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ADHD Severity as it Relates to Comorbid Psychiatric Symptomatology in Children with Autism Spectrum Disorders (ASD)

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Abstract

Comorbid diagnoses identified in pediatric samples have been correlated with a range of outcomes, including greater levels of emotional, behavioral, and educational impairment and the need for more intensive treatment. Given that previous research has documented high levels of comorbid Attention-Deficit/Hyperactivity Disorder (ADHD) in children with Autism Spectrum Disorders (ASD), this study closely examines the relationship between parent-reported ADHD symptoms (i.e., Conners' Parent Rating Scale, Revised [CPRS-R]) and the prevalence of additional comorbid psychiatric diagnoses in a pediatric ASD sample ($n = 99$). Regression analyses revealed that greater severity of ADHD symptomatology was significantly related to a greater number of comorbid psychiatric diagnoses, as identified using the Diagnostic Interview for Children and Adolescents, 4th Edition (DICA-IV). Additionally, more severe ADHD symptoms were also associated with higher levels of symptom severity on Child Behavior Checklist (CBCL) syndrome subscales. Interestingly, increasing severity of ASD symptomatology, as measured by the Autism Diagnostic Interview, Revised (ADI-R), was not associated with a higher prevalence of comorbid psychiatric diagnoses or CBCL syndrome severity. Our study concluded that higher levels of ADHD severity—not ASD severity—were associated with a higher prevalence of comorbid psychiatric symptomatology in school-age children with ASD. These findings may encourage clinicians to thoroughly assess ADHD symptomatology in ASD children to better inform treatment planning.

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Keywords

Autism Spectrum Disorder; Attention-Deficit/Hyperactivity Disorder; Comorbidity; Psychiatric Symptom Severity; DSM-5 Diagnostic Criteria; ASD-ADHD

Introduction

Autism Spectrum Disorder (ASD) is a lifelong developmental disorder characterized by deficits in social communication as well as restricted, repetitive patterns of behaviors. The current Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (APA, 2013) formulation of ASD encompasses many children formerly characterized as having Autistic Disorder (AD), Asperger's Disorder, and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) in the DSM-IV-TR (APA, 2000). ASD is a neurodevelopmental disorder with recent rates estimated to be as high as 1% in the pediatric population (Baird et al., 2006). Given its prevalence and pervasive nature, it is common for individuals with ASD to experience coexisting psychiatric conditions (e.g., Simonoff et al., 2008). Although the core features of ASD can be impairing and pervasive, the co-occurrence of other psychiatric conditions can further undermine the individual's functioning and quality of life (Loveland & Tunali-Kotoski, 2005; Pearson et al., 2006). Identification of these comorbid conditions is critical, as these conditions can often be targeted effectively by psychiatric and psychosocial interventions.

A growing body of research strongly suggests that the prevalence rate of psychiatric comorbidity in individuals with ASD is higher than it is in the general population (e.g., Brereton, Tonge, & Einfeld, 2006; Gadow, DeVincent, Pomeroy, & Azizian, 2004; Joshi et al., 2010). Previous research suggests that 70% of children with ASD meet criteria for one comorbid psychiatric disorder, while 40% meet criteria for two or more comorbid diagnoses (APA, 2013; Abdallah et al., 2011; Leyfer et al. 2006; Simonoff et al., 2008). Psychiatric conditions that are particularly common in children with ASD include Attention-Deficit/Hyperactivity Disorder (ADHD), mood disorders, and anxiety disorders. Prevalence rates of ADHD symptoms in ASD range from 28.2-87% (Amr et al., 2012; Ames & White, 2011; Frazier et al., 2001; Ponde, Novaes, & Losapio, 2010; Sinzig, Walter, & Doepfner, 2009; Simonoff et al., 2008); prevalence rates of mood disorders comorbid with ASD have been estimated to range from 2-57% (Amr et al., 2011; Matson & Nebel-Schwalm, 2007; Mazefsky, Folstein, & Lainhart, 2008, Whitehouse, Durkin, Jacquet, Ziatas, 2009); and prevalence rates for anxiety disorders in ASD range from 15.7-84.1% (Mannion, Leader, & Healy, 2013; Muris, Steerneman, Merckelbach, Holdrinet, & Meesters, 1998). This emerging body of literature suggests that children and adolescents with ASD are at very high risk for developing a range of psychiatric concerns.

