Overlap Between Autism Spectrum Disorders and Attention Deficit Hyperactivity Disorder: Searching for Distinctive/Common Clinical Features

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Recent studies support several overlapping traits between autism spectrum disorders (ASD) and attention-deficit/hyperactivity disorder (ADHD), assuming the existence of a combined phenotype. The aim of our study was to evaluate the common or distinctive clinical features between ASD and ADHD in order to identify possible different phenotypes that could have a clinical value. We enrolled 181 subjects divided into four diagnostic groups: ADHD group, ASD group, ASD+ADHD group (that met diagnostic criteria for both ASD and ADHD), and control group. Intelligent quotient (IQ), emotional and behavior problems, ADHD symptoms, ASD symptoms, and adaptive behaviors were investigated through the following test: Wechsler Intelligence Scale for Children, Wechsler Preschool and Primary Scale of Intelligence or Leiter International Performances Scale Revised, Child Behavior Checklist, Conners' Rating Scales-Revised, SNAP-IV Rating Scale, the Social Communication Questionnaire, Vineland Adaptive Behavior Scales. The ASD+ADHD group differs from ADHD or ASD in some domains such as lower IQ mean level and a higher autistic symptoms severity. However, the ASD+ADHD group shares inattention and hyperactivity deficit and some emotional and behavior problems with the ADHD group, while it shares adaptive behavior impairment with ASD group. These findings provide a new understanding of clinical manifestation of ASD+ADHD phenotype, they may also inform a novel treatment target. ***Autism Res*** *2015, 8: 328–337*. © 2015 International Society for Autism Research, Wiley Periodicals, Inc.

Keywords: autism spectrum disorders; attention deficit hyperactivity disorder; overlapping; intelligent quotient; emotional and behavior problems; ADHD symptoms; ASD symptoms; adaptive behaviors

Introduction

Autism spectrum disorders (ASD) and attention-deficit/hyperactivity disorder (ADHD) are childhood-onset neurodevelopmental disorders, with prevalence, respectively, of 1% and 5% in the pediatric population [American Psychiatric Association, 2013]. According to the Diagnostic and Statistical Manual of Mental Disorders—4th edition—Text Revision (DSM-IV-TR) criteria, a diagnosis of ADHD cannot be made if the symptoms of inattention and hyperactivity occur exclusively during the course of a pervasive developmental disorder (PDD). However, epidemiological, clinical and neuroimaging findings have led a revision of the ADHD exclusion criteria in the recent publication of the DSM-5 [American Psychiatric Association, 2013]. In fact, autism is no longer an exclusion criteria and both ASD and ADHD can be diagnosed together [DSM-5, 2013]. Although there are some important differences (e.g., core symptom definition and recommended treatment), ASD and ADHD share many similar impairments in different domains that could complicate a differential diagnosis. Researchers have shown an increased interest in the overlapping features between these disorders, including attention deficit [Mayes et al., 2011; Sturm, Fernell, & Gillberg, 2004], behavior problems [Mayes et al., 2011], and difficulty in social skills [de Boo & Prins, 2007]. Moreover, several studies have shown high rates of ADHD comorbidity in children with ASD [Gadow et al., 2006; Holtmann, et al., 2007; Lee & Ousley, 2006; Simonoff et al., 2008; Wozniak & Biederman, 2012; Yoshida & Uchiyama, 2004]. On the other hand, several studies observed elevated rates of autistic symptoms in children with ADHD [Grzadzinski et al., 2011; Kotte et al., 2013; Reiersen et al., 2007;

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Santosh & Mijovic, 2004]. Recent studies on biological risk factors, neuropsychological domains, and brain imaging support several overlapping traits between ASD and ADHD. In a review study, Taurines et al. (2012) suggests that comorbidity is caused by overlapping genetic or non-genetic biological risk factors [Taurines et al., 2012]. Family and twin studies provide support for the hypothesis that ADHD and ASD originate partly from similar familial/genetic factors [Reiersen, Constantino, Volk, & Todd, 2007; Ronald, Simonoff, Kuntsi, Asherson, & Plomin, 2008]. Only a few candidate gene studies, linkage studies, and Genome-Wide Association (GWA) studies have specifically addressed this co-occurrence, pointing to some promising pleiotropic genes, loci, and single-nucleotide polymorphisms (SNPs) [Freitag et al., 2012; Rommelse, Franke, Geurts, Hartman, & Buitelaar, 2010; Taurines et al., 2012]. The specific nongenetic biological risk factors associated with overlapping between ASD and ADHD seem to include maternal psychotropic medications, preterm birth, maternal pre-eclampsia, maternal autoimmune disease, and maternal infection disease [Cohen et al., 2011; Croen et al., 2011; Kroger et al., 2011; Lyall et al., 2012; Taurines et al., 2012].

