity, distractibility), and depression (APA 2013; Bunford et al. 2015; Fayyad et al. 2017; Geller et al. 2002). Thus, 30–62% of individuals diagnosed with ADHD also have ODD (Biederman et al. 1991; Fayyad et al. 2017; Wilens et al. 2002), 15–47% also have BPD (Fayyad et al. 2017; Wilens et al. 2002; Wingo and Ghaemi 2007), and 42–47% have a comorbid depression (Wilens et al. 2002). The high percentages of comorbidities with disorders that are characterized by emotional problems further indicate the relationship between ADHD and emotional dysfunction. In addition to having difficulties in handling anger, frustration, or further negative emotions, some people with ADHD also have problems in managing positive emotions such as enthusiasm, excitement, or exuberance (Bunford et al. 2015).

As ADHD represents a neurodevelopmental disorder (APA 2013), it would be of interest to further investigate the connection between individual differences in ADHD tendencies and emotionality with a self-report questionnaire anchored in Affective Neuroscience Theory (ANT; Montag and Panksepp 2017), the *Affective Neuroscience Personality Scales* (ANPS; Davis and Panksepp 2011; Davis et al. 2003). Panksepp (1998) established the ANT based on comprehensive animal research, employing pharmacological challenge as well as deep brain stimulation approaches. According to

the ANT, mammals have seven specific and highly conserved subcortical emotional systems, also called "primary emotions" that influence their behaviour in a bottom-up way. Four out of these seven emotional systems represent positive primary emotions, namely SEEKING, PLAY, CARE, and LUST, whereas three emotional systems represent negative primary emotions, namely RAGE, FEAR, and PANIC/GRIEF. All primary emotions are written in capital letters so as not to confound them with similar terms in the literature (Davis and Panksepp 2011; Davis et al. 2003; Panksepp 1998). The ANPS questionnaire was developed on the background of Panksepp's ANT and assesses six primary emotional traits that are based on the primary emotions, whereby the primary emotion of LUST was not included in the questionnaire. LUST is not assessed with the ANPS as the authors were concerned that participants would not answer questions regarding their sexual behaviour truthfully and social desirable answers to these questions may influence the psychometric quality of the entire questionnaire (Davis et al. 2003). For the ANPS, Davis and Panksepp (2011) decided to use the word ANGER instead of RAGE, and SADNESS instead of PANIC/GRIEF since these labels appear more appropriate for the human context. For more details on the scales' content, see the method section of the present paper or the original publication of the questionnaire (Davis et al. 2003).

Research question and hypotheses

Until now, most research on the connection between ADHD and emotionality has been conducted in children and adolescents (e.g. Braaten and Rosén 2000; Bunford et al. 2015; Graziano and Garcia 2016). Since ADHD symptoms are often still present in adulthood, it is of particular interest whether a connection between ADHD and negative emotionality is still present in (young) adults. For this reason, we decided to investigate adults instead of children or adolescents and hypothesized that negative emotionality would be positively correlated with ADHD tendencies in healthy adults. Evidence suggests that ADHD, along with many other disorders, should no longer be seen as a categorical but more as a dimensional construct (Coghill and Sonuga-Barke 2012; Marcus and Barry 2011). Every person has inattentive or hyperactive and impulsive tendencies to some extent. In patients with ADHD, these tendencies are so strong that they lead to significant impairments in everyday functioning. To better understand the underlying mechanisms of ADHD—and given the dimensional approach to understand individual differences in ADHD—it is not only of relevance to investigate patients with severe forms of symptoms but also to conduct research relying on healthy individuals with only slight impairments. To follow the latter approach, we conducted an online questionnaire-based study investigating whether there is a connection between ADHD tendencies and negative emotionality in healthy adults. Moreover, we aimed to find the same associations between individual differences in ADHD tendencies and primary emotional traits in two different countries, namely Germany and China. If similar associations could be demonstrated in these two independent and culturally diverse samples, this would help to support the assumption of generalizability of our findings. We intentionally have not offered a hypothesis for the connection between ADHD tendencies and positive emotionality while individuals with ADHD can also have problems in regulating positive emotions (Bunford et al. 2015), this association is less established.

In summary, the following two hypotheses were investigated in the present paper:

Hypothesis 1 ADHD tendencies and negative emotionality are positively correlated in healthy adults.

Hypothesis 2 Same pattern of associations of the positive correlations between ADHD tendencies and negative emotionality in healthy adults are expected for both samples with different cultural backgrounds.

Methods

Participants

In total, $N = 828$ subjects from Germany and China participated in this online study, whereas recruitment was performed via several projects on both sides, which are described in more detail further below. Participants with self-reported current or past neurological or psychological disorders were excluded from the data analyses (Germany: $n = 36$, China: $n = 12$). We also had to exclude some participants due to incomplete data sets (Germany: $n = 4$, China: $n = 5$) or inconsistencies within the data (Germany: $n = 0$, China: $n = 5$). In total, $n = 40$ Germans and $n = 22$ Chinese were excluded from the data set. Thus, the final data set used for analysis was from 766 participants: 377 German participants (117 males, 260 females; $M_{age} = 23.25$, $SD_{age} = 8.47$; 85.4% students) were recruited via the Ulm Gene Brain Behavior Project (UGBBP). Furthermore, 389 Chinese participants (279 males, 110 females; $M_{age} = 20.74$, $SD_{age} = 2.47$; 95.6% students) were recruited. Of the Chinese participants, 123 (69 males, 54 females, $M_{age} = 19.15$, $SD_{age} = 1.04$) were recruited at Beijing University of Civil Engineering and Architecture in Beijing, China, and 266 (210 males, 56 females, $M_{age} = 21.48$, $SD_{age} = 2.59$) were recruited via the Chengdu Gene Brain Behavior Project (CGBBP) at the University of Electronic Science and Technology of China (UESTC) in Chengdu, China. Given that

we did not expect systematic differences concerning the variables of ADHD and primary emotional traits across the different Chinese universities (all students), the samples from China were pooled for further analyses. The Chinese and German samples differed in their mean age (Welch's $t(437.580) = 5.535$, $p < .001$, Germany > China), but both samples still can be characterized as young adults. The different gender ratio ($Chi^2(1) = 126.93$, $p < .001$) in the country samples may be due to the fact that most of the German participants were psychology students, whom are oftentimes women, whereas the majority of Chinese participants were recruited at a technical university, where usually most of the students are men.