Prior to the release of the DSM-5, there was much controversy regarding whether clinicians should diagnose ADHD in individuals with ASD. In fact, the diagnosis of ADHD was prohibited in the presence of an ASD diagnosis in the previous version of the DSM (DSM-IVTR). Some clinicians felt that symptoms of ADHD were just a "part of autism." Interestingly, a body of research has indeed identified overlapping features in ASD and

ADHD. For example, there are shared genetic factors as well as common cognitive and executive functioning features (Gargaro et al., 2011; Jang et al., 2013; Reiersen & Todd, 2008; Taurines et al., 2012). Rommelse et al. (2011)'s recent review suggested substantial shared endophenotypes, such as behavior concerns, emotional regulation issues, and poor social awareness of behavioral consequences.

Although ASD and ADHD may share overlapping cognitive and behavioral features, many recent studies have supported ASD and ADHD as two distinct syndromes that may cooccur. In fact, within the diagnostic criteria for both disorders, there are few to no overlapping symptoms (Ghanizadeh, 2010). Additionally, the treatment approach for the core symptoms of ADHD is distinct from the treatment approach for the core symptoms of ASD. For instance, although stimulant medications have been effective in treating ADHD symptoms in children with ADHD and ASD (e.g., inattentiveness, hyperactivity), their symptoms of ASD remain unchanged (Hazell, 2007; Pearson et al., 2013; Santosh, Baird, Pituaratstian, Tavare, & Gringas, 2006). Overall, the distinct characteristics and unique treatment approaches support the utility of separate ASD and ADHD diagnostic models, as is currently the case in the DSM-5.

There is also evidence that comorbid ADHD presents additional risk beyond that contributed by ASD alone. For instance, Jang et al. (2013) determined that children with both ASD and ADHD had higher rates of other comorbid symptoms (e.g., conduct problems) compared to children with either ASD or ADHD alone. Additionally, ADHD symptoms have been found to further impair overall psychiatric adjustment and functioning in children with ASD (Frazier et al., 2001; Gadow, DeVincent, & Pomeroy, 2006; Goldstein & Schwebach, 2004; Lecavalier, et al., 2009; Yoshida & Uchiyama, 2004). ADHD symptoms comorbid with ASD place children at a higher risk for psychiatric hospitalization (Frazier et al., 2001), predict more difficulties with general life functioning (Goldstein and Schwebach, 2004; Ogino et al., 2005; Yerys et al., 2009), and are positively correlated with receiving mental health services (Bryson, et al., 2008). Previous research also suggests that comorbid ADHD may exacerbate externalizing behavior problems within the pediatric ASD symptom profile (Yerys et al., 2009). Other studies have found that children with both ASD and ADHD appear to have greater deficits in their ability to recognize facial affect than children who meet diagnostic criteria for either ASD or ADHD alone (Sinzig, Morsch & Lehmkuhl, 2008, Tye et al., 2013). Furthermore, Ames and White (2011) found that those with ASD and ADHD had greater difficulty with inhibitory control and regulating impulsivity leading to increased deficits in social interaction relative to those with only ASD.

Although this emerging literature strongly suggests that ADHD and ASD each contribute risk for suboptimal functioning and life outcomes, relatively little is known about the relationship of ADHD to the development of specific comorbid psychiatric syndromes in persons with ASD. Additionally, it is of interest to know whether children with ASD who have more severe symptoms of ADHD are at higher risk for comorbid psychiatric symptomatology than are children with ASD who have milder presentations of ADHD symptoms. Thus, the first goal of this study was to examine the prevalence of various comorbid psychiatric disorders—including disruptive behavior disorders, mood disorders, anxiety disorders, elimination disorders, and eating disorders—in children with ASD. Based

on previous research, we hypothesized that greater ADHD severity in those with ASD would lead to a greater incidence of co-morbid psychiatric disorders (e.g., ADHD, social phobias, obsessive compulsive disorder, generalized anxiety disorder). The second goal of this study was to determine whether higher severity of ADHD symptomatology in children with ASD is associated with greater levels of psychiatric symptoms and syndrome severity. We expected higher levels of ADHD symptom severity in children with ASD would be highly correlated with greater levels of psychiatric symptoms and syndrome severity than those children with ASD demonstrating lower levels of ADHD symptom severity. Unlike past research (e.g., Joshi et al., 2010), this study is unique in that it explores the impact of ADHD symptom severity on co-morbid psychiatric symptoms.

