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Differentiation of ADHD and Depression Based on Cognitive Performance

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Abstract

Objective: The aim of this study was to assess whether self-report scales and neuropsychological tests used for adult patients with ADHD can help to distinguish between ADHD-specific and depressive symptoms. **Method:** In a cross-sectional design, differences in self-report questionnaires and neuropsychological tests among clinical subgroups and healthy controls (HC) were evaluated. Patients in clinical groups were diagnosed with major depressive disorder (MDD) or ADHD with or without depressive symptoms according to *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*) guidelines. **Results:** The Hyperactivity subscales of the Conners' Adult ADHD Rating Scale (CAARS) differed between MDD and ADHD, whereas self-concept and inattention scales even distinguished comorbidity subgroups within the ADHD population. A reduced alertness and higher variations in reaction times measured by performance tests indicated problems in sustained attention in ADHD patients compared with HC. **Conclusion:** The diagnostic process of ADHD, and thereby the distinction from other symptom-overlapping, comorbid mental disorders, might be improved by utilizing ADHD-specific self-report questionnaires and neuropsychological tests, which are short, cost-effective, and standardized screening methods. *(J. of Att. Dis. 2021; 25(7) 920-932)*

Keywords

ADHD, adult, cognition, depression, neurocognitive measures

Introduction

The symptomology and psychopathology of Attention Deficit/Hyperactivity Disorder (ADHD) in adults overlap with several other psychiatric conditions including personality disorders, anxiety, substance use, sleep disorders, and mood disorders (Kooij et al., 2012; Sobanski, 2006). Moreover, these conditions may also occur as comorbidities in up to 89% of all ADHD patients (Sobanski, 2006).

Establishing a differential diagnosis can therefore be challenging for clinicians. To support the process, standardized rating scales and psychological tests can be used as more objective screening and progression assessments (Ebert, Krause, & Roth-Sackenheim, 2003). Unfortunately, at present, there is no diagnostic tool that allows the reliable diagnosis of ADHD by itself (Kooij et al., 2010).

Moreover, frequently used rating scales lack diagnostic specificity, especially regarding the differentiation to mood disorders, one of the most co-occurring conditions (Van Voorhees, Hardy, & Kollins, 2011). Major depressive disorder (MDD) has prevalence rates as high as 18.6% in adults with ADHD (Kessler et al., 2006). The distinction of ADHD from MDD and the recognition of comorbid depressive symptoms in ADHD patients are essential as they have major impacts on therapy considerations (Kooij et al., 2010; Spencer, 2008). Common subjectively reported symptoms of ADHD also frequently occur in MDD, including decline in cognitive functions such as concentration, attention, and memory (Searight, Burke, & Rottnek, 2000). Reversely, mood instability is also often associated with ADHD presenting as increased levels of irritability, volatility, or swift changes in mood (Skirrow, McLoughlin, Kuntsi, & Asherson, 2009).

To this date, it is unclear whether ADHD and MDD patients, and those with both co-occurring disorders, show specific patterns of cognitive impairments. This is also due to the fact, that only few studies have investigated the differences in cognition between those subgroups of patients.

In the first relevant studies of Katz, Wood, Goldstein, Auchenbach, and Geckle (1998), ADHD patients reached lower test results on a range of different neuropsychological tests compared with depressive patients. The two groups significantly differed in measures for inhibition and interference (Stroop test), verbal memory (California Verbal Learning Test [CVLT]), and also attention (Paced Auditory Serial

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Table 1. Clinical Characteristics of ADHD–, ADHD+, MDD Participants, and HC.

	ADHD– (n = 18)	ADHD+ (n = 26)	MDD+ (n = 23)	HC (n = 54)	F/χ^2	p value	η^2
Age (M [SE])[a,c,d]	29.9 (1.7)	33.0 (1.8)	41.5 (2.8)	29.3 (1.1)	5.85	.002	.442
Gender (male/female)	11/7	18/8	7/16	37/17	10.97	.012	.091
WURS-K (M [SE])[a,b,c]	36.9 (2.9)	40.1 (2.7)	14.8 (2.2)	11.1 (1.3)	55.08	.000	.765
BDI (M [SE])[a,b,c,d]	5.8 (0.9)	23.4 (1.6)	30.5 (1.9)	3.0 (0.4)	42.15	.000	.889
Medication (%)					107.10	.000	.884
None	77.8	50	0	96.3	—	—	—
Antidepressants	5.6	26.9	39.1	0	—	—	—
Neuroleptics	0	3.8	0	0	—	—	—
Anticonvulsants	5.6	0	0	0	—	—	—
Thyroid medication	5.6	0	0	3.7	—	—	—
More than one medication	5.6	11.5	60.9	0	—	—	—

Note. MDD = major depressive disorder; HC = healthy controls; WURS = Wender Utah Rating Scale; BDI = Beck Depression Inventory.
[a]Covariate Medication not significant.
[b]Covariate Age was not significant.
[c]Covariate Gender was not significant.
[d]In case of unequal variances, the Welch-Test was used.

Addition Test [PASAT]; Wechsler Memory Scale–Revised [WMS-R]). However, overall, the group also concluded that there was no single test or combination to consistently distinguish between the two clinical groups (Katz et al., 1998).

In a study from 2011, Larochette, Harrison, Rosenblum, and Bowie compared the performance of ADHD patients with MDD patients and those with both co-occurring conditions. They found that the comorbid group performed poorly in comparison with the groups suffering from only either of the conditions. Specifically, the group with both co-occurring conditions showed deficits in processing speed and delayed recall for verbal conceptual material. However, differences in cognitive performance between ADHD and depression groups itself could not be noted (Larochette et al., 2011).