Procedure

All participants volunteered to complete an online survey programmed on the SurveyCoder tool (more information on ckannen.com, accessed on 01.03.18). Informed consent was obtained from all individual participants included in the study. For this, each of the participants received online information about the study and signed a digital informed consent by clicking on a button "I agree to participate" before they started to fill in the questionnaires. For entering, the UGBBP participants received 30 Euros. Chinese participants received either 25 RMB or 80 RMB for filling in the online questionnaires, dependent on the length of the respective project. The research protocols were approved by the local ethics committees at Ulm University, Ulm, Germany and at UESTC, Chengdu, China. Procedures were in accordance with the latest revision of the Declaration of Helsinki.

Questionnaires

For this study, both the ANPS and ASRS questionnaires were used. German versions of both questionnaires were already available (Reuter et al. 2006, 2017). The ANPS was also available in Chinese (Sindermann et al. 2018). The ASRS was translated from German into Chinese and afterwards independently back-translated into German again by two independent Chinese native speakers. The original German version of the questionnaire was compared with the retranslation to make sure that the meaning of the items did not change. A thorough translation process was followed, but the translation is pending approval as the official WHO translation of the 18-Q ASRS instrument. The Chinese version of the ASRS is presented in "Appendix" section.

Affective Neuroscience Personality Scales (ANPS) The ANPS is a self-report questionnaire and was developed to measure six primary emotional traits based on subcortical brain emotion systems (Davis and Panksepp 2011). The scales representing these primary emotional traits are called PLAY, SEEKING, CARE (positive emotional traits), and FEAR, ANGER, SADNESS (negative emotional traits). High scores on the SEEKING scale describe persons who are striving for new positive experiences, who are curious, eager to solve problems, and love exploring. Individuals with high scores on the PLAY dimension are defined as enjoying social games with physical contact, laughter, humour, and having fun. The CARE dimension of the ANPS assesses tendencies towards nurturing, caring for others, enjoying to interact with young children or pets, and feeling benevolent towards people and animals in need. The ANGER scale includes questions about being easily provoked, irritated, and frustrated as well as expressing anger verbally or physically. FEAR refers to experiencing anxiety and worry, and individuals scoring high on this scale have tendencies towards rumination, tense feelings, sleeplessness, and difficulties in making decisions. The SADNESS scale combines tendencies to have strong feelings when confronted with social separation distress, tendencies to cry often and feelings of loneliness. Furthermore, high SADNESS—as a trait—is associated with often thinking of loved ones and past relationships. Additionally, a Spirituality scale was included describing feelings of connectedness with all of life and oneness with creation (Davis and Panksepp 2011; Davis et al. 2003). Of note, this latter scale is not related to specific subcortical circuits.

Each scale for the six primary emotional traits consists of 14 items. In addition to the named six primary emotional traits, the ANPS also includes a scale for Spirituality (12 items) and 14 filler items (Davis et al. 2003). We do not discuss the Spirituality scale and the filler items any further, because they are not of interest for this current study. Two slightly different versions of the ANPS have been used in Germany and China. A German translation of the 110-item ANPS (Reuter et al. 2017) from Davis et al. (2003) was used in Germany, and a Chinese translation of the 112-item ANPS (Sindermann et al. 2018) from Davis and Panksepp (2011) was used in China. With the revision of the 110-item ANPS, some items were edited and two more filler items were added to the questionnaire; wherefore, the 112-item ANPS consists of 112 items. Please note, both ANPS versions are comparable to a large extent, because only 21 items from the relevant six scales were changed. In both versions of the ANPS, the items have to be answered using a four-point Likert scale ranging from "1 = strongly disagree" to "4 = strongly agree". For all scales of the ANPS, the sum score was calculated. Internal consistencies for all scales were satisfactory for both countries and were from $\alpha = .671$ for SEEKING to $\alpha = .851$ for ANGER in Germany and from $\alpha = .693$ for SEEKING to $\alpha = .791$ for FEAR in China (details can be found in the supplement). All Cronbach's alpha values are consistent with those reported by the original authors (cf. Davis and Panksepp 2011; Davis et al. 2003).

Table 1 Distribution of participants across groups of likelihood for ADHD based on ASRS scores, separately for Germany and China

	Group	Germany			China		
		Total	Males	Females	Total	Males	Females
ASRS inattentive	1	272 (72.1%)	75 (64.1%)	197 (75.8%)	222 (57.1%)	156 (55.9%)	66 (60.0%)
	2	99 (26.3%)	39 (33.3%)	60 (23.1%)	148 (38.0%)	107 (38.4%)	41 (37.3%)
	3	6 (1.6%)	3 (2.6%)	3 (1.2%)	19 (4.9%)	16 (5.7%)	3 (2.7%)
ASRS hyperactive/impulsive	1	324 (85.9%)	103 (88.0%)	221 (85.0%)	296 (76.1%)	208 (74.6%)	88 (80.0%)
	2	50 (13.3%)	12 (10.3%)	38 (14.6%)	82 (21.1%)	62 (22.2%)	20 (18.2%)
	3	3 (0.8%)	2 (1.7%)	1 (0.4%)	11 (2.8%)	9 (3.2%)	2 (1.8%)
ASRS overall	1	321 (85.1%)	99 (84.6%)	222 (85.4%)	281 (72.2%)	198 (71.0%)	83 (75.5%)
	2	56 (14.9%)	18 (15.4%)	38 (14.6%)	96 (24.7%)	71 (25.4%)	25 (22.7%)
	3	0 (0.0%)	0 (0.0%)	0 (0.0%)	12 (3.1%)	10 (3.6%)	2 (1.8%)

Total number of participants followed by percentages in brackets. ASRS inattentive: group 1: sum scores 0–16, unlikely that attentional deficits exist; group 2: sum scores 17–23, likely that attentional deficits exist; group 3: sum scores > 23, highly likely that attentional deficits exist. ASRS hyperactive/impulsive: group 1: sum scores 0–16, unlikely that hyperactive/impulsive deficits exist; group 2: sum scores 17–23, likely that hyperactive/impulsive deficits exist; group 3: sum scores > 23, highly likely that hyperactive/impulsive deficits exist. ASRS overall: group 1: sum scores 0–33, unlikely that attentional and hyperactive/impulsive deficits exist; group 2: sum scores 34–47, likely that attentional and hyperactive/impulsive deficits exist; group 3: sum scores > 47, highly likely that attentional and hyperactive/impulsive deficits exist. Discrepancies in total are due to rounding