1. Method

1.1 Participants

The participants in this study were from a larger NIH funded study assessing the cognitive and behavior functioning in children with ASD (see Pearson et al., 2012; Pearson et al., 2013). Participants were recruited from the general community, special education programs of local schools, special needs schools, community agencies/clinics, community autism events, and parent advocacy groups. A screening phone interview was conducted using the SCQ to screen for symptoms of Autism. Participants with SCQ greater than or equal to 15 were invited to come into the clinic for the psychological assessment visit.

During the psychological assessment visit participants underwent a psychological assessment battery that included the SB5, a computerized screener for DSM-IV-TR psychiatric disorders [Diagnostic Interview for Children and Adolescents, 4th Edition, Parent Version (DICA-IV; Reich, Welner, & Herjanic, 1997)], parent questionnaires assessing psychiatric symptom severity [Conners' Parent Rating Scale, Revised (CPRS-R, Conners, 1997); Child Behavior Checklist (CBCL; Achenbach, 2001)], and a clinical/developmental interview conducted by a licensed psychologist with the child's parent. Written informed consent was obtained from parents and assent was obtained from the children able to provide it. This study was approved by the Committee for the Protection of Human Subjects at the University of Texas Health Science Center at Houston.

Children were determined to meet DSM-IV-TR criteria for Autistic Disorder, Asperger's Disorder, or Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) using the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994), the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999) (administered by research-reliable clinicians), a follow-up clinical interview by a licensed psychologist, and case review by two licensed psychologists. An ADHD diagnosis was established if the child had sufficient DSM-IV-TR symptoms of ADHD as reported by the parent on the DICA-IV and the follow-up clinical interview with a licensed psychologist, behavioral observations, and having a T score of ≥ 65 on the Conners Parent Rating Scale, Revised-Long (CPRS-R:L) and the Conners Teacher Rating Scale, Revised-Long (CTRS-R:L) ADHD Indexes. Additional comorbid diagnoses were established if the child had sufficient DSM-IV-TR symptoms as reported by the parent on the clinical interview during the clinical interview. Exclusion criteria included having an IQ of less than 40, not having English as the primary

language, and sensory and motor limitations that were severe enough to prevent adequate testing.

Of the 128 total participants who were invited to participate in the psychological assessment visit, 29 participants were not enrolled in the study: 22 did not meet our study criteria for an ASD, 6 had such severe behavioral or cognitive difficulties that they could not complete the study procedures, and one participant withdrew. Demographics and sample characteristics are described in Table 1. The final sample consisted of 99 children between the ages of 6 and 13 (mean age = 9.37 years) with Full Scale IQ scores ranging from 46 to 128 (mean Full Scale IQ = 84) on the Stanford-Binet Intelligence Scale, 5th Edition (SB5; Roid, 2003). It was determined that the mental ages of this study's sample ranged from 3.1 to 21 years old. Mental age (SB5 Full Scale Age Equivalent) was used as a covariate in this study to combine the hypothesized influence of both age and cognitive level (as seen in Dawson et al., 2004). Within this sample, there were 78 boys and 85 met diagnostic criteria for ADHD. The male to female prevalence ratios identified in this sample (65 males; 20 females) were slightly higher than those reported in other pediatric ADHD community samples (e.g., Ramtekkar, Reiersen, Todorov, & Todd, 2010 [2.28:1]). Among the 99 children who were enrolled in the study, 60 children met criteria for Autistic Disorder, 21 met criteria for PDD-NOS, and 18 met criteria for Asperger's Disorder (n=18).

Forty-seven participants (or 47%) were being treated with psychoactive medication at study entry, including psychostimulants (n=33), antipsychotics (n=1), atypical antipsychotics (n=17), antidepressants (n=3), a norepinephrine reuptake inhibitor [Atomoxetine] (n=5), antihypertensives (n=5), a mood stabilizer (n=1), and an anxiolytic (n=1). Nineteen children (19%) were taking two medications, and six children (6%) were receiving three or more. Although we recognized that children taking psychotropic medications were likely to have greater comorbid psychiatric symptoms, if we had excluded them, we would have created a sample that was not representative of children with ASD (Aman et al, 1995).