Moreover, neuropsychological impairments, as attention and executive function (EF), were frequently reported in individuals with ASD and ADHD. A meta-analysis study of the EF in ADHD children found that response inhibition, vigilance, working memory, and planning were the strongest and most consistent deficits found across studies [Willcutt et al., 2005]. However, executive functions deficits are also detected in children with ASD who reported deficits in the areas of planning and cognitive flexibility [Hill, Berthoz, & Frith, 2004; Kenworthy et al., 2005; Ozonoff et al., 2004], response selection/monitoring [Happé et al., 2006], and task initiation/task shifting [Hill & Bird, 2006]. These impairments are due to the fact that ASD and ADHD are neurodevelopmental disorders affecting key fronto-striatal and fronto-parietal circuits that are important for executive functions. Neuroimaging findings describe common gray matter reductions in the left medial temporal lobe and increased gray matter volumes in the left inferior parietal cortex in both disorders [Brieber et al., 2007]. Recently, Christakou et al. (2013) compared ASD children and ADHD children using functional magnetic resonance imaging (fMRI) during a parametrically modulated vigilance task with a progressively increasing load of sustained attention demonstrating that ADHD and ASD boys had significantly reduced activation relative to controls in bilateral striato-thalamic regions, left dorsolateral prefrontal cortex (DLPFC), and superior parietal cortex [Christakou et al., 2013]. Despite the fact that there have been an increasing amount of molecular genetic and imaging studies about the overlapping of ASD and ADHD, there are no definitive findings.

These literature data highlight the need for further studies on the overlap between ASD and ADHD, assuming the existence of a combined phenotype. For this reason, the aim of our study was to evaluate the common or distinctive clinical features between ASD and ADHD in order to identify possible different phenotypes that could have a clinical value.

Method

The sample consisted of 181 subjects referred to University Hospital of Bari. Participants were divided into four groups: ADHD group, ASD group, ASD+ADHD group, and a control group. The ADHD group comprised 51 children/adolescents, the ASD group comprised 43 children/adolescents, and the ASD+ADHD group comprised 31 children/adolescents. These patients were enrolled at the Child Neuropsychiatry Unit and clinical diagnoses were made by clinical experts according to DSM-IV-TR. The diagnoses were based on the developmental histories of the children, taken from clinical interviews with the parents, observations and extended neuropsychological testing of the children themselves. To be eligible for the current study, ASD patients had to present the typical triad of symptoms of autism: social deficits, communication impairment, and rigid ritualistic interests. The clinical diagnosis of ASD was supported by the Autism-Diagnostic Interview-Revised [Rutter et al., 2003b] and the Autism Diagnostic Observation Scale [Lord et al., 1999]. ADHD patients had to present the typical core symptoms of inattention, hyperactivity, and impulsivity. ADHD children that were included in our sample had received the DSM subtype diagnosis. The ASD+ADHD patients met DSM-IV-TR diagnostic criteria for both ASD and ADHD.

Exclusion criteria were the presence of any genetic or medical condition underlying ADHD or ASD symptoms. Considering the difficulty in recruiting healthy children, the control group comprised 56 children/adolescents enrolled at the Pediatric Surgery Unit, admitted for mild surgical diseases (hernia, ingrown nails, appendicitis, hemorrhoids, syndactylia, phimosis), in which neurological and psychiatric disorders were excluded. All participants were consecutively examined in the period between September 2010 and February 2014.

Parental informed consent was obtained for all participants and the study was approved by the local ethical committee of the "Azienda Ospedaliero-Universitaria Consorziale Policlinico di Bari."

Assessment

In order to evaluate the common or distinctive clinical features in ASD, ADHD, ASD+ADHD, and the control groups we investigated intelligent quotient (IQ),

emotional and behavior problems, ADHD symptoms, ASD symptoms, and adaptive behaviors.

In ASD, ADHD, ASD+ADHD patients, the IQ was assessed according to the age through Wechsler Intelligence Scale for Children (WISC-III) [Wechsler, 1991], Wechsler Preschool and Primary, Scale of Intelligence (WPPSI) [Wechsler, 2002], and Leiter International Performances Scale Revised (Leiter-R) [Roid & Miller, 1997] alternatively to WISC-III, in nonverbal subjects. The control group was not assessed for IQ.

Emotional and behavior problems, ADHD symptoms, ASD symptoms, and adaptive behaviors were investigated through the following scales: Child Behavior Checklist (CBCL), Conners' Rating Scales-Revised (CRS-R), SNAP-IV Rating Scale, the Social Communication Questionnaire (SCQ), Vineland Adaptive Behavior Scales (VABS).