Adult ADHD Self-Report Scale Symptom Checklist (ASRS) The ASRS was constructed on behalf of the World Health Organization (WHO) and is a self-report questionnaire to measure ADHD symptoms with eighteen items. The ASRS questionnaire comprises all eighteen DSM-IV-TR criteria for ADHD and includes 9 specific items for inattentive and 9 specific items for hyperactive/impulsive symptoms. All items can be rated on a five-point Likert scale ranging from "0 = never" to "4 = very often". Since we investigated healthy student samples in the present work, our aim was not to diagnose ADHD in our participants, but rather measure individual differences in ADHD tendencies. For that reason, we decided to use the dimensional approach to analyse the data even if it is less powerful than a dichotomous approach in terms of specificity and total classification accuracy in the context of diagnostic assessment of ADHD (Kessler et al. 2005). However, dichotomization always comes at the cost of loss of information, and thus, we preferred a dimensional analysis strategy. We calculated sum scores separately for the inattentive and hyperactive/impulsive items (hereinafter, sum scores are called "inattentive scale" and "hyperactive/impulsive scale") as well as one sum score over all 18 items (hereinafter, sum score is called "overall scale"). The sum score for the inattentive and hyperactive/impulsive scale can range between 0 and 36, whereas the sum score for the overall scale can range from 0 to 72. A sum score over all 18 items was calculated to measure ADHD tendencies for the combined ADHD subtype. In 2003, the WHO indicated cut-off values for the inattentive and the hyperactive/impulsive scales to use the ASRS for a dimensional screening approach for ADHD. According to these cut-off values, individuals can be assigned to three "groups of likelihood" that express to what extent inattentive or hyperactive/impulsive ADHD tendencies are present within a person. The assignment to the groups of likelihood based on the cut-off values for the inattentive and hyperactive/impulsive scales are as follows: 0–16: unlikely that attention, respectively, hyperactive/impulsive deficits exist; 17–23 likely that attention, respectively, hyperactive/impulsive deficits exist; > 23 highly likely that attention, respectively, hyperactive/impulsive deficits exist (see http://www.mentalhealthprofessionalsinc.com/Forms/Adult_ADHD_Self-Report_Scale_%28ASRS-v1.1%29.pdf; accessed on 22.03.18). To our knowledge, neither the WHO nor other scientific papers recommend cut-off values to assign individuals into three groups of likelihood based on their sum score on the ASRS overall scale. Different validation studies just tried to determine the best cut-off values for the ASRS overall scale to differentiate between patients with ADHD and healthy participants (e.g. Kessler et al. 2005; Takeda et al. 2017). However, to also take the combined ADHD subtype into account we doubled the cut-off values to assign the participants into three groups of likelihood, too (0–33: unlikely that attention and hyperactive/impulsive deficits exist; 34–47: likely that attention and hyperactive/impulsive deficits exist; > 47 highly likely that attention and hyperactive/impulsive deficits exist). We decided to double the cut-off values for the overall scale in case participants had very high scores on either the inattentive or the hyperactive/impulsive scale. By doubling the cut-off values, these participants are not assigned to the second or the third group of likelihood for the overall scale by mistake just because they scored very high on only one

of the inattentive or hyperactive/impulsive scales. Table 1 shows how many participants in the German and Chinese cohorts belong to each of the three groups of likelihood. We only present this information for reasons of completeness, but use a dimensional approach in the main analysis to investigate relationships between tendencies towards ADHD and individual differences in primary emotional traits. The internal consistencies for the three ASRS scales are a little lower in the German compared to the Chinese respondents, but all of them are satisfactory (Germany: inattentive $\alpha = .745$, hyperactive/impulsive $\alpha = .702$, overall $\alpha = .805$; China: inattentive $\alpha = .790$, hyperactive/impulsive $\alpha = .808$, overall $\alpha = .871$).

Control variables

As the mean age in both countries differed significantly (Welch's $t(437.580) = 5.535$, $p < .001$, Germany > China), and due to the lifetime decline in ADHD symptoms (Buitelaar et al. 2011), age was implemented as control variable in the present work. Furthermore, more males than females suffer from ADHD (APA 2013; Huang et al. 2017; Huss et al. 2008; Polanczyk et al. 2014) and females with ADHD are reported to show more inattentive symptoms than males, whereas males show more hyperactive and impulsive symptoms than females (Gershon 2002). We therefore also included subject gender as an additional control variable. Differences in recruiting locations for the Chinese cohort were not included as a control variable since students of the different universities have hometowns in many different parts of China and thus their study location does not reflect their original home region.

Statistical analyses

Descriptive statistics on demographic variables as well as on the ANPS and ASRS scales are provided in the results section. We conducted separate principal component analyses (PCA) with a varimax rotation for the German and the Chinese samples based on the six ANPS scales representing the primary emotional traits. We used a varimax rotation (orthogonal rotation) because it allows a simple factor interpretation as it maximizes the variation of loadings within one factor what, in turn, minimizes the number of variables with high loadings for each factor. Based on the literature, we assumed two factors in advance, one factor for positive and one for negative emotionality (Davis et al. 2003; Davis and Panksepp 2011; Reuter et al. 2017). In accordance with the literature, two factors with eigenvalues > 1.0 were found for the German (eigenvalue 1 = 2.042, explained variance: 34.04%; eigenvalue 2 = 1.454, explained variance: 24.24%) and the Chinese sample (eigenvalue 1 = 2.241, explained variance: 37.35%; eigenvalue 2 = 1.718, explained variance: 28.63%): one factor for negative emotionality (FEAR, ANGER, SADNESS) and one factor for positive emotionality (PLAY, SEEKING, CARE). Detailed results regarding intercorrelations of the ANPS scales in Germany and China as well as varimax rotated factor loadings are presented in the supplement.