A number of other studies (Holst & Thorell, 2017; Potvin, Charbonneau, Juster, Purdon, & Tourjman, 2016; Walker, Shores, Trollor, Lee, & Sachdev, 2000) were not able to show any notable differences in neuropsychological test performance between ADHD and depression groups, whereas Pettersson, Söderström, and Nilsson (2018) found that a combination with self-reported clinical interviews could be beneficial for diagnosis (Pettersson et al., 2018).

Recently, Fasmer and colleagues assessed the Conners' Continuous Performance Test (CPT) as a useful tool to discriminate between patients with ADHD and other psychiatric disease, especially mood and anxiety disorders, and promoted the need to use more objective tests in the diagnosis of patients with mixed complaints including mood, anxiety, and attentional problems (Fasmer et al., 2016).

To contribute to the understanding and identification of key differences in cognition and therefore promote viable differential diagnosis of ADHD and depression patients, we studied their performance in neuropsychological tests and self-reported questionnaires. As an objective measure for selective attention, alertness, and processing speed, the subscales Go/NoGo and alertness of the Tests for Attentional Performance (TAP) were used. However, the long version of the Conners' Adult ADHD Rating Scale–Self Report (CAARS-S: L) was applied as a self-assessment questionnaire.

Method

Participants

Participants were included in the study if they were between the ages of 18 and 66 years, had no known psychiatric disorders or neurological diseases, and received no relevant ADHD medication. They were screened for psychotropic drugs (antidepressants, neuroleptics, anticonvulsants, thyroid medication) and depressive symptoms. Main demographic data of the four groups are compiled in Table 1.

44 outpatients with clinically defined ADHD according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994) were recruited during regular visits at the local ADHD outpatient clinic for adults of the University Hospital in Leipzig (Germany). A group of 18 ADHD patients without depressive symptoms (ADHD−; BDI < 13) were analyzed in comparison to a group of 26 ADHD patients with depressive symptoms (ADHD+; BDI ≥ 13).

23 inpatients or outpatients with diagnosed depression (MDD) according to the *DSM-IV* criteria were recruited at the Department of Psychiatry and Psychotherapy of the University Hospital Leipzig in Germany. 54 healthy controls

(HC) were recruited through local postings. HC were defined as having a BDI score lower than 13, whereas MDD patients had a BDI score of more than 13.

The protocol was reviewed and approved by the local ethics committee (199-13-15072013, University of Leipzig).

Assessments

For screening purposes, the German short version of the Wender Utah Rating Scale (WURS-k, Retz-Junginger et al., 2002) and the German version of the Beck Depression Inventory (BDI, Beck, Hautzinger, & Steer, 1995) were administered. The WURS-k is a standardized self-report questionnaire with 21 items to retrospectively assess symptoms of ADHD in a participant's childhood on a 5-point scale (Retz-Junginger et al., 2002). The BDI is a similar self-report scale with 21 questions on the participant's current state of health to be answered on a scale of 0 to 4 (Beck et al., 1995).

In the course of the study, the Conners' Adult ADHD Rating Scale (CAARS; Christiansen, Hirsch, Abdel-Hamid, & Kis, 2014) was applied. It measures the presence and severity of ADHD symptoms on a 66-item self-report form by providing raw scores and standardized scores (*t* scores) for all scales. In this study, the empirically derived subscales (Inattention/Memory Problems, Impulsivity/Emotional Lability, Hyperactivity/Restlessness, and Problems With Self-Concept), the three *DSM-IV* ADHD symptom subscales and the ADHD Index (that identifies respondents who might benefit from a more detailed clinical assessment) were used. Elevated *t* scores of one standard deviation (value of 10) above the mean of 50 are indicative of ADHD in the CAARS and its subscales.

To objectify performance-based aspects of attention, the alertness, and Go/NoGo subtests of the computerized Test of Attentional Performance (TAP; Zimmermann & Fimm, 2012) were used. Alertness is defined as general wakefulness or arousal enabling a person to respond effectively to any given demand. It is essential to, and the basis of, every attentional or cognitive performance. The test comprises of a simple reaction time task lasting approximately 4.5 min. The Go/NoGo paradigm was developed to test behavioral control, which is crucial to suppress a reaction triggered by an external stimulus to the benefit of an internally controlled behavioral response. In this paradigm, the focus of attention is directed to predictably occurring stimuli that require a selective reaction (to react "x" or not to react "+"). The Test Form "1 of 2" was used lasting approximately 2 min.

The standard values (*t* scores) of the index of phasic alertness, information processing speed, standard deviation for intrinsic (without warning signal) and phasic (with warning signal) alertness, and standard values of information processing speed, standard deviation, errors, and omissions for Go/NoGo were the dependent variables. Age-corrected, education-corrected, and sex-corrected standard values were used where possible. *t* scores of one standard deviation (value of 10) below the mean of 50 are indicative of abnormal TAP results.