1.2 Measures

1.2.1 The Stanford-Binet Intelligence Scale, 5th Edition (SB5)—The SB5 was used as the measure of intellectual level. The SB5 is a widely used, individually administered test normed for ages 2 through 80 years. It yields a measure of full scale IQ, verbal IQ, and nonverbal IQ, each with a mean of 100 and a standard deviation of 15. It also provides age-equivalent scores for overall IQ (mental age), verbal IQ, and nonverbal IQ. The SB5 has established good reliability and validity (Roid, 2003).

1.2.2 Diagnostic Interview for Children and Adolescents, 4th Edition-Parent Interview (DICA-IV)—The DICA-IV (Parent Version) is a structured, computerized psychiatric interview administered to parents or primary caregivers to screen for major childhood and adolescent DSM-IV disorders. The DICA-IV, is a diagnostic tool based on DSM-IV criteria that identifies symptoms for clinicians to confirm using follow-up inquiry. The DICA has been established as a reliable a screener for psychiatric disorders in children with developmental disabilities (Reich, 2000; Reich, Welner, & Herjanic, 1997). In our study, this measure was used to screen DSM-IV diagnoses including ADHD, Oppositional

Defiant Disorder, Conduct Disorder, Major Depressive Disorder, Dysthymic Disorder, Mania or Hypomania, Separation Anxiety Disorders, Panic Disorder, Generalized Anxiety Disorder, Specific Phobia Disorder, Social Phobia Disorder, Obsessions, Compulsions, Post-Traumatic Stress Disorder, Eating Disorders, and Elimination Disorders.

1.2.3 The Autism Diagnostic Interview, Revised (ADI-R)—The ADI-R, a semi-structured interview covering current and historical symptoms of Autism, was administered to the primary caregiver of participants. It is based on both DSM-IV and ICD-10 criteria. Domains include: 1) reciprocal social interaction, 2) communication and language, and 3) restricted, repetitive, and interests. The interview yields scores on each of the three major domains as well as a diagnostic algorithm. The sum of the ADI-R total scores was used to index participants' overall ASD symptom severity in this study.

1.2.4 Autism Diagnostic Observation Schedule (ADOS)—The ADOS consists of a standard series of events (e.g., activities, conversations), observations, and codes of behavior that can yield a formal DSM IV/ICD-10 diagnosis of Autism. Specific domains that are assessed by the ADOS include social behaviors, communication, and restricted and repetitive behaviors. The ADOS yields scores on each of its subdomains; it also yields a summary score reflecting the severity of ASD symptomatology.

1.2.4 Social Communication Questionnaire, Lifetime (SCQ)—The SCQ is a 40-item, parent-report questionnaire used to screen for symptoms associated with ASD. This measure provides a total score that ranges from 0-40. Scores exceeding the cut-off score of 15 indicate that an individual may suffer from ASD and suggests that a more comprehensive diagnostic and psychological assessment should be completed.

1.2.5 The Conners Parent Rating Scale, Revised-Long (CPRS-R:L) and Conners Teacher Rating Scale, Revised-Long (CTRS-R:L)—The CPRS-R:L and CTRS-R:L was used to assess severity of ADHD symptomatology. The CPRS-R:L and CTRS-R:L are widely used screening measures to assess ADHD symptoms as well as symptoms of other behavioral and emotional disorders frequently associated with ADHD (e.g., oppositional behavior, social problems). The Conners scales are normed for children of ages 3-17 years. The CPRS-R:L and CTRS-R:L ADHD Index cut-off of 65 was used for ADHD diagnosis. The CPRS-R:L Global Index was used as the measure of overall ADHD symptom severity. This T-score was used because the Global Index score comprises the best set of items used for differentiating children and adolescents with ADHD symptoms from those without symptoms (Conners, 1997); therefore, we felt that this score would most efficiently highlight the severity of ADHD symptoms in each of the study's participants.

1.2.6 Children's Behavioral Checklist, Ages 6-18 (CBCL)—The CBCL (Ages 6-18) was used to assess comorbid psychiatric symptomatology using parent ratings. This questionnaire is a widely-used instrument normed for children ages 6-18 years. The 120-item scale yields several subscales including social withdrawal, somatic complaints, anxiety and depression, rule-breaking behavior, social problems, thought problems, attention problems, and aggressive behavior.