Shapiro–Wilk (SW) tests were conducted for all variables under investigation, separately for Germany and China to check whether the normal distribution of the investigated variables was given. According to the SW tests, only within the German sample normal distribution was present for a few variables (see supplement for detailed results). However, the SW test reaches significance easily with large sample sizes. Due to the large sample sizes, we therefore decided to conduct further statistical analyses using parametric tests based on the central limit theorem that with a larger sample size the distribution is approximately normally distributed (Bortz 2005). We also checked the histograms of all variables under investigation. The courses of all variables except age showed that the assumption of a normal distribution of the variables was reasonable. We also checked whether the results of parametric tests and nonparametric tests differ. This was not the case. For that reason, we only report results based on parametric tests.

All variables of interest were checked for associations with age by means of Pearson's product–moment correlations. Moreover, putative effects of nationality and gender on the ANPS/ASRS were tested via a two-way MANCOVA (nation and gender as independent variables, age as covariate). We always tested two-tailed for all control variables.

Given the influence of age on the variables under investigation (please see the supplement for detailed results), we used partial correlations (controlled for age) to test our hypotheses. Note that we tested one-tailed for the associations between ASRS and ANPS' negative emotionality but two-tailed for putative associations between ASRS and ANPS' positive emotionality because for the latter we had no a priori hypothesis. Furthermore, we used bootstrapping to conduct bootstrap bias-corrected and accelerated (BCa) 95% confidence intervals (1000 samples) for every correlation coefficient to confirm their significance. The bootstrap is a statistical method that uses resampling with replacement to estimate the distribution of a variable in the whole population based on the present sample (Haukoos and Lewis 2005). Next, Fisher z-tests were performed to assess whether two correlations differed significantly between groups. For this, groups were compared as follows: German males versus German females, Chinese males versus Chinese females, German males versus Chinese males, German females versus Chinese females. As ADHD is reported to occur in almost all cultures and no differences in ADHD symptoms

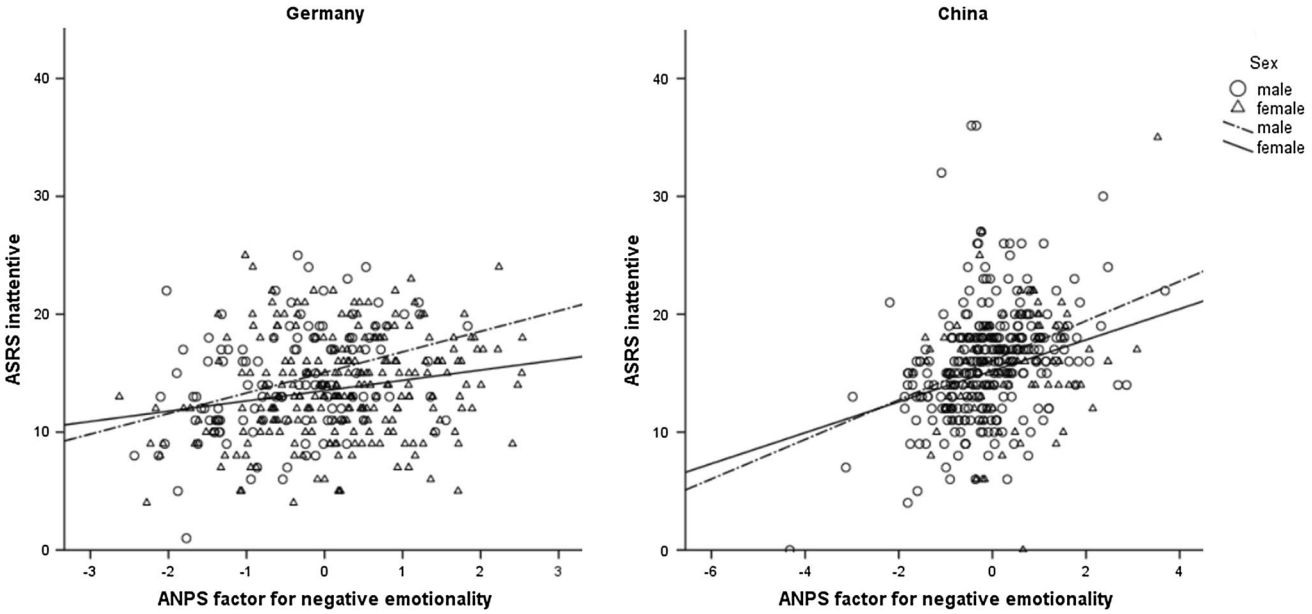

Fig. 1 Scatterplots of the main result, the positive correlation of ADHD tendencies and negative emotionality, shown as an example on the correlation of the ANPS factor for negative emotionality and the ASRS inattentive scale in Germany and China, separately for males and females. Note that both scatterplots just show the actual values of the variables ANPS factor for negative emotionality and ASRS inattentive without a correction for age

have been reported between them (Polanczyk et al. 2014), we did not expect any group differences in the correlations between emotionality and ADHD tendencies and accordingly conducted all Fisher *z*-tests two-tailed.

As general alpha level .05 was accepted, whereby if necessary this alpha level was adjusted by Bonferroni correction for multiple testing. All statistical analyses were conducted using SPSS 24.

Results

Since we investigate the association of ADHD tendencies and emotionality in two independent and culturally different country samples, all results are presented separately for Germany and China.

Descriptive statistics

Descriptive statistics for all variables under investigation, including mean and standard deviation, are presented separately for Germany and China in Table 2.

Influence of age and gender on ADHD tendencies and emotionality in Germany and China

Both age and gender control variables influenced the variables under investigation significantly (for detailed results see the supplement). We therefore controlled for age in further analyses through the use of partial correlations. Due to gender differences on three ANPS scales and on the ANPS factor for negative emotionality, we conducted all further analyses separately for males and females. Gender differences regarding ADHD tendencies did not exist, neither in Germany nor in China.

ADHD tendencies and emotionality in Germany and China

In line with our first hypothesis, the results showed that negative emotionality is significantly positive correlated with all ASRS scales for males and females in Germany as well as in China. After a Bonferroni correction for multiple testing (three ASRS scales, two ANPS emotionality factors, two nations, and two genders to α of .0021 (.05/24)), most correlations still remain significant except for the correlation between the ANPS factor for negative emotionality and the ASRS hyperactive/impulsive scale ($r = .189$, $p = .021$; corrected for age; one-sided significance testing) in German males. Exemplary for the main findings, Fig. 1 depicts the positive correlation between the ANPS factor for negative emotionality and the ASRS inattentive scale separately for Germany and China.