Statistical Analysis

Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS®/IBM® Version 24.0 for Windows). Cross-sectional analysis was conducted using the Chi-square test (χ^2) and analysis of covariance for independent samples (ANCOVA with covariates medication, gender [and age—in case of clinical characteristics]; post hoc test: Bonferroni) with respect to demographical, psychometric, and psychological variables. In case no covariate was significant, the analysis of variance was used (post hoc test: Tukey's honestly significant difference). In case of unequal variances between groups, the Welch statistic and post hoc test Games-Howell was used. For the TAP subtest alertness, a repeated measure ANCOVA was conducted. The interaction of alertness (intrinsic vs. phasic) and group (ADHD–, ADHD+, MDD, HC) were our parameters of interest. The Spearman correlation coefficient was calculated to measure the strength of correlations. Discriminant function analyses were conducted to evaluate the extent to which significant self-report and performance-based measures accurately predicted group membership. Significance was assumed at a level of $p \leq .05$. All scores were natural log transformed (see supplementary materials) prior to statistical modeling to approximate a normal distribution.

Results

Clinical Characteristics of the Patient Population

In Table 1, the main demographic and clinical characteristics of the patient population are displayed. Age and gender differed between MDD and ADHD and HC. Notably, there were more female and older participants in the MDD group compared with ADHD patients ($ps < .069$) and HC ($ps < .007$). The medication was also inconsistent between the four groups. Therefore, all statistical analyses have been made using gender and medication as covariates and age-corrected *t* scores as the dependent measure. As expected, the ADHD patients scored higher in retrospective ADHD symptoms (WURS-K in Table 1) compared with MDD ($ps < .001$) and HC ($ps < .001$), respectively.

Self-Report Measures

We found significant group effects in all CAARS subscales (see Table 2). Compared with HC, post hoc analysis revealed higher *t* scores in ADHD− and ADHD+ patients for all subscores and global scores, respectively ($ps < .001$).

Table 2. Percentage of Patients Scoring Above Average in the Self-Report Measure.

					Post hoc analysis		
Subscale	χ^2	*p* value	Participant group	%	ADHD– (*n* = 18)	ADHD+ (*n* = 26)	MDD+ (*n* = 23)
Inattention	97.63	.000	ADHD–	94.4	/		
			ADHD+	100.0		/	
			MDD+	78.3	>.058	>.012	/
			HC	1.9	>.000	>.000	>.000
Hyperactivity	57.57	.000	ADHD–	77.8	/		
			ADHD+	84.6		/	
			MDD+	21.7	>.000	>.000	/
			HC	9.3	>.000	>.000	
Impulsivity	60.09	.000	ADHD–	72.2	/		
			ADHD+	88.5		/	
			MDD+	39.1	>.035	>.000	/
			HC	5.6	>.000	>.000	>.000
Self-concept	69.11	.000	ADHD–	50.0	/	>.000	>.058
			ADHD+	100.0		/	
			MDD+	78.3		>.012	/
			HC	9.3	>.000	>.000	>.000
DSM-inattention	90.13	.000	ADHD–	94.4	/		
			ADHD+	100.0		/	
			MDD+	78.3		>.012	/
			HC	5.6	>.000	>.000	>.000
DSM-hyperactivity/ impulsivity	54.28	.000	ADHD–	77.8	/		
			ADHD+	80.8		/	
			MDD+	30.4	>.003	>.000	/
			HC	7.4	>.000	>.000	>.008
DSM-global	79.29	.000	ADHD–	94.4	/		
			ADHD+	92.3		/	
			MDD+	56.5	>.007	>.004	/
			HC	3.7	>.000	>.000	>.000
ADHD-index	87.52	.000	ADHD–	100.0	/		
			ADHD+	96.2		/	
			MDD+	60.9	>.003	>.002	/
			HC	3.7	>.000	>.000	>.000

Note. Scale *p* value represents statistical differences between the groups. MDD = major depressive disorder; HC = healthy controls; *DSM* = Diagnostic and Statistical Manual of Mental Disorders.

For MDD patients, all subscales (excluding the Hyperactivity and *DSM*-hyperactivity/impulsivity scale—which were not significant) were higher compared with the HC group ($ps <$ .002) (see Table 3).

Both ADHD groups had significantly higher subscores ($ps < .032$) than the MDD group, except for the inattention and the self-concept subscale. Only the inattention and *DSM*-Inattention subscales were higher in ADHD+, but not in ADHD–, compared with MDD. In contrast, the Self-concept subscale was lower in ADHD–, but not in ADHD+, compared with MDD. Differences between the ADHD groups were not significant apart from the self-concept ($p <$ .001) and the *DSM*-Inattention ($p < .036$) subscale, where the ADHD+ group showed significantly higher subscores compared with ADHD– patients.

Performance-Based Measures

In the alertness subtest for intrinsic and phasic alertness, more ADHD ($ps < .072$) and, in the subtest for phasic alertness, more MDD patients ($p = .004$) than HC performed below average (defined as t scores lower than 40) in the median analyses (see Table 4). In the *SD* analyses of intrinsic alertness, more ADHD and more MDD patients performed below average compared with HC ($ps < .002$). No other effects were found.

In the *SD* analyses of Go/NoGo, more ADHD+ patients ($p = .002$) performed below average in comparison to HC. All other comparisons were not significant.

The ANCOVA of information processing speed of the alertness subtest of the TAP revealed a significant interaction

Table 3. Differences in *t* Scores of Self-Report Measures Between ADHD–, ADHD+, MDD, and HC.