The CBCL [Achenbach & Rescorla, 2001] is a common tool used to assess emotional and behavioral problems in children. The first section of the scale includes 20 items related to the child's social competency, as rated by parents. These items address the child's participation in sports, hobbies, games, activities, organizations, jobs, chores, friendships, social interactions during play, independent work, and school functioning. The second section consists of 120 items on behavior or emotional problems during the past 6 months as rated on a three-point scale. The main areas of this construct are aggression, hyperactivity, bullying, conduct problems, defiance, and violence. The following behavioral and emotional problems are also measured: aggressive behavior, anxious/depressed, attention problems, delinquent rule-breaking behavior, social problems, somatic complaints, thought problems, withdrawal, externalizing, internalizing, and total problems. Lower scores indicate lower functioning on the academic performance and adaptive functioning scales [Achenbach & Rescorla, 1991]. Higher scores indicate higher levels of maladaptive behavior on the syndrome, total problems, externalizing and internalizing scales. The instrument has an internal validity of 0.90–0.91 for the scales of internalizing disorders and of 0.95–0.96 for externalizing disorders. Cronbach's coefficient alpha was 0.95 and 0.96, respectively.

CRS [Conners, 1997] is used as part of a comprehensive examination and is designed to be easily administered and scored. Conners' Rating Scales-Revised (CRS-R) is an assessment for children aged 3 through 17 years designed to measure cognitive, behavioral, and emotional problems from teacher and parent perspectives. CRS-R are available in long and short versions for both parents and teachers. We used the long version for parents [Conners et al., 1998] that consisted of 80 items in the following subscales: oppositional, social problems, cognitive problems/inattention, psychosomatic, hyperactivity, DSM-IV symptom subscales, anxious-shy, ADHD Index, perfectionism, Conners' Global Index. Conners' Global Index includes 10 items related to problem behavior critically associated with the severity of childhood problems. Each of the column scores can then be converted to a T-score. T-scores are standardized scores with a mean of 50 and a standard deviation of 10. These can be further converted to percentile scores, when needed. As a rule, T-scores above 60 are cause for concern and have interpretive value. Interpretable scores range from a low T-score of 61 (mildly atypical) to above 70 (markedly atypical).

The SNAP-IV Rating Scale [Swanson et al., 2001] is a revision of the Swanson, Nolan, and Pelham (SNAP) Questionnaire (Swanson, 1983). The 26 items of the SNAP-IV include the 18 ADHD symptoms (nine for inattentive, nine for hyperactive/impulsive) and eight ODD symptoms specified in the DSM-IV. The SNAP-IV is based on a 0 to 3 rating scale: Not at All = 0, Just A Little = 1, Quite A Bit = 2, and Very Much = 3. Subscale scores on the SNAP-IV are calculated by summing the scores on the items in the subset and dividing by the number of items in the subset.

The SCQ [Rutter, et al., 2003a] is a 40-item, parent completed, screening questionnaire, based on the initial mandatory probes from the original Autism Diagnostic Interview [Le Couteur et al., 1989]. It includes the areas of communication, reciprocal social interactions, and restricted and repetitive behaviors and interests. Each item is checked as "yes" or "no," and is assigned a rating point of "1" (presence of abnormal behavior) or "0" (absence of abnormal behavior). Total scores are compared to a cut off of $\geq$15 for ASD. A lower cut-off score of $\geq$12 has been suggested for children under the age of 5 years. There are two different versions of the SCQ: 1) a "current" version designed for children under the age of 5 years and 2) a "lifetime" version designed for children of 5 years of age or older, with all questions based on lifetime or past behavior.

The VABS [Sparrow et al., 1984] is a semistructured parental interview that evaluates adaptive functioning in four domains: communication, daily living skills, socialization, and motor skills. Age-equivalent scores and standard scores are provided for each domain. Scores across domains can be combined to create an overall adaptive behavior composite standard score.