Significant correlations between positive emotionality and ADHD tendencies could only be found in Chinese males. The correlations remained significant after the

Table 2 Means and standard deviations for the variables under investigation, separately for Germany and China

	Germany			China		
	Total ($n=377$)	Males ($n=117$)	Females ($n=260$)	Total ($n=389$)	Males ($n=279$)	Females ($n=110$)
Age	23.25	24.77	22.57	20.74	21.06	19.95
	(8.47)	(10.53)	(7.28)	(2.47)	(2.59)	(1.92)
SEEKING	39.71	39.23	39.92	39.06	39.34	38.35
	(4.23)	(4.51)	(4.09)	(4.21)	(4.24)	(4.07)
FEAR	36.27	34.14	37.23	35.68	35.38	36.45
	(6.01)	(5.95)	(5.79)	(5.23)	(5.23)	(5.17)
CARE	41.97	39.14	43.25	39.04	39.07	38.97
	(5.70)	(4.90)	(5.57)	(4.96)	(5.13)	(4.52)
ANGER	36.08	35.29	36.44	35.61	35.37	36.21
	(6.53)	(6.45)	(6.55)	(5.47)	(5.57)	(5.18)
PLAY	42.56	42.69	42.50	39.16	39.35	38.69
	(5.14)	(5.22)	(5.12)	(4.71)	(4.82)	(4.39)
SADNESS	33.96	31.99	34.85	36.07	35.41	37.77
	(5.05)	(4.69)	(4.97)	(5.03)	(5.01)	(4.69)
ANPS factor for negative emotionality	.00	−.44	.20	.00	−.09	.24
	(1.00)	(.92)	(.97)	(1.00)	(1.00)	(.96)
ANPS factor for positive emotionality	.00	−.30	.14	.00	.04	−.10
	(1.00)	(.97)	(.99)	(1.00)	(1.02)	(.94)
ASRS inattentive	13.88	14.29	13.70	15.81	15.93	15.52
	(4.32)	(4.54)	(4.21)	(4.73)	(4.79)	(4.56)
ASRS hyperactive/impulsive	11.71	11.53	11.79	13.03	13.22	12.55
	(4.48)	(4.61)	(4.43)	(5.18)	(5.45)	(4.40)
ASRS overall	25.59	25.82	25.48	28.84	29.15	28.06
	(7.59)	(7.75)	(7.54)	(8.95)	(9.29)	(8.01)

Values in brackets are standard deviations. Tests on differences in all variables of interest between Germany and China are presented in the supplement

Bonferroni correction for multiple testing (we applied the same Bonferroni adjustment as described above).

The results from the correlation analyses are presented in detail in Table 3. Confidence intervals supported the significance of the findings as the intervals of significant coefficients did not include the 0, except for the correlation between the ANPS factor for negative emotionality and the ASRS hyperactive/impulsive scale in German males.

The correlations between the ANPS factor for negative emotionality and the ASRS hyperactive/impulsive scale in German females and males exhibited descriptively the largest difference and were therefore checked with the Fisher z-test. The correlations did not differ significantly from each other ($\sigma=.11$, $z=1.57$, $p=.117$). As the high difference in the sample size between German males and females was almost the same as between Chinese males and females (but the ratio was skewed in the opposite direction) and due to the very similar correlation patterns in all samples, we decided to investigate none of the other correlations on significant differences.

Specific connections between ADHD tendencies and negative and positive emotionality

In the German as well as in the Chinese samples, all correlations of FEAR and ANGER with the three ASRS scales were significantly positive (see Tables 4 and 5). For SADNESS all correlations with the ASRS scales were significantly positive in the German samples, except for the ASRS hyperactive/impulsive scale in German males. In the Chinese sample, SADNESS only showed a significantly positive correlation with the ASRS scales in males but not in females.

After Bonferroni correction for multiple testing (three ASRS scales, three ANPS scales, two nations, and two genders to α of .00139 (.05/36)), several correlations were no longer significant. Note, however, that results differ when considering those derived via bootstrapping as opposed to following Bonferroni correction. Bootstrapping and Bonferroni correction are two different statistical methods of significance testing, and all BCa confidence intervals were conducted on an alpha level of .05, whereas the alpha level

after Bonferroni correction was lower. Therefore, the Bonferroni correction is more stringent, and fewer correlations remained significant compared with the BCa confidence intervals. The greatest difference between bootstrapping and Bonferroni correction was that almost all correlations between ANGER and the ASRS scales were no longer significant after the Bonferroni correction, whereas all correlations, except between ANGER and the ASRS hyperactive/impulsive scale in German males, were statistically meaningful based on their BCa confidence intervals.

While the correlations between FEAR and the ASRS hyperactive/impulsive scale in German males and females showed descriptively the largest difference, the Fisher *z*-test was not significant ($\sigma = .11$, $z = 1.42$, $p = .155$). No other correlations were tested for significant differences.

Based on the significant negative correlations between the ANPS factor for positive emotionality and the ASRS scales in Chinese males, we conducted a further partial correlation analysis to assess which of the three ANPS scales of the factor for positive emotionality had the strongest influence. All

Table 3 Partial correlations with BCa 95% CIs between the two ANPS factors for emotionality and the ASRS scales, separately for Germany and China