Subscale	*F*	η^2	Participant group	*M* (*SE*)	Post hoc analysis ADHD– (*n* = 18)	ADHD+ (*n* = 26)	MDD+ (*n* = 23)
Inattention[a]	49.10^{000}	.806	ADHD–	74.1 (2.4)	/		
			ADHD+	79.2 (1.6)		/	
			MDD+	66.0 (3.0)		>.005	/
			HC	45.9 (1.2)	>.000	>.000	>.000
Hyperactivity[a]	35.33^{000}	.689	ADHD–	68.8 (3.5)	/		
			ADHD+	72.2 (2.6)		/	
			MDD+	50.6 (3.0)	>.000	>.000	/
			HC	46.3 (1.2)	>.000	>.000	
Impulsivity[a]	48.44^{000}	.764	ADHD–	67.8 (2.6)	/		
			ADHD+	71.7 (1.8)		/	
			MDD+	55.7 (3.0)	>.014	>.000	/
			HC	43.2 (1.1)	>.000	>.000	>.002
Self-concept	48.14^{000}	.772	ADHD–	58.3 (3.0)	/	>.001	>.022
			ADHD+	76.0 (1.5)		/	
			MDD+	70.6 (2.2)		>.176	/
			HC	46.8 (1.2)	>.011	>.000	>.000
DSM-inattention[a,b]	49.45^{000}	.824	ADHD–	74.2 (2.2)	/	>.036	
			ADHD+	81.9 (1.5)		/	
			MDD+	71.5 (3.2)		>.032	/
			HC	47.3 (1.1)	>.000	>.000	>.000
DSM-hyperactivity/ impulsivity[a]	$27.44^{.000}$	.643	ADHD–	69.3 (3.2)	/		
			ADHD+	70.1 (3.1)		/	
			MDD+	51.7 (2.9)	>.000	>.000	/
			HC	44.5 (1.0)	>.000	>.000	
DSM-global[a]	$67.14^{.000}$	.795	ADHD–	75.1 (2.2)	/		
			ADHD+	77.9 (2.7)		/	
			MDD+	63.1 (3.1)	>.006	>.000	/
			HC	45.3 (1.0)	>.000	>.000	>.000
ADHD-index	72.51^{000}	.806	ADHD–	76.0 (1.9)	/		
			ADHD+	78.1 (2.6)		/	
			MDD+	63.8 (2.7)	>.013	>.003	/
			HC	43.4 (1.0)	>.000	>.000	>.000

Note. Scale *p* value represents statistical differences between the groups. MDD = major depressive disorder; HC = healthy controls; *DSM* = Diagnostic and Statistical Manual of Mental Disorders.
[a]In case of unequal variances, the Welch Test is used.
[b]Covariate gender is slightly significant (.096).

of alertness and patient group, $F(3, 115) = 2.98$, $p = .034$, $\eta^2 = .072$ (see Table 5). Subsequent analyses revealed a slightly lower alertness effect in ADHD–, $F(1, 68) = 3.41$, $p = .069$, $\eta^2 = .048$, and ADHD+, $F(1, 76) = 3.38$, $p = .074$, $\eta^2 = .041$, in comparison with HC, but no other significant interactions (*ps* > .315). The *SD* analysis found no interaction ($p = .658$). Looking at intrinsic and phasic alertness separately, we found a significant group effect in the *SD* analysis of intrinsic alertness. ADHD–, but not ADHD+ showed lower *SD* in intrinsic alertness compared with HC ($p = .023$).

In the Go/NoGo subtest of the TAP (see Table 5), we found a significant group effect for the standard deviation, however not for median, omission, or errors (*ps* > .181). ADHD+ revealed lower *t* scores in the Go/NoGo subtest of the TAP compared with HC ($p = .025$).

Correlation of Self-Report and Performance-Based Measures

Intrinsic alertness correlated negatively with the CAARS impulsivity, CAARS *DSM*-Inattention subscale, the *DSM-global* score and with the CAARS ADHD index in ADHD– (see Table 6 for more details). In contrast, it correlated positively with inattention and impulsivity in ADHD+. The

Table 4. Percentage of Patients Scoring Below Average in the TAP Alertness and Go/NoGo Subtest.

					Post hoc analysis		
Subscale	χ^2	*p* value	Participant group	%	ADHD– (*n* = 18)	ADHD+ (*n* = 26)	MDD+ (*n* = 23)
Intrinsic alertness—median	8.66	.034	ADHD–	44.4	/		
			ADHD+	38.5		/	
			MDD+	30.4			/
			HC	14.8	>.009	>.018	
Phasic alertness—median	9.03	.029	ADHD–	38.9	/		
			ADHD+	34.6		/	
			MDD+	47.8			/
			HC	16.7	>.050	>.072	>.004
Intrinsic alertness—*SD*	16.97	.001	ADHD–	44.4	/		
			ADHD+	30.8		/	
			MDD+	34.8			/
			HC	5.6	>.000	>.002	>.001
Phasic alertness—*SD*	2.27	.518	ADHD–	22.2	/		
			ADHD+	15.4		/	
			MDD+	17.4			/
			HC	9.3			
Index of phasic alertness	3.05	.384	ADHD–	16.7	/		
			ADHD+	26.9		/	
			MDD+	39.1			/
			HC	35.1			
Go/NoGo—omission	2.77	.428	ADHD–	5.6	/		
			ADHD+	15.4		/	
			MDD+	13.0			/
			HC	5.6			
Go/NoGo—error	3.00	.392	ADHD–	11.1	/		
			ADHD+	7.7		/	
			MDD+	8.7			/
			HC	1.9			
Go/NoGo—median	7.02	.071	ADHD–	22.2	/		
			ADHD+	15.4		/	
			MDD+	26.1			/
			HC	5.6	>.039		>.010
Go/NoGo—*SD*	9.89	.020	ADHD–	22.2	/		
			ADHD+	38.5		/	
			MDD+	17.4			/
			HC	9.3		>.002	

Note. Scale *p* value represents statistical differences between the groups. TAP = tests for attentional performance; MDD = major depressive disorder; HC = healthy controls.