1.3 Procedure

Participants and their parents completed measures in a quiet, private clinic. To the extent possible, parents of children taking psychotropic medications were asked to complete their ratings with respect to when their children were not taking their psychiatric medication to better assess psychiatric symptomatology in the child's natural state.

2. Results

The statistical analyses were conducted using SPSS for Windows, Version 18.0 and JMP PRO Version 11.0. Given past research demonstrating that mental age affects the number of comorbid symptoms (Witwer & Lecavalier, 2010), mental age was used as a control variable in the regression analyses.

Distributions of all variables were examined prior to statistical analyses. Mental age, number of comorbid diagnoses, CBCL rule-breaking behavior and CBCL somatic complaints were the only variables that were highly skewed. To reduce skew, all of these variables were transformed using a $\ln(X)$ transformation except for the number of comorbid diagnoses, which was transformed using $\ln(X+1)$ since some children had no comorbid diagnoses. These transformed variables were used in all analyses.

2.1 Comorbid Diagnoses

Within this sample of children with ASD, ADHD was the most frequent comorbid diagnosis with 86% of subjects also meeting criteria for a comorbid ADHD diagnosis. The next most frequent diagnoses were Specific Phobias, Oppositional Defiant Disorder, and Obsessive Compulsive Disorder, (see Table 2 for the frequency of all comorbid diagnoses in the overall sample). As seen in Table 3, the overall sample had a mean of 1.03 comorbid diagnosis, excluding ADHD, with the range of 0 to 5.

Table 4 shows the Pearson correlations among number of comorbid diagnoses, ADHD severity, and mental age. As can be seen in Table 4, the number of comorbid diagnoses were moderately and significantly correlated with ADHD and mental age. There was no evidence of a significant correlation between ASD severity and number of comorbid diagnoses. There was a negative correlation between mental age and ASD severity, suggesting that children with higher MA's had less severe ASD symptomatology.

The data were further analyzed using multiple regression techniques, with the total number of comorbid diagnoses as the dependent variable, ADHD severity and ASD severity as the primary variables, and mental age as a control variable. A preliminary analysis was conducted to test for an interaction between ADHD severity and ASD severity and there was no evidence for such an interaction, $F(1,94) = 1.37$, $p=0.24$. Therefore, subsequent analyses were done without the interaction term in the model. This analysis tested each predictor variable independently of each other.

Figure 1 shows a partial plot (Velleman & Welsch, 1981) of the relationship between ADHD severity and Number of Comorbid diagnoses. A partial plot shows the relationship between a regressor and the criterion with all other regressors partialled out of both the regressor and

the criterion. A partial plot is preferable to a plot of raw scores because it shows the relationship that is tested by the regression model.

As can be seen in Figure 1, the relationship between ADHD severity and the number of comorbid diagnoses was positive with a partial slope was .011 and an incremental R^2 of .082, $F(1,95)=9.04$, $p=.003$. Figure 2 shows a partial plot of the relationship between ASD and the number of comorbid diagnoses. This relationship was practically zero and was not significant, partial slope=-0.002, incremental $R^2=.002$, $F(1,95)=0.24$, $p=.628$. Mental age was significantly related to the number of comorbid diagnoses, partial slope=0.302, incremental $R^2=.045$, $F(1,95)=4.88$, $p=.029$. Thus, as ADHD severity increases, there is a higher likelihood of having more comorbid psychiatric diagnoses—but no higher likelihood of having more severe ASD symptoms.

2.2 CBCL Symptom Severity

Table 5 shows Pearson correlations between number of comorbid diagnoses, ADHD Severity, ASD Severity, and Mental Age with the CBCL subscales. ADHD severity was positively and significantly correlated ($p<0.02$) with all the subscales except for the withdrawn subscale which was positive but not significant, $p = 0.067$. None of the CBCL subscale scores were significantly correlated with ASD severity, all p 's > 0.20 . Mental age was significantly and positively correlated with anxiety/depression ($p<.01$) and social problems ($p=.014$), but was not significantly correlated with any of the other CBCL scales. Thus, higher functioning children appear to be at higher risk for anxiety/depress and social problems.