			ASRS inattentive	ASRS hyperactive/impulsive	ASRS overall
German males (n = 117)					
ANPS factor for negative emotionality		*r*	**.347**	**.189**	**.314**
		p	**<.001**	**.021**	**<.001**
	BCa 95% CI	Lower	.182	−.018	.119
		Upper	.491	.389	.483
ANPS factor for positive emotionality		*r*	−.057	.014	−.024
		p	.546	.879	.795
	BCa 95% CI	Lower	−.238	−.222	−.244
		Upper	.107	.237	.181
German females (n = 260)					
ANPS factor for negative emotionality		*r*	**.196**	**.352**	**.316**
		p	**.001**	**<.001**	**<.001**
	BCa 95% CI	Lower	.065	.220	.192
		Upper	.327	.468	.434
ANPS factor for positive emotionality		*r*	−.121	−.085	−.117
		p	.052	.173	.059
	BCa 95% CI	Lower	−.223	−.206	−.226
		Upper	−.020	.034	−.010
Chinese males (n = 279)					
ANPS factor for negative emotionality		*r*	**.346**	**.224**	**.310**
		p	**<.001**	**<.001**	**<.001**
	BCa 95% CI	Lower	.226	.109	.193
		Upper	.479	.341	.444
ANPS factor for positive emotionality		*r*	**−.264**	**−.271**	**−.296**
		p	**<.001**	**<.001**	**<.001**
	BCa 95% CI	Lower	−.393	−.378	−.410
		Upper	−.129	−.138	−.164
Chinese females (n = 110)					
ANPS factor for negative emotionality		*r*	**.279**	**.277**	**.311**
		p	**.0017**	**.0018**	**<.001**
	BCa 95% CI	Lower	.076	.091	.115
		Upper	.474	.461	.506
ANPS factor for positive emotionality		*r*	−.049	−.105	−.085
		p	.615	.277	.377
	BCa 95% CI	Lower	−.298	−.301	−.294
		Upper	.227	.085	.146

Partial correlations (controlled for age). BCa 95% CI: bias-corrected and accelerated bootstrap confidence interval (1000 samples). Correlations printed in bold are significant on an alpha level of .05. Correlations for negative emotionality were one-tailed and for positive emotionality two-tailed tested. Four decimal places for *p* values are reported in cases in which otherwise verifying significance after Bonferroni correction was not possible

Table 4 Partial correlations with BCa 95% CIs between the ANPS scales for negative emotionality and the ASRS scales, for German males ($n = 117$) and females ($n = 260$)

			ASRS inattentive		ASRS hyperactive/impulsive		ASRS overall	
			Males	Females	Males	Females	Males	Females
FEAR		*r*	**.301**	**.193**	**.194**	**.342**	**.290**	**.309**
		p	**.0005**	**.0009**	**.0185**	**<.0001**	**.0008**	**<.0001**
	BCa 95% CI	Lower	.122	.082	.019	.232	.120	.203
		Upper	.446	.303	.348	.459	.441	.409
ANGER		*r*	**.205**	**.150**	**.183**	**.278**	**.228**	**.247**
		p	**.0137**	**.0079**	**.0245**	**<.0001**	**.0068**	**<.0001**
	BCa 95% CI	Lower	.011	.020	− .050	.143	.019	.117
		Upper	.372	.275	.387	.397	.418	.359
SADNESS		*r*	**.300**	**.172**	.123	**.304**	**.248**	**.275**
		p	**.0005**	**.0027**	.0943	**<.0001**	**.0037**	**<.0001**
	BCa 95% CI	Lower	.136	.052	− .108	.189	.052	.157
		Upper	.452	.287	.314	.414	.420	.383

Partial correlations (controlled for age). BCa 95% CI: bias-corrected and accelerated bootstrap confidence interval (1000 samples). Correlations printed in bold are significant on an alpha level of .05, one-tailed tested. Four decimal places for *p* values are reported as otherwise verifying significance after Bonferroni correction was not possible

three ANPS scales showed a significant negative correlation with all ASRS scales (see Table 6). After Bonferroni correction for multiple testing (three ANPS scales and three ASRS scales to α of .0056 (.05/9)), most correlations remained significant except that between CARE and the ASRS inattentive scale ($r = -.132$, $p = .027$; corrected for age; two-sided significance testing).

The correlations between PLAY and the ASRS inattentive scale and between CARE and the ASRS inattentive scale showed descriptively the largest differences. The Fisher *z*-test was significant ($\sigma = .09$, $z = 2.27$, $p = .023$; Cohen's $q = .193$), indicating that the correlation between PLAY and the ASRS inattentive scale was significantly higher compared with the correlation between CARE and the ASRS inattentive scale.

Table 5 Partial correlations with BCa 95% CIs between the ANPS scales for negative emotionality and the ASRS scales, for Chinese males ($n = 279$) and females ($n = 110$)

			ASRS inattentive		ASRS hyperactive/impulsive		ASRS overall	
			Males	Females	Males	Females	Males	Females
FEAR		*r*	**.382**	**.328**	**.221**	**.353**	**.327**	**.381**
		p	**<.0001**	**.0002**	**.0001**	**<.0001**	**<.0001**	**<.0001**
	BCa 95% CI	Lower	.253	.138	.088	.202	.190	.213
		Upper	.494	.508	.347	.508	.450	.546
ANGER		*r*	**.237**	**.244**	**.208**	**.233**	**.245**	**.267**
		p	**<.0001**	**.0053**	**.0002**	**.0073**	**<.0001**	**.0025**
	BCa 95% CI	Lower	.117	− .006	.082	.040	.123	.036
		Upper	.343	.442	.330	.400	.355	.461
SADNESS		*r*	**.265**	.153	**.179**	.129	**.242**	.158
		p	**<.0001**	.0565	**.0014**	.0909	**<.0001**	.0506
	BCa 95% CI	Lower	.145	− .077	.067	− .077	.131	− .069
		Upper	.372	.376	.286	.329	.352	.381

Partial correlations (controlled for age). BCa 95% CI: bias-corrected and accelerated bootstrap confidence interval (1000 samples). Correlations printed in bold are significant on an alpha level of .05, one-tailed tested. Four decimal places for *p* values are reported as otherwise verifying significance after Bonferroni correction was not possible

We next tested the correlations between PLAY and the ASRS overall scale and between CARE and the ASRS inattentive scale, as there was descriptively the second largest difference between two correlation coefficients. The Fisher z-test was also significant ($\sigma = .09$, $z = 2.24$, $p = .025$; Cohen's $q = .191$), indicating that the correlation between PLAY and the ASRS overall scale was significantly higher than between CARE and the ASRS inattentive scale. The Fisher z-test was not significant for the correlations between PLAY and the ASRS hyperactive/impulsive scale and between CARE and the ASRS inattentive scale ($\sigma = .09$, $z = 1.50$, $p = .133$) (third largest difference). Due to the very similar correlation patterns of the remaining correlations, no other patterns of correlations were tested.

Discussion

The present study aimed to investigate the connection between individual differences in ADHD tendencies, as assessed using online surveys with the ASRS, and individual differences in emotionality, as assessed with the ANPS, in healthy adults. It also investigated whether the same associations between ADHD tendencies and emotionality occurred in subjects from two countries with completely different cultural backgrounds, namely Germany and China.