SD of intrinsic alertness correlated positively with the CAARS *DSM*-Hyperactivity/Impulsivity subscale in ADHD+ patients and negatively with the *DSM-global* score in ADHD– patients. Phasic alertness correlated negatively with CAARS Impulsivity in ADHD– and the *SD* of phasic alertness negatively with the CAARS *DSM-Inattention* subscale in MDD patients. The *SD* of phasic alertness correlated positively with Inattention in ADHD+.

Error in the selective attention task correlated negatively with the CAARS *DSM-Inattention* subscale, the Inattention and Impulsivity subscale, the CAARS global score, and the CAARS ADHD index in ADHD+ patients (see Table 6 for more details). Omissions also correlated negatively with the CAARS *DSM*-Inattention subscale in ADHD+ and MDD patients and with hyperactivity in MDD patients. The median of the Go/NoGo task correlated negatively with hyperactivity and positively with the inattention subscale in ADHD+. The *SD* of the selective attention task correlated negatively with the CAARS ADHD index and with inattention in ADHD–.

Table 5. Differences in *t* Scores of Performance-Based Measures Between ADHD–, ADHD+, MDD, and HC.

					Post hoc analysis		
Subscale	*F*	η^2	Participant group	*M* (*SE*)	ADHD– (*n* = 18)	ADHD+ (*n* = 26)	MDD+ (*n* = 23)
Intrinsic alertness—median	0.92^{435}	.151	ADHD–	41.1 (2.0)	/		
			ADHD+	44.4 (2.4)		/	
			MDD+	45.2 (2.6)			/
			HC	48.2 (1.4)			
Phasic alertness—median	0.68^{565}	.131	ADHD–	40.5 (1.3)	/		
			ADHD+	43.2 (1.7)		/	
			MDD+	41.4 (2.3)			/
			HC	44.7 (1.0)			
Intrinsic alertness—*SD*[a]	3.48^{018}	.286	ADHD–	43.5 (2.4)	/		
			ADHD+	47.2 (2.2)		/	
			MDD+	47.0 (2.4)			/
			HC	51.8 (1.2)			
Phasic alertness—*SD*[a]	1.75^{162}	.207	ADHD–	44.6 (2.0)	/		
			ADHD+	47.6 (2.0)		/	
			MDD+	46.8 (2.2)			/
			HC	50.4 (1.2)			
Index of phasic alertness	2.05^{111}	.223	ADHD–	47.9 (2.6)	/		
			ADHD+	47.9 (2.2)		/	
			MDD+	42.7 (1.5)			/
			HC	43.9 (1.0)			
Go/NoGo—omission[b]	44.01^{602}	.141	ADHD–	48.7 (1.3)	/		
			ADHD+	47.4 (1.2)		/	
			MDD+	48.4 (0.9)			/
			HC	49.2 (0.5)			
Go/NoGo—error	1.14^{337}	.168	ADHD–	49.2 (1.6)	/		
			ADHD+	48.5 (1.4)		/	
			MDD+	50.4 (1.2)			/
			HC	50.8 (0.7)			
Go/NoGo—median	0.78^{506}	.140	ADHD–	48.4 (2.2)	/		
			ADHD+	49.9 (2.1)		/	
			MDD+	51.0 (2.4)			/
			HC	53.6 (1.4)			
Go/NoGo—*SD*[b,c]	44.24^{012}	.312	ADHD–	46.2 (2.6)	/		
			ADHD+	44.5 (2.2)		/	
			MDD+	46.9 (1.8)			/
			HC	51.3 (1.1)			

Note. Scale *p* value represents statistical differences between the groups. MDD = major depressive disorder; HC = healthy controls.
[a]Covariate medication slightly significant.
[b]In the case of unequal variances, the Welch Test is used.
[c]Covariate gender slightly significant.

To determine how the self-report and performance-based measures differentiate the groups, we conducted an explorative, discriminant function analysis, although the assumptions (homogeneity of variances) are violated.

All three functions significantly differentiated the groups, $\Lambda = .111$, $\chi^2(12) = 2{,}544.76$, $p < .001$; $\Lambda = .499$, $\chi^2(6) = 80.71$, $p < .001$; $\Lambda = .914$, $\chi^2(2) = 10.45$, $p < .005$. The structure matrix and group centroids for the functions are presented in Tables 7 and 8, respectively. According to the structure matrix, the first function primarily represents BDI and CAARS ADHD index. The group centroids suggest this function tends to be most elevated in ADHD+ and least pronounced in HC. As shown in Table 7, high scores on the second discriminant function were associated with CAARS Hyperactivity, especially in ADHD– and less pronounced in MDD. Finally, the third function seems to represent CAARS

Table 6. Correlations of Self-Report and Performance-Based Measures for Patients With ADHD and MDD.