Statistical Analysis

All demographic and clinical variables were subjected to statistical analysis. Descriptive analysis was conducted for sociodemographics featuring of the four samples. Raw scores obtained from each subscale of the CSR, CBCL, SNAP-IV, SCQ, and VABS were transformed into *t*-scores to allow for consideration of how an individual's response compares with that of the population

Table 1. Sociodemographic Characteristics and IQ of ASD, ADHD, ASD+ADHD, and Control Groups

	ASD ($N = 43$)	ASD+ADHD (N=31)	ADHD ($N = 51$)	Control ($N = 56$)	P Value
Gender (N)					
Male	36	26	46	43	.323
Female	7	5	5	13	
Age (years)					
Range	5.6–8.6	7.05–9.5	7.2–9.8	7.6–9.5	—
Mean ± SD	7.11 ± 4.7	8.28 ± 3.3	8.54 ± 3.9	8.6 ± 3.46	.26
IQ (Mean ± SD)	72.09 ± 36.7	59.03 ± 34.5	85.17 ± 19.7	—	*ASD+ADHD vs ASD *ASD+ADHD vs ADHD
IQ level					
Borderline	27%	13%	19%	—	—
Mild	11%	22%	12%	—	—
Moderate	9%	16%	5%	—	—
IQ measures					
WISC-III	30%	3%	72%	—	—
WPPSI	16%	13%	20%	—	—
Leiter-R	54%	84%	8%	—	—

Autism Spectrum Disorders (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), Intelligence Quotient (IQ), borderline (IQ 71-84), mild (IQ 50–70), moderate (IQ 35–49), Wechsler Intelligence Scale for Children (WISC-III), Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Leiter International Performances Scale Revised (Leiter-R); *P <.005.

norms. For CBCL, the borderline (t-score > 65) and clinical (t-score > 70) scores were put together. In line with the interpretive guidelines from CRS-R, participants with a t-score of 66 on a subscale represent individuals who score much above the average and were categorized as symptomatic for that trait. Analysis of variance (ANOVA) test was used to evaluate the differences of the means of the CBCL, CRS-R, SNAP-IV, SCQ, and VABS scales among overlap, ASD, ADHD and control groups. Additionally, Bonferroni correction was used to conduct the post hoc analysis. A P-value of less than. 05 was considered as statistically significant. For statistical processing, we used the data processing program the Statistical Package for Social Science version 20.0.

Results

Socio-demographic characteristics of ASD, ADHD, ASD+ADHD and Control groups are summarized in Table 1. No statistical differences among the four groups in age ($P = .26$) and gender ($P = .323$) were found. Among the ASD participants in our study, 72% met the DSM-IV-TR diagnostic criteria for pervasive developmental disorder not otherwise specified (PDD-NOS), 14% for Autistic Disorder, and 14% for Asperger's Syndrome. Among the ADHD patients, 8% met the DSM-IV-TR diagnostic criteria for the inattentive subtype of ADHD and 92% met the criteria for the combined subtype. Among the ASD+ADHD patients, 68% met the DSM-IV-TR diagnostic criteria for PDD-NOS+ADHD combined subtype, 19% for Autistic Disorder + ADHD combined subtype, and 13% for Asperger's disorder + ADHD combined subtype.

Intelligent Quotient

A statistically significant difference was found between the groups in IQ mean score ($F = 7.27$; $P < .001$). The post-hoc analysis showed that ASD+ADHD groups had lower IQ mean score, compared with ASD ($P = .023$) and ADHD ($P = .001$) groups. No statistical difference was found between the ADHD and the ASD group. Results about IQ are summarized in Table 1.

Emotional and Behaviors Problems

Emotional and behaviors problems assessed with CBCL (Table 2) showed a statistically significant difference between the groups in internalizing ($F = 8.32$, $P < .001$), externalizing ($F = 20.04$, $P < .001$), and total problems ($F = 19.9$, $P < .001$). ADHD and ASD+ADHD groups showed higher Internalizing scores compared with the control group. ADHD and ASD+ADHD groups showed higher Externalizing and Total problems scores compared with the ASD and control groups.

Emotional and behaviors problems assessed with CRS-R (Table 3) showed a statistically significant difference between the groups in all subscales ($P < .05$). The ADHD group had higher ODD, cognitive problems, anxiety, perfectionism, social problems, somatic complain and CGI total scores compared with the ASD and Control groups. The ASD+ADHD group had higher ODD, cognitive problems, anxiety, perfectionism, social problems, somatic complaints, CGI emotional lability, and CGI total scores compared with the ASD group. The ASD+ADHD group had higher ODD, cognitive problems, perfectionism, social problems, CGI