In contrast to a work by Gershon (2002), we did not observe gender differences regarding inattentive tendencies or hyperactive/impulsive tendencies, neither in the German nor in Chinese sample. It is conceivable that gender differences regarding inattentive and hyperactive/impulsive symptom severity can only be observed in patients with ADHD but not in healthy individuals.

The main findings of the present study are the significant positive correlations between inattentive, hyperactive/impulsive and combined ADHD tendencies and negative emotionality. The results were in line with our first hypothesis and could be replicated in direction and pattern of associations between both nations as well as between genders (even across both nations) what also proved our second hypothesis. The results are in line with former ADHD research and indicate that even in healthy adults, independent of their cultural background, more inattention, hyperactivity and impulsivity is accompanied by more negative emotionality. Based on Cohen's general rules for interpretation of correlation coefficients (Cohen 1988), the observed effects can be considered as small to moderate. Additionally, the results support the view that ADHD can be seen as a dimensional construct since we found the same associations between negative emotionality and inattentive, hyperactive and impulsive tendencies in healthy adults as previously reported in younger individuals with ADHD (e.g. Braaten and Rosén 2000; Graziano and Garcia 2016). Furthermore and in line with our second hypothesis, our results demonstrate that this association occurs across cultures and genders since we found similar correlation patterns in Germany and China as well as in males and females. Please note that we found the same results in both nations even though the two used versions of the ANPS questionnaire differ to some extent.

For a more detailed understanding of the underlying causes of the found results, we also considered the single ANPS scales with the ASRS scales. The negative primary emotional traits FEAR and ANGER correlated significantly positively (small to moderate) with the three ASRS scales in German and Chinese males and females, although by contrast, the findings for SADNESS were not as clear. For

Table 6 Partial correlations with BCa 95% CIs between the ANPS scales for positive emotionality and the ASRS scales, only for Chinese males ($n = 279$)

			ASRS inattentive	ASRS hyperactive/impulsive	ASRS overall
SEEKING		r	**−.204**	**−.195**	**−.220**
		p	**.001**	**.001**	**<.001**
	BCa 95% CI	Lower	−.315	−.303	−.324
		Upper	−.075	−.079	−.099
CARE		r	**−.132**	**−.213**	**−.194**
		p	**.027**	**<.001**	**.001**
	BCa 95% CI	Lower	−.261	−.317	−.304
		Upper	.004	−.094	−.069
PLAY		r	**−.315**	**−.255**	**−.313**
		p	**<.001**	**<.001**	**<.001**
	BCa 95% CI	Lower	−.427	−.368	−.419
		Upper	−.188	−.137	−.197

Partial correlations (controlled for age). BCa 95% CI: bias-corrected and accelerated bootstrap confidence interval (1000 samples). Correlations printed in bold are significant on an alpha level of .05, two-tailed tested

Chinese females, none of the three ASRS scales correlated significantly with SADNESS although there was a trend in this direction (range *p* values: .0506 to .0909). The lack of significant associations in Chinese females might be related to the smaller sample size of Chinese females which could only be recruited in much lower numbers in our present work.

According to Panksepp's ANT, subcortical brain regions including central and lateral amygdala, medial hypothalamus, and dorsal periaqueductal gray (PAG) represent the brain anatomy underlying the primary emotion of FEAR. On a molecular level, ANT among others proposes that the neuropeptide oxytocin has an inhibitory effect on the activation of this FEAR circuit (Montag and Panksepp 2016). In line with this, several previous studies demonstrated that patients with ADHD have lower endogenous oxytocin levels compared to healthy controls (e.g. Demirci et al. 2016; Sasaki et al. 2015). Since higher ADHD tendencies are accompanied by lower oxytocin levels, one could assume that this leads to higher activation in the brain circuitry underlying the primary emotion of FEAR. Fittingly, dysregulation in the amygdala in ADHD has been reported, too. Among other things, Brotman et al. (2010) reported hyperactivity in the left amygdala of adolescent ADHD patients, while these rated neutral faces according to the subjective fear the faces arouse. Moreover, Tajima-Pozo et al. (2016) reported smaller amygdala volumes in adult ADHD patients as well as higher amygdala activation in response to unpleasant pictures. In sum, it is conceivable that lower oxytocin levels and associated hyperactivity of the amygdala may partly underlie the observed positive correlations of ADHD tendencies and FEAR. Please note that this is highly speculative because we do not have gathered neuroscientific data in the present work to back this up.

Of note, Panksepp also carved out brain regions underlying the primary emotion of ANGER: the medial amygdala, bed nucleus of stria terminalis (BNST), medial and perifornical hypothalamus, and PAG, as well as—on a neurotransmitter level—glutamate (Montag and Panksepp 2016). Therefore, the aforementioned dysregulation of the amygdala might not only influence the FEAR-related neuroanatomical structures but also the relevant ones for ANGER. Additionally, connections between glutamate and ADHD have earlier been observed, whereby the scientific results indicate that the glutamate status in the brain of ADHD patients changes over lifetime. On the one hand, Carrey et al. (2007) observed elevated glutamate levels in children with ADHD, whereas on the other hand the studies of Maltezos et al. (2014) and Perlov et al. (2007) found that ADHD is accompanied by lower glutamate levels in adults. Moreover, neuroimaging studies demonstrated that pharmacological modulation of the glutamate-sensitive receptors affects amygdala activity during processing of negative emotional stimuli (Becker et al. 2017; Scheidegger et al. 2016). As such, it is possible that anomalous glutamate levels and an altered amygdala activity cause changes within the circuitry underlying the primary emotion of ANGER.

Based on the ANT, the primary emotion SADNESS is associated with the anterior cingulate, BNST, preoptic area, dorsomedial thalamus, and PAG. Among others, the neuropeptide oxytocin has an inhibitory effect on these brain structures, too (Montag and Panksepp 2016). The connection of oxytocin and ADHD has already been discussed. Apart from this, ADHD is accompanied with alterations in the shape and connectivity of the thalamus in children (Ivanov et al. 2010, Xia et al. 2012). An interaction of thalamic alterations and lower oxytocin levels may be a possible explanation for the connection between ADHD tendencies and SADNESS in healthy adults even if the alterations are still in a normal range. In summary, it seems that none of the primary emotional traits is exclusively linked to ADHD tendencies, but rather a factor comprising the different negative emotional traits FEAR, ANGER and in parts also SADNESS in healthy adults.