We chose *a priori* to use multivariate multiple regression to analyze the effects of ADHD severity and ASD severity on CBCL symptomatology severity using eight CBCL subscale T-scores as dependent variables: anxious/depressed, withdrawn, somatic complaints, social problems, thought problems, attention problems, rule breaking behavior, and aggressive behavior with mental age as a control variable. This analysis tested each predictor variable independently of each other. ADHD severity was significantly related to a linear combination of CBCL scales, $F(8, 88)=23.56$, $p<.001$, with 68% of the variance explained (1- *Wilks' Lambda*). Also significant was the relationship between mental age and symptomatology severity, $F(8, 88)=2.78$, $p=.009$, with 20% of the variance explained. In contrast, ASD severity was not significantly related to CBCL symptoms, $F(8, 88)=1.17$, $p=.325$, with 10% of the variance explained.

Figures 3 and 4 use CBCL Total scores to illustrate the effects graphically. These figures are based on a multiple regression in which CBCL total was predicted by ADHD severity, ASD severity and mental age, the same predictors as used in the multivariate multiple regression. The results of this analysis were essentially identical to those from the multivariate multiple regression (p 's for ADHD severity, mental age, and ADSD severity were <0.001 , 0.009 , and 0.266 respectively). The advantage of using CBCL Total in the figures is that the alternative of using the canonical variables from the multivariate analysis would portray the relationships as stronger than they actually are since the multivariate analysis is more able to take advantage of sampling fluctuations than is univariate analysis (the inferential statistics

take this into account so are valid for both the multivariate multiple regression and multiple regression with one dependent variable).

As can be seen in Figure 3, the relationship between ADHD severity CBCL Total was strongly positive. Figure 4 shows that there is no evidence of a relationship between CBCL total and ASD Severity.

This analysis was followed by univariate tests of individual CBCL subscales, with severity of ADHD and ASD as primary variables, and using mental age as a control. Severity of ADHD was significantly related to the CBCL subscales of anxious/depressed, $F=16.81$, $p<.001$, log(somatic complaints), $F=13.54$, $p<.001$, social problems, $F=49.75$, $p<.001$, thought problems, $F=28.05$, $p<.001$, attention problems, $F=77.01$, $p<.001$, log(rule breaking), $F=32.85$, $p<.001$, and aggressive behavior, $F=106.04$, $p<.001$. There was a strong hint of a relationship with withdrawal, $F=3.68$, $p=.056$. In contrast, ASD severity was not significantly related to any levels of CBCL symptomatology. The two lowest p values were for log(somatic complaints) with a p of 0.074 and thought problems with a p of 0.094. All other p 's were above 0.25. Mental age was positively and significantly related to scores on the CBCL subscales of anxiousness/depressed, $F=20.14$, $p<.001$, social problems, $F=9.60$, $p=.003$, and log(somatic complaint, $F=3.96$, $p=.029$, but not with any other subscales scores, all p 's > 0.20 .

3. Discussion

The present study confirmed the exceedingly high rate of clinically significant ADHD symptoms in children with ASD. In fact, 86% of our ASD group also met DSM-IV-TR criteria for a comorbid diagnosis of ADHD. It is important to note that this sample was recruited to mirror the general school-age population of children with ASD (i.e., no attempt was made to "hyperrecruit" children with ASD who also had ADHD). These ADHD prevalence rates in ASD are consistent with other studies [e.g., 87% (Ames & White, 2011); 83% (Frazier et al., 2001); 53% (Sinzig, Walter, & Doepfner, 2009)]. Although some studies have found lower rates of ADHD in those with ASD (e.g., Simonoff et al., 2008), a benefit of the present study was the utilization of a thorough assessment battery for ADHD including parent diagnostic interviews (DICA-IV and clinical interview by licensed psychologist), parent and teacher rating scales, and clinic observations. The use of both parent and teacher ratings for determining ADHD diagnosis in the current study adheres to the DSM-IV requirement of demonstrating that symptoms are present in more than one setting. Additionally, this study used the gold standard, research-reliable assessment techniques for ASD diagnosis, including the ADI-R, ADOS, and clinical judgment of two licensed psychologists who are highly experienced in assessing ASD to determine a diagnosis.