Table 2. Significant Differences in CBCL Symptom Scores Between Groups

	ASD ($N = 43$)		ASD+ADHD ($N = 31$)		ADHD($N = 51$)		Control ($N = 56$)				
	%>Cut-off	M ± SD	%>Cut-off	M ± SD	%>Cut-off	M ± SD	%>Cut-off	M ± SD	F	*P* Value	Bonferroni's Test
Internalizing problems	59.7%	60.4±8.8	78.6%	64.7±7.2	84.9%	66.1±8.4	49.9%	53.9 ±16.4	8.3	<.001	ASD+ADHD=ASD=ADHD>*Control
Externalizing problems	32.7%	56.5±8.2	67.9%	63.9±9.3	86.8%	69.6±10.3	21.6%	53.5±9.3	20	<.001	ADHD=ASD+ADHD>*ASD=Control
Total Problems	53.3%	59.7±8.2	92.8%	69±8.1	90.1%	70.1±9.8	34.9%	56.2±8.8	19.9	<.001	ADHD=ASD+ADHD>*ASD=Control
Mood symptoms	25.2%	58.1±7.3	23.4%	62.5±8	49.8%	65±8.6	28.5%	58.7±7.4	5.9	.001	ADHD>*ASD=Control
Social Withdraw	75.6%	69.2±12.1	62.3%	68.4±9.8	60.6%	65.3±7	17.1%	57.7±6	11.7	<.001	ASD+ADHD=ASD=ADHD>*Control
Somatic Complain	9.4%	55±7	22.6%	57.3±6.9	45.5%	62.4±9.3	14.1%	56.7±6.2	6.3	.001	ADHD>*ASD+ADHD=ASD=Control
Attention deficit	37.2%	62.5±7.3	80.6%	71.3±7.9	78.8%	70.7±8.3	22.9%	59.9 ± 7.5	18.5	<.001	ASD+ADHD=ADHD>*ASD=Control
Aggressive problem	28.1%	56.6±7	48.4%	64.4 ±8.7	68.3%	71.4±10.7	8.4%	55.9±7.6	24.5	<.001	ADHD>*ASD+ADHD>*ASD=Control
Depression	34.4%	60.6±9.7	48.4%	67.2±9.6	69.7%	67.1±6.5	17.2%	57.8±7.2	11	<.001	ADHD=ASD+ADHD>*ASD=Control
Anxiety	25%	57.8±7.2	70%	66.1±8	65.3%	65.9±7.7	40%	61.3±8	8.5	<.001	ADHD>*ASD+ADHD=ASD
ADHD	18.3%	59±6.7	65.5%	67.8±7.3	78.9%	69.8±7.8	17.2%	57.8±6.8	24.4	<.001	ADHD=ASD+ADHD>*ASD=Control
ODD	6.2%	55.5±5.5	16.8%	61.1 ±7.7	64.6%	68.1 ±8.8	12%	55.1±6.6	24.1	<.001	ADHD>*ASD+ADHD>*ASD=Control

Autism Spectrum Disorders (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional defiant disorder (ODD), Mean (M), standard deviation (SD), Child Behavior Checklist (CBCL); *$P < .05$.

Table 3. Significant Differences in CRS-R Scores Between Groups

	ASD ($N = 43$)		ASD+ADHD ($N = 31$)		ADHD ($N = 51$)		Control (N=56)				
	%>Cut-off	M ± SD	%>Cut-off	M ± SD	%>Cut-off	M±SD	%>Cut-off	M±SD	F	*P* Value	Bonferroni's Test
ODD	9.8%	46 ± 12.9	41.9%	60.7 ± 13	82.9%	74.8 ± 17.9	18.9%	51.5 ± 9.3	36	<.001	ADHD>*ASD+ADHD>*ASD=Control
Cogntive problems	46.3%	60 ± 13.1	80.6%	74.4 ± 15	88.6%	74.8 ± 9.6	43.4%	59.8 ± 14.3	16.1	<.001	ADHD=ASD+ADHD>*ASD=Control
Hyperactivity	19.5%	54.6 ± 9.2	83.9%	73.7 ± 12.6	88.6%	77.8 ± 13.9	20.8%	52.3 ± 11.3	49.3	<.001	ADHD=ASD+ADHD>*ASD=Control
Anxiety	19.5%	49.4 ± 9.2	41.4%	60.2 ± 13.9	57.1%	62.3 ± 15	32.1%	54.9 ± 11.9	8.1	<.001	ADHD=ASD+ADHD>*ASD; ADHD>*Control
Perfeczionism	12.2%	49.7 ± 8.9	64.5%	64.6 ± 15.1	54.3%	64.3 ± 13.6	11.3%	46.9 ± 9.2	26.4	<.001	ADHD=ASD+ADHD>*ASD=Control
Social problems	41.5%	60.9 ± 14.8	80.6%	77.4 ± 18.9	70.6%	73.3 ± 20.1	17%	52.8 ± 9.5	21.5	<.001	ADHD=ASD+ADHD>*ASD=Control
Psychosomatic	9.3%	49.9 ± 9.5	29%	58.7 ± 14.3	51.4%	65 ± 16.5	15.1%	51.3 ± 9.4	12.6	<.001	ADHD=ASD+ADHD>*ASD; ADHD>*Control
ADHD INDEX	46.3%	60.4 ± 10.3	90.3%	77 ± 12	89.7%	76.5 ± 9	41.5%	58.7 ± 12.3	32	<.001	ADHD=ASD+ADHD>*ASD=Control
CGI restlessness	29.3%	56.2 ± 8.2	71%	68.4 ± 12.4	82.9%	75.1 ± 12.6	22.6%	54.9 ± 10.9	31.4	<.001	ADHD=ASD+ADHD>*ASD=Control
CGI emotional lability	22%	51 ± 10.4	58.1%	66.4 ± 16.4	80%	67.3 ± 13.5	9.4%	48.4 ± 9.1	27	<.001	ADHD=ASD+ADHD>*ASD=Control
CGI total	19.5%	54.8 ± 8	71%	70 ± 13.3	88.6%	75.7 ± 12.6	11.3%	53.3 ± 9.9	42	<.001	ADHD=ASD+ADHD>*ASD=Control
DSM-IV inattention	36.6%	59.8 ± 11.3	83.9%	73.7 ± 14.4	91.4%	75.6 ± 9.4	39.6%	58.4 ± 12.9	22.1	<.001	ADHD=ASD+ADHD>*ASD=Control
DSM-IV hyperactivity	22%	54.4 ± 10.8	83.9%	72.2 ± 12.7	85.7%	76.3 ± 11.5	26.4%	53.4 ± 11	43.3	<.001	ADHD=ASD+ADHD>*ASD=Control
DSM-IV ADHD	34.1%	57.6 ± 9.7	96.8%	81.9 ± 33.3	91.4%	78.6 ± 10.5	32.1%	56.2 ± 11.2	23.7	<.001	ADHD=ASD+ADHD>*ASD=Control