	DSM-UA_T			*DSM*-Hy/I_T			*DSM*-Ges_T			ADHS-index_T		Inattention				Hyperactivity			Impulsivity			Self-concept	
	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+	MDD	ADHD−	ADHD+
Go/NoGo error	−.151	**−.358**^{036}	.045	−.092	−.0197	.046	−.078	**−.423**^{016}	.085	.055	**−.629**^{000}	.160	.234	**−.605**^{001}	.096	.140	−.122	.138	−.379	**−.410**^{019}	.041	−.285	.067
Go/NoGo omission	−.117	**−.336**^{047}	**−.419**^{023}	−.117	.005	−.136	−.023	−.178	−.341	−.353	−.301	−.224	.094	−.216	−.253	.094	.138	**−.361**^{045}	−.187	−.158	−.049	−.399	−.106
Go/NoGo median	−.176	.158	−.005	−.196	−.144	.155	−.259	.028	.086	−.308	.096	.151	−.364^{069}	**.476**^{007}	.188	−.118	**−.349**^{040}	−.074	−.060	.187	.067	−.010	.267
Go/NoGo *SD*	−.262	−.055	.042	−.334^{088}	.056	.075	−.375	−.018	.088	**−.639**^{002}	−.110	.208	**−.481**^{022}	.009	.324	−.265	−.123	.074	−.032	.031	.204	−.003	.134
Intrinsic alertness median	**−.419**^{042}	.217	−.183	−.384^{058}	.224	−.124	**−.549**^{009}	.274	−.113	**−.484**^{021}	.189	−.047	.012	**.386**^{026}	−.049	−.238	.144	−.204	**−.551**^{009}	**.382**^{027}	−.091	−.335	−.142
Intrinsic alertness *SD*	−.362	.240	−.249	−.209	**.390**^{025}	−.245	**−.457**^{028}	.266	−.209	−.246	.247	−.013	.171	.304	−.060	−.134	.163	−.323	−.307	.224	−.051	.103	.166
Phasic alertness median	−.243	.074	−.218	−.256	.011	−.082	−.333	.152	−.109	−.249	.092	−.008	.169	.324	−.028	−.210	−.022	−.141	**−.505**^{016}	.285	−.048	−.103	.192
Phasic alertness *SD*	−.029	.132	**−.367**^{042}	−.110	.152	−.190	−.182	.269	−.260	−.036	.177	−.042	.196	**.407**^{020}	−.001	−.200	.001	−.245	−.191	.294	−.092	.222	.010

Note. DSM = Diagnostic and Statistical Manual of Mental Disorders; MDD = major depressive disorder.
Significance was assumed when $p < 0.05$. Significant measures are marked in bold, p values in superscript, respectively.

Table 7. Structure Matrix That Emerged From the Discriminant Function Analysis.

	1	2	3
BDI	.791[a]	−.532	.191
CAARS *DSM-inattention*	.757[a]	.366	**−.112**
CAARS *ADHD-index*	**.678**[a]	.541	−.360
CAARS *DSM-global*[b]	.659[a]	.634	−.145
CAARS *inattention*[b]	.616[a]	.345	−.125
CAARS *self-concept*[b]	.568[a]	.006	−.134
CAARS *impulsivity*[b]	.480[a]	.472	.012
Phasic alertness/*SD*[b]	−.121[a]	−.059	−.082
Go/NoGo—*SD*[b]	−.099[a]	−.047	.053
Go/NoGo error[b]	−.081[a]	−.040	.066
Go/NoGo—median[b]	−.074[a]	−.043	.018
Phasic alertness—median[b]	−.063[a]	−.039	.010
Intrinsic alertness—median[b]	−.054[a]	−.023	.050
CAARS *hyperactivity*	.382	**.661**[a]	.599
CAARS *DSM hyperactivity/impulsivity*[b]	.417	.649[a]	−.021
index of phasic alertness[b]	−.025	−.065	−.169[a]
Go/NoGo—omission[b]	−.003	−.038	.149[a]
Intrinsic alertness/*SD*[b]	−.037	−.028	−.110[a]

Note. Bold values are the highest/lowest values for the variables used for this measure.
BDI = Beck Depression Inventory; DSM = Diagnostic and Statistical Manual of Mental Disorders.
[a]Highest absolute correlation between all variables and all discriminant functions.
[b]Variable not used in this analysis.

Table 8. Group Centroids That Emerged From the Discriminant Function Analysis.

	Function	
	1	2
ADHD–	0.624	1.656
ADHD+	2.186	0.356
HC	−1.977	−0.136
MDD	1.683	−1.379

Note. HC = healthy controls; MDD = major depressive disorder.

DSM-Inattention subscale. The group centroids indicate highest in ADHD+ and lowest in ADHD–.

The three discriminant functions associated with BDI, CAARS *DSM*-Inattention, Hyperactivity, and CAARS ADHD Index predict group membership by 87.6% correctly (ADHD–: 83.3%, ADHD+: 88.5%, MDD: 73.9%, HC: 94.4%). 97.9% of variance is explained by the first and second function associated with the BDI, CAARS Index, and CAARS Hyperactivity score.

Without the independent variable BDI, group membership was predicted by 80.2% correctly with an explained variation of 95.6% by two functions (associated with CAARS *DSM*-Inattention, CAARS Index and Self-concept). The groups of ADHD+ (84.6%) and HC (94.4%) were best predicted. In contrast, ADHD– (61.1%) and MDD (56.5%) patients were only predicted by chance.

Discussion

ADHD in adults has been shown to have a high frequency of symptom overlap with depression (Kooij et al., 2012; Sobanski, 2006). Therefore, a reliable distinction between the two in the course of the diagnostic process of ADHD is desirable. In this study, we investigated whether self-report scales and neuropsychological tests used for ADHD patients could be of help to separate ADHD-specific from depressive symptoms.