Although the high rate of ADHD comorbidity within the pediatric ASD population has been well demonstrated, few studies have investigated whether the ADHD symptoms serve as a risk factor for additional comorbid conditions (e.g., Holtmann et al., 2007; Jang et al., 2013). As predicted, our results clearly indicate that greater ADHD severity was significantly related to greater numbers of total comorbid diagnoses (including Disruptive Behavioral

Disorders, Anxiety Disorders, Mood Disorders, Elimination Disorders, Eating Disorders, and Separation Anxiety Disorder), when controlling for mental age. On the other hand, greater levels of ASD severity were not significantly related to a higher number of total comorbid diagnoses. These results lend much support to the notion that the presence of ADHD symptoms, particularly severe symptoms, serves as a risk factor for greater comorbid psychiatric problems in children with ASD. If ADHD is a major factor associated with psychiatric concerns in those with ASD, then ADHD symptoms have important and distinct clinical implications in the assessment and treatment of children with ASD.

ADHD symptom severity was associated with greater psychiatric symptoms in this study; however, we did not directly examine the underlying contributing factors. An extensive body of research has suggested that ADHD symptoms can negatively affect social, emotional, and behavioral aspects of a child's life. For example, Wehmeier, Schacht, and Barkley (2010) note that because ADHD significantly undermines executive functioning, most ADHD children with this diagnosis experience more impulsive and severe emotional reactions towards events compared to others their age. Likewise, approximately 25% of children with ADHD also develop conduct disorder due to this challenge of appropriately expressing emotions (e.g., anger, hostility, and frustration) initiated by their ADHD diagnosis (Barkley, 2014). Additionally, children and adolescents with ADHD are known to have underdeveloped social and communication skills, when compared to other children without ADHD (Klimkeit et al., 2006); this pattern may lead to difficulties establishing and maintaining positive relationships with peers and family. The resulting social isolation may possibly increase a child's susceptibility to developing additional psychiatric symptoms. Although there are many reasons for such a high comorbidity rate within the ADHD population, research suggests that shared genetic risks or exposure to repeated social stressors may also be contributing factors. Based on these previous findings, it can be argued that ADHD enhances the vulnerability of a child with ASD to developing other psychiatric symptoms, such as depression, anxiety, and ODD.

Not only did we find that a greater number of concurrent diagnoses were associated with ADHD, but we also found that more severe ADHD symptoms led to greater severity of other psychiatric symptoms in those with ASD. Specifically, we found that those with higher levels of ADHD had higher levels of parent-rated anxiety/depression, somatic complaints, social problems, thought problems, attention problems, and oppositional behaviors (e.g., rule breaking and aggression) as rated with the CBCL. Again, there was no evidence that ASD severity as measured by the ADI-R and ADOS contributes to increases in the severity of these symptoms. These findings are consistent with past research demonstrating the impact of ADHD symptoms on comorbid symptoms in those with ASD (Jang et al., 2013, Guttman-Steinmetz et al., 2009). Our findings also demonstrated that ADHD severity did not contribute to greater levels of withdrawn/depressed symptoms in those with ASD.

Although we hypothesized that greater ADHD severity would contribute to greater comorbidities and greater psychiatric impairment, it was a surprising finding that ASD severity (by itself) did not significantly contribute to more severe psychiatric symptomatology. Indeed, ASD symptoms alone are impairing and would theoretically lead to greater overall psychopathology. Many researchers have hypothesized that it is the

comorbidity of ASD and another behavioral or emotional concern together that leads to greater functional impairments in children (as noted in Leitner, 2014). Interestingly, symptoms of autism have been noted to be associated with greater impairments in social, family, and cognitive functioning (Geurts et al., 2008; Kotte, et al., 2013). However, these studies tended to examine ASD symptoms by comparing symptoms in populations with and without ASD.

Prior to the DSM-5, the DSM-IV-TR precluded a comorbid diagnosis of ADHD in those with ASD; however, the current DSM-5 criterion acknowledges the well-established and high concurrence of ADHD symptoms in those with ASD, as well as the importance of identifying these as separate conditions. Our findings support this important paradigm shift in the diagnosis and treatment of children with both ASD and ADHD. Given the distinct symptoms associated with these conditions, these symptoms should receive separate clinical focus and treatment (Gargaro et al., 2011). Additionally this paradigm shift may improve the accuracy of diagnosing ASD, in that it is important to identify all the comorbid conditions that may overlap or even better account for some of the symptoms of ASD (Gillberg & Fernell 2014).