Autism Spectrum Disorders (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional defiant disorder (ODD), Conners Global Impairment (CGI), Diagnostic and Statistical Manual of Mental Disorders (DSM), Mean (M), standard deviation (SD), Conners' Rating Scales-Revised (CRS-R); *$P < .05$.

emotional lability, and CGI total scores, compared with the control group.

ADHD Symptoms

ADHD symptoms assessed with SNAP-IV (Table 4) showed a statistically significant difference among the groups in inattention scores ($F = 51.4$, $P < .001$) and hyperactivity scores ($F = 75.4$, $P < .001$). ADHD and ASD+ADHD groups had higher SNAP-IV inattention score compared with ASD and control groups; ASD groups had higher SNAP-IV inattention score compared with the Control group. ADHD and ASD+ADHD groups had higher SNAP-IV hyperactivity score compared with ASD and Control groups; ASD groups had higher SNAP-IV hyperactivity score compared with the control group.

ADHD symptoms assessed with CRS-R (Table 3) showed a statistically significant difference among the groups in Hyperactivity ($F = 49.3$, $P < .001$); ADHD Index ($F = 32$, $P < .001$); Restlessness-Impulsivity ($F = 31.4$, $P < .001$); DSM-IV inattention ($F = 22.1$, $P < .001$); DSM-IV Hyperactivity ($F = 43.3$, $P < .001$), DSM-IV ADHD Total ($F = 23.7$, $P < .001$). The Bonferroni test showed that ADHD and ASD+ADHD groups had higher hyperactivity, ADHD index, restlessness-impulsivity, DSM-IV inattention, DSM-IV hyperactivity, DSM-IV ADHD total scores, compared with ASD ($P < .001$ for every scales) and Control groups ($P < .001$ for every scales). No differences were found between ASD and control groups.

ADHD symptoms assessed with CBCL (Table 2) showed a statistically significant difference between the groups in ADHD scores ($F = 24.4$, $P < .001$) and attention deficit scores ($F = 18.5$, $P < .001$). The Bonferroni test showed that ASD+ADHD and ADHD groups had higher ADHD symptoms and attention deficit scores, compared with ASD and control groups. No differences were found between ASD and control groups.

ASD Symptoms

All four groups differed significantly from each other in SCQ total scores ($F = 47.7$, $P < .001$). The ASD+ADHD group had higher SCQ score (Table 4) compared with ASD ($p = .009$), ADHD ($P < .001$) and Control ($P < .001$) groups. The ASD group had higher score compared with ADHD ($P = .023$) and control ($P < .001$) groups. The ADHD group had higher score compared with the control ($P < .001$) group.