Even if the majority of ADHD-related brain structures are not addressed by Panksepp's ANT, this is not contradicted to the found results or the idea of the underlying brain structures assumed by the ANT and the ANPS. The brain structures assumed by the ANT are phylogenetic old structures within the human brain. Panksepp includes in his ANT that brain structures like the prefrontal cortex (PFC), which are achievements of the modern human, are relevant to control the mentioned subcortical regions and consequently the primary emotions (Montag and Panksepp 2016; Reuter et al. 2017). Since the PFC is affected in ADHD (for an overview see Buitelaar et al. 2011), the control mechanism for the relevant subcortical regions is not carried out properly. Therefore, even single alterations within one primary emotional circuit may lead to an increased negative emotionality in individuals with inattentive or hyperactive/impulsive deficits. Further research is needed to enhance the understanding of the underlying neurochemical mechanisms of ADHD.

Due to page limitations and lower robustness of associations between ADHD tendencies and positive emotionality in Chinese males, these results are further discussed in the supplement.

Strengths and limitations of the present study

Regarding the main results, it is important to recognize that the observation of a positive robust association between ADHD tendencies and negative emotionality in two independent samples from different cultural backgrounds, Germany and China, as well as in males and females points towards a valid global effect. Going beyond this, the present work investigated such associations in subclinical populations, thereby strongly relying on a dimensional approach to understand individual differences in ADHD tendencies. A further new aspect of the present work is its anchor in Affective Neuroscience Theory (ANT), hopefully encouraging also other researchers to include ANT in their ADHD research portfolio. Finally, the present findings are based on a relatively large sample of participants reducing the chance of false-positive effects.

Next to the mentioned strengths, the present work also has some weaknesses. The fact that we used self-report questionnaires via an online survey at one time point means that we cannot make any conclusions in terms of causality between the ANPS and ASRS measures. Instead, we could only report correlations which describe associations between two variables. A further limitation is that in the German as well as in the Chinese sample the percentage of students among the participants was very high. Therefore, both samples do not represent the normal or even a representative population. A final limitation is that both samples differ in gender distribution and age. Nevertheless, (mostly) similar results could be found in both samples, at least in terms of the associations between higher tendencies towards ADHD and higher negative emotionality.

Research implications

Through the investigation of emotionality with a questionnaire that is anchored in Affective Neuroscience Theory, the present study gives new impulses for further research in ADHD. The ANPS assesses primary emotional traits that are based on different subcortical brain systems. Moreover, different neuropeptides and neurotransmitters are relevant for the examined primary emotions in humans as also depicted in a new work by Montag and Davis (2018). Our work infers from the ANPS questionnaire data. It might be worthwhile to further investigate the underlying subcortical brain systems, neuropeptides, and neurotransmitters regarding their relation to ADHD. In connection with this, it would be an important research endeavour to compare a patient sample with healthy controls with respect to the ANPS. It seems that at least single components of the different systems underlying the primary emotions influence the manifestation of ADHD in an individual. For that reason, the present study can be a new starting point for further research approaches to better understand the underlying mechanisms of ADHD.

Authors' contributions JW and CM designed the present study. JW drafted the present manuscript and conducted the statistical analysis. CS double-checked the statistical analysis. PS and MZ have been responsible for the Chinese translation process of the ASRS questionnaire. JW and ML conducted the data collection in Beijing, whereas JW and CS collected the German data and the data from Chengdu. BB and KMK critically revised the manuscript. The final version of the manuscript was approved by all authors.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Appendix

Chinese version of the Adult ADHD Self-Report Scale (ASRS) Symptom Checklist.

Adult Self-Report Scale (ASRS)

请回答以下问题，选出在右边适合的一项。请根据您**在近6个月的**行为和感受标记最贴切的一个答案。

		从不	极少	有时候	频繁	很频繁
1.	当您干无趣或者困难的事情的时候经常出现纰漏吗?	○	○	○	○	○
2.	当您干无趣或者重复的事情的时候，您经常很难保持注意力吗?	○	○	○	○	○
3.	即便是当别人直接跟您说话的时候，您经常很难集中注意力吗?	○	○	○	○	○
4.	当您把一个项目中有趣的部分已经做完了的时候，您有困难完成这个项目?	○	○	○	○	○
5.	当您必须做一件对组织能力有要求的任务的时候，您经常很难组织这些事情吗?	○	○	○	○	○
6.	如果您接到一个需要很多深思熟虑的任务，您经常避免或者拖延去开始这个任务吗?	○	○	○	○	○
7.	您经常在家或者在公司忘记把东西放哪了或者丢东西吗?	○	○	○	○	○
8.	您经常被活动或者喧闹声转移注意力吗?	○	○	○	○	○
9.	您经常很难想起您的约定或者承诺吗?	○	○	○	○	○
10.	当您必须长时间静坐的时候，您经常手脚动个不停，扭来扭去吗?	○	○	○	○	○
11.	当您在开会或者其他场合本该静坐的时候，您经常离开席位吗?	○	○	○	○	○
12.	您经常感觉自己心神不定，坐立不安吗?	○	○	○	○	○
13.	当您有空的时候也经常很难放松自我吗?	○	○	○	○	○
14.	您经常感觉自己过度活跃或者被逼迫做一些活动，就像有个发动机在驱动您一样?	○	○	○	○	○
15.	您经常感觉自己在社交场合说话过多吗?	○	○	○	○	○
16.	当您和别人交谈的时候，您经常突然发觉自己在人家还没把话说完的时候，您就替人家把接下来的话说了，这话人家自个儿本能够说完的?	○	○	○	○	○
17.	当需要时间等待才能轮到您的时候，您经常觉得很难等吗?	○	○	○	○	○
18.	当别人正忙的时候，您经常干扰或者中断别人吗?	○	○	○	○	○

Our Chinese version of the ASRS is pending approval as the official WHO translation of the 18-Q ASRS instrument. Item order is the same as in http://www.mentalhealthprofessionalsinc.com/Forms/Adult_ADHD_Self-Report_Scale_(ASRS-v1.1).pdf (accessed on 22.03.18).

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