We used the German version of the Conners' Adult ADHD Rating Scale (CAARS; Christiansen et al., 2014) to assess self-report measures in the ADHD-specific symptom domains inattention, hyperactivity, impulsivity, and self-concept as well as *DSM-IV* scales for inattention, hyperactivity/impulsivity and global scores. We compared the results of ADHD patients with and without comorbid depression, MDD patients, and healthy controls (HC). As expected, both ADHD groups showed significantly higher scores in all subscales and also the global score compared to healthy controls. With respect to MDD patients, both ADHD groups scored higher in the hyperactivity, impulsivity, and global scales, These findings are partially in line with an earlier study by Stewart and Liljequist (2015) revealing that the CAARS subscale for impulsivity was one of the scales that best predicted the distinction between ADHD and other Axis I disorders (Stewart & Liljequist, 2015). As hyperactivity scores were comparable between MDD patients and HC, but ADHD patients had significantly higher scores compared with MDD, hyperactivity could be one distinguishing feature between ADHD and MDD patients.

Interestingly, in our sample, the comparison of ADHD and MDD varied noticeably in two subscales between the comorbidity groups of ADHD. Namely, ADHD patients with, but not without, comorbid depression, had higher subscores in the inattention scale than MDD patients; while only ADHD patients without depression had lower self-concept subscores than MDD patients. Looking at the mean values for inattention chronologically, ADHD+ scored highest, followed by MDD patients and ADHD–, with all the groups being significantly more impaired than healthy controls. One possible explanation might be that not only ADHD, but also depressive patients suffer from attention deficits, which might cause a potentiation of the symptom severity when both diseases occur as comorbidities (see also Larochette et al., 2011 for cognitive impairment associated with comorbidity). This phenomenon has already been observed in children with ADHD and comorbid depression, who also showed increased subscale scores for inattention

(Di Trani et al., 2014). A similar effect of symptom intensification could cause the results seen for the self-concept subscale, where ADHD- had lower scores compared with ADHD+ and MDD patients.

The self-concept subscale, together with the *DSM*-Inattention subscale, was also significantly distinctive between the two ADHD subgroups themselves. More precisely, ADHD patients with comorbid depression presented higher problems with self-concept and inattention than patients without depressive symptoms. These results are in line with the aforementioned study of Stewart and colleagues, who concluded that inattention was the best parameter to distinguish ADHD from other Axis I diagnoses, whereas the self-concept scale also contributed to this, especially regarding the differentiation to depression (Stewart & Liljequist, 2015). Another recently published study by Nankoo, Palermo, Bell, and Pestell (2019) also found the subscales for inattention, impulsivity, and self-concept to create unique variance in depression scores and might therefore be a great tool for the distinction of ADHD with and without comorbid depression (Nankoo et al., 2019). Our results support that, in addition to hyperactivity, inattention and self-concept subscales of the CAARS are other distinguishing features between ADHD with and without comorbid depression and MDD.

Notable differences between both studies and our study are that no external evaluation of ADHD criteria was used and ADHD patients were not divided according to their depressive comorbidity status. To our knowledge, this is the first study that evaluated CAARS subscales based on the occurrence of comorbid depression in adult ADHD patients. The relevancy of our classification is supported by a study of Simon, Czobor, and Bitter (2013) that found the ADHD index measured by the CAARS to be significantly associated with the lifetime prevalence of depression, thereby indicating that overall ADHD severity increases in the presence of a comorbid depression and should be evaluated in clinical practice (Simon et al., 2013). Moreover, comorbidities with other mental disorders, especially depression, are a crucial factor in the process of choosing the adequate therapy for each individual ADHD patient, as recommended by national guidelines (Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften, 2017).

The second evaluation in our study was done by measuring cognitive performance with the help of the German version of the computerized Test of Attentional Performance (TAP). The test was applied to assess alertness and behavioral control (Zimmermann & Fimm, 2012). Altogether, more ADHD patients performed below average in intrinsic and phasic alertness than HC. The alertness effect was slightly lower in both ADHD groups compared with HC. ADHD– revealed higher variations of reaction times in intrinsic alertness, whereas ADHD+ revealed higher *SD* in the Go/NoGo task compared with HC.

Other differences in performance-based measures between depressive patients, healthy participants, and ADHD patients were not significant. We also found no significant effects when looking at group differences in the ADHD population.

To our knowledge, no studies have looked at TAP results for ADHD and MDD patients thus far, but some data exist to suggest ADHD patients have deficits in alertness. Hegerl, Himmerich, Engmann, and Hensch (2010) proposed the brain arousal regulation model of ADHD (Hegerl & Hensch, 2014; Strauß et al., 2018), in which inattention is associated with hypoarousal and hyperactivity is interpreted as an autoregulatory reaction of the organism to stabilize the hypoarousal and stay awake and alert. This can be operationalized neuropsychologically with the alertness subtest of the TAP (for an overview about sleep and alertness, see Konofal, Lecendreux, & Cortese, 2010).

However, a lot of data exist for the Continuous Performance Test (CPT)—a test similar to the TAP Go/NoGo task. CPT results comparing ADHD and MDD patients vary and are not as consistent as for ADHD patients compared with HC (Armengol, 2003; Bálint et al., 2009; Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Mesquita et al., 2016; Pettersson et al., 2018; Riordan, 1999; Solanto, Etefia, & Marks, 2004). A study comparing depressed and non-depressed college students with ADHD from 2003 observed no differences in reaction times between both groups, however the comorbid group made significantly more errors of commission and omission in an uncued CPT (measuring a kind of tonic alertness) compared with the ADHD only group and normative controls. In the cued CPT, both ADHD groups made more errors compared with normative controls, indicating that ADHD patients had problems with phasic alertness. Altogether, the group summarized that the comorbidity with depression decreased attentional performance of ADHD patients (Armengol, 2003). This is in contrast to our study where only ADHD patients without depression revealed higher *SD* for intrinsic alertness compared with healthy controls. Notably, there are some differences between this study and ours. First, the used paradigm and the relevant markers for attention differed to the point that we used a simple reaction task for testing alertness in a cued and uncued condition and a selective reaction task for testing behavioral control, whereas Armengol used a selective reaction task in a cued and uncued condition. Second, they did not test patients with depression only and are therefore not able to compare all three clinical groups.