Adaptive Behaviors

Adaptive behaviors assessed with VABS (Table 4), showed a statistically significant difference among the groups in communication skills ($F = 13.6$, $P < .001$), daily living skills ($F = 15.4$, $P < .001$), social skills

Table 4. Significant Differences in SNAP-IV, SCQ, VABS Scores Between Groups

	ASD (N=43)		ASD+ADHD (N=31)		ADHD(N=51)		Control (N=56)				
	%>Cut-off	M±SD	%>Cut-off	M±SD	%>Cut-off	M±SD	%>Cut-off	M±SD	F	p-value	Bonferroni's Test
SNAP-IV											
Inattentive	45%	1.5 ± 0.6	96.8%	2.3 ± 0.3	89%	2.2 ± 0.5	7.5%	1.1 ± 0.5	51.4	<.001	ADHD=ASD+ADHD>*ASD>Control
Hyperactive/impulsive	25%	1.1 ± 0.4	93.1%	2.1 ± 0.4	91.7%	2.2 ± 0.6	11.3%	0.7 ± 0.6	75.4	<.001	ADHD=ASD+ADHD>*ASD>Control
ODD	2.5%	1 ± 1.2	54.8%	1.6 ± 0.9	65.7%	2 ± 0.7	9.4%	0.7 ± 0.5	18.5	<.001	ADHD=ASD+ADHD>*ASD=Control
SCQ	62.5%	15.4 ± 7.7	87.1%	20 ± 6.8	25.7%	11.4 ± 4.9	1.9%	4.9 ± 4.3	47.7	<.001	ASD+ADHD>*ASD>*ADHD>*Control
VABS											
Communication skills	—	52.1 ± 44.7	—	59 ± 39.7	—	86 ± 28	—	101.3 ± 37.7	13.6	<.001	ASD+ADHD=ASD<*ADHD=Control
Daily living skills	—	48.2 ± 37.8	—	41.7 ± 22.9	—	71 ± 30.7	—	93.4 ± 46.2	15.4	<.001	ASD+ADHD=ASD<*ADHD=Control
Social skills	—	42.2 ± 28.6	—	35.2 ± 19.2	—	60.8 ± 33.3	—	99.3 ± 48.1	25.5	<.001	ASD+ADHD=ASD<*ADHD<*Control
Motor skills	—	38.7 ± 18.3	—	42.7 ± 12.6	—	56.4 ± 14	—	69.6 ± 36.7	13.7	<.001	ASD+ADHD=ASD<*ADHD=Control

Autism Spectrum Disorders (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional defiant disorder (ODD), Mean (M), standard deviation (SD), Swanson, Nolan and Pelham (SNAP), Social Communication Questionnaire (SCQ), Vineland Adaptive Behavior Scales (VABS); *$P < .05$.

(F = 25.5, $P < .001$.), and motor skills (F = 13.7, $P < .001$). ASD+ADHD and ASD groups had lower communication skills, daily living skills, socialization skills, and motor skills compared with ADHD and control groups.

Discussion

Comparative studies between ASD, ADHD, and ASD+ADHD disorders are rare. Scheirs and Timmers investigated the IQ differentiating among children with PDD-NOS, ADHD, and those with a combined diagnosis on the basis of WISC-III [Scheirs & Timmers, 2009]. The authors found that the mean IQ score did differ among the three groups, in particular the PDD-NOS group attained the highest scores, whereas the scores of the ADHD and combined diagnosis groups were lower and highly similar to one another. Statistically significant differences were found only between the PDD-NOS and the ADHD group. The authors conclude that a distinction between the PDD-NOS and ADHD diagnoses can be validated on the basis of IQ scores; however, the existence of a distinct combined diagnosis group could not be warranted. In the current study, we found that the ASD+ADHD group (where the 68% met the DSM-IV-TR diagnostic criteria for PDD-NOS) was characterized by a statistically significant lower IQ mean score compared with ASD and ADHD groups. These findings suggest that the assessment of IQ could help to identify distinctive characteristics in ASD+ADHD phenotype. Further studies, which take these variables into account, will need to be undertaken.