Together with the higher *SD* for intrinsic alertness in ADHD–, the reduced alertness effect in both ADHD groups and the higher *SD* in the Go/NoGo task for ADHD+ indicate problems in sustained attention, that is, showing an unstable state of alertness in ADHD patients compared with HC. In contrast, differences to MDD patients were not found. So, we must conclude that performance-based measures alone are not able to differentiate ADHD from MDD patients.

A more recent study in Norwegian psychiatric patients compared the CPT results of ADHD patients to patients with mood, anxiety, or other attentional problems. The reaction times between the ADHD groups did not differ, which was also true in our TAP results. However, the ADHD group in this study showed significantly elevated values for omission, commission, and variability (Fasmer et al., 2016). Only the latter was also observed by us for the Go/NoGo task in patients with ADHD and comorbid depression compared to HC. Unfortunately, the study by Fasmer et al. (2016) did also not differentiate the clinical groups according to their comorbidity status; therefore a comparison to our results remains vague.

Finally, as a measure of whether performance-based measures are associated with the specific characteristics of the disorders measured via self-reports, we performed correlation analyses. We were able to find differences between both ADHD patient groups regarding the *DSM* and global scores of the CAARS. Specifically, better intrinsic alertness scores were associated with lower *DSM*-Inattention and global scores (*DSM-global* and index score) in ADHD–. In ADHD+ patients, more errors—as an indicator for behavior control—and omissions—as an indicator for inattention—in the Go/NoGo task were associated with attentional problems (*DSM*-Inattention) and elevated global scores (*DSM global* and index score).

Looking at the CAARS subscales, more errors in the selective attention task were associated with increased attentional problems and impulsivity in ADHD+. Intrinsic alertness also differed in inattention and impulsivity between the ADHD groups. The faster ADHD– patients were in intrinsic alertness, the lower their scores for impulsivity. In contrast, the faster ADHD+ patients performed in intrinsic alertness, the higher their problems with impulsivity and inattention. These results add to former findings by Armengol, who reported problems in phasic alertness in ADHD patients (Armengol, 2003). Together with our data, we can now conclude that the differentiation between ADHD with and without depression could be associated with intrinsic alertness.

MDD patients showed comparable correlations to ADHD+. This is in line with former reports of Alexander and Harrison, who found positive correlations between CAARS scores and depression (Alexander & Harrison, 2013).

The correlations found in our study are not as high and as consistent as we expected. This might be attributable to a finding published by Toplak, West, and Stanovich (2013), where they reported that the two types of measures used in performance-based tests and self-reports on executive functions appear to capture different levels of cognition: the efficiency of cognitive abilities and the success in goal pursuit (Toplak et al., 2013).

Finally, we performed exploratory discriminant analyses, which indicated the BDI, CAARS ADHD-Index, hyperactivity, and *DSM*-Inattention subscale as the best predictors for differentiating the four groups. The three discriminant functions were able to classify 88% of all participants correctly. The discriminant analysis validated the results of the analysis of variances. On the one side, the symptom inattention, measured with the CAARS *DSM*-Inattention subscale, differentiates well between ADHD with and without comorbid depression. On the other side, the symptom hyperactivity differentiates well between ADHD– and MDD. Furthermore, depressive symptoms, measured with the BDI, were able to differentiate between ADHD+ and HC (and between the two ADHD subgroups).

Limitations of this study include the lack of control of the possible influence of pharmacotherapy and psychotherapy on the cognitive performance of ADHD and depressed patients.

Taken together, these results on both, self-report and performance-based measures, support previous findings that patients with MDD also suffer from decreased cognitive functions, but are not as severely affected as ADHD patients (Strohmeier, Rosenfield, DiTomasso, & Ramsay, 2016). Notably, depression as a comorbid disorder exacerbates the symptoms of ADHD in self-report measures. This is not only of clinical relevance regarding the diagnostic process, but also regarding the subsequent treatment of ADHD patients. More research needs to be done in regard to performance-based measures and their validity in differential diagnosis before a general statement can be made about their use. Utilizing ADHD-specific self-rating scales however seem to be very useful for the diagnostic differentiation between ADHD and depression in clinical practice and can improve the accuracy of the diagnosis.

Authors' Note

Madlen Paucke and Tina Stibbe contributed equally.

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Supplemental Material

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Maria Strauss acquired her medical license as a physician in 2002 at the University Leipzig, Germany. She subsequently specialised in Neurology, Psychiatry and Psychotherapy in clinics at Bayreuth, Leipzig and Halle, Germany. She finished her PhD in 2005 and qualified as a specialist in Neurology in 2007 in Madgeburg, Germany and as a specialist in Psychiatry and Psychotherapy in 2010 in Dresden, Germany, thereafter. Since 2007 she works as a Psychiatrist at the Department for Psychiatry and Psychotherapy of the University Leipzig, where she also habilitated in 2015 and is the head of the outpatient clinic for affective disorders.