In literature data, studies regarding psychiatric comorbid disorders that compare children with ASD and ADHD are lacking. Recently, van Steensel et al. (2013) found that children with ASD did not differ from children with ADHD with respect to their overall comorbidity rate, however, anxiety disorders were more often present in children with ASD compared to children with ADHD [van Steensel et al., 2013]. To our knowledge, only the study of Yerys et al. (2009) investigated emotional and behavior problems comparing children with ASD+ADHD, children with ASD without ADHD and a typically developing control group. The authors found that the ASD+ADHD group received significantly higher ratings for externalizing problems, attention problems, and hyperactivity than the ASD and Control groups [Yerys et al., 2009]. An advantage of our study, in comparison with previous research, was the use of a four-sample design including ADHD vs. ASD vs. ASD+ADHD vs. control. We found that ADHD, ASD, and ASD+ADHD groups showed higher internalizing and externalizing scores compared with the control group; ADHD and ASD+ADHD groups showed higher externalizing scores and ADHD symptoms compared with ASD and control groups. These findings suggest that ADHD and ADHD+ASD phenotypes are characterized in equal measure by externalizing behavior problems and ADHD symptoms. Moreover, ASD phenotype reported more ADHD symptoms than the Control group confirming previous studies which found that inattentive and hyperactive symptoms are often reported in individuals with ASD [Lord et al., 2000; Leyfer et al., 2006]. Further study is needed to extend the analysis of differences between groups of patients on the clinical aspects.

Regarding the prevalence of ASD symptoms, we found that the ASD+ADHD group reported more ASD symptoms than ASD, ADHD, and control groups. These results are in accordance with Sprenger et al. (2013) who reported that patients with ASD and ADHD symptoms showed more strongly expressed autistic symptoms than children with ASD with no additional ADHD symptoms. Therefore, in ASD+ADHD phenotype, the inattentive and hyperactive symptoms may exacerbate the severity of ASD. However, another possible explanation for the greater severity of autistic symptoms may be the fact that we found a lower IQ in the ADHD+ASD group, compared to the other groups. We also found that ADHD phenotype reported more ASD symptoms than healthy children. The presence of ASD symptoms in individuals with a primary diagnosis of ADHD has been increasingly noted [Hattori et al., 2006; Nijmeijer et al., 2008, 2009]. Several studies have shown social deficits, peer relationship and empathy problems are common in ADHD children [Gillberg et al., 2004; Kadesjö & Gillberg, 2001]. Recently, Cooper et al. (2014) investigated whether higher levels of autistic traits, indicated a more severe presentation in a large sample of children with ADHD symptoms, and suggested that ADHD children reported elevated ratings of core ASD traits not accounted for by ADHD or behavioral problems [Cooper et al., 2014].

Although studies have shown adaptive behavioral difficulties in children diagnosed with ASD and in children with ADHD, it remains poorly investigated whether ASD+ADHD children share similar adaptive functioning impairments. Studies comparing ASD and ADHD groups reported that adaptive functioning is generally impaired in both disorders, but individuals with ASD show more severe impairments [Happé, Booth, Charlton, & Hughes, 2006; Saulnier & Klin, 2008]. Yeyrs et al. (2009) detected that both ASD and ASD+ADHD groups received significantly lower adaptive functioning ratings on the communication, daily living skills, and socialization domains relative to the healthy children group, but the ASD+ADHD group exhibited a more severe impairment in daily living skills compared to the ASD group [Yeyrs et al., 2009]. Recently, Mattard-Labrecque, Ben Amor, & Couture (2013) investigated adaptive behaviors in children with

a dual diagnosis of ASD+ADHD compared with children with ADHD or ASD alone. The authors found that children with ASD+ADHD had a lower performance in all of the adaptive functions except home/school living than children with ADHD [Mattard-Labrecque et al., 2013]. In the present study, no statistically significant difference in adaptive functions between ASD+ADHD and ASD group was found. However, ASD+ADHD and ASD groups reported more impairment in communication, daily living skills, and motor skills compared to ADHD and control groups. These findings suggest that the presence of ADHD does not lead to a greater impairment in adaptive functions, but impairments in these domains may results from increased neurocognitive deficits related to the autism phenotype characterized by difficulties in executive function, organization, and planning skills [Kenworthy et al., 2005]. However, ASD+ADHD, ASD, and ADHD children reported a lower score in social skills compared with the control group. These findings, suggest that the Social skills deficit could be due to impairments in social perception and/or difficulties in emotion recognition, which characterize both ASD and ADHD disorders.

Conclusion

In conclusion, the ASD+ADHD phenotype differs from ADHD or ASD phenotypes in some domains such as IQ and autistic symptoms severity. However, the ASD+ADHD phenotype maintains some clinical aspects that characterize ASD or ADHD phenotypes. In fact, the ASD+ADHD phenotype shares inattention and hyperactivity deficit and emotional and behavior problems with the ADHD phenotype, while it shares the adaptive behavior impairment with the ASD phenotype.

The findings in this study provide some new understanding of the clinical manifestation of the ASD+ADHD phenotype, and it represents a starting point for future research that needs to investigate aspects such as treatment response, neuropsychological measures, etiopathogenesis, and developmental trajectories of the ASD+ADHD phenotype.

Conflict of Interest

All authors declare that they have no conflicts of interest.

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