Furthermore, the diagnostic updates in DSM-5 highlights the importance of determining whether any comorbid diagnoses (e.g., ADHD) exist prior to initiating treatment within the ASD population. In particular, given the high prevalence rate of ADHD in pediatric ASD, it is very important to assess ADHD symptom severity in this population. Our results further suggest that a diagnosis of ADHD in children with ASD may place such a child at higher risk for additional comorbid symptomatology, which needs to be carefully explored. This finding may lead clinicians to consider employing more intensive treatment techniques, whether psychiatric, psychological, or educational, to appropriately manage greater levels of psychiatric symptomatology when working with children with ASD who also have severe ADHD symptomatology.

Interestingly, the present study found that severity of ASD symptomatology was not associated with greater psychiatric symptomatology. This finding once again highlights the importance of assessing the severity of ADHD in children with comorbid ASD-ADHD rather than just ASD severity, given that ADHD symptom severity appears to be a strong indicator of further psychiatric symptomatology.

4. Limitations

The sample size did not lend itself to including all psychiatric diagnostic categories used in the general linear model; therefore, these diagnoses were not included in our analyses. Perhaps when replicating this study with a larger sample, it may be of interest to determine whether ADHD severity significantly predicted other specific comorbid psychiatric disorders. It was also beyond the scope of this current study to assess the impact of ADHD presentation types (e.g., combined presentation, predominately inattentive presentation, and predominantly hyperactive/impulsive presentation) on number of comorbid psychiatric diagnoses or level of symptom severity. However, investigating whether all three ADHD presentations are significantly associated with number of comorbid diagnoses and/or the

severity of the comorbid symptomatology could potentially greatly inform intervention for children with comorbid ASD and ADHD.

As noted in Pearson et al. (2013), the children seen in this study were higher functioning (e.g., mean IQ=84) relative to the broader functional spectrum of ASD. As a result, generalization of our results may be limited to relatively higher functioning children with ASD. It is interesting to note, that previous studies (e.g., Pearson et al., 2006; Witwer & Lecavalier, 2010) have found differing patterns of psychopathology in children with ASD of various different functional profiles. Although it is beyond the scope of this project to undertake a systematic analysis of functional status and patterns of psychopathology, researchers attempting to replicate the findings of this study in a larger sample may wish to explore this issue that has clear clinical implications. It is clearly an issue that warrants further investigation.

Additionally, our study examined the effects of ADHD symptoms within a sample of children with ASD who had a high rate of ADHD (even though they were not selectively recruited for it). Thus, a potential limitation of our study is that it did not include a large number of children with ASD who did not have significant ADHD symptoms, nor did it include children without ASD and without ASD or ADHD. Although it was beyond the scope of this investigation to do so, future studies including non-ASD and non-ASD-ADHD groups to more fully examine the effects of ADHD symptom severity (Rommelse, 2011).

5. Conclusion

Previous research has noted that comorbid ADHD presents additional risk in youth with ASD and is supported by the findings of this study. In this sample, greater levels of ADHD severity were significantly related to greater numbers of comorbid psychiatric diagnoses. This study also found that higher levels of ADHD symptom severity was associated with higher levels of anxiety and depression, somatic complaints, aggressive behavior, and social, thought, and attention problems, as measured by the CBCL. These findings may encourage clinicians to thoroughly assess ADHD symptomatology in ASD children to better inform treatment planning.

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Figure 1.

The relationship between ADHD Severity and the Number of Co-Morbid Diagnoses. The X-axis contains residuals of ADHD Severity partialling out Mental Age and ASD Severity with the mean ADHD Severity added to maintain the consistency of the scale. The Y-axis contains residuals of Log (Number of Co-Morbid Diagnoses +1) partialling out Mental Age and ASD Severity with the mean Log (Number of Co-Morbid Diagnoses +1) added to maintain the consistency of the scale. The slope of the line (0.11) is equal to the partial slope in the multiple regression analysis.

Figure 2.

Partial plot of the relationship between ASD Severity and Log (Number of Co-Morbid Diagnoses +1). The X-axis contains residuals of ASD Severity partialling out Mental Age and ADHD Severity with the mean ASD Severity added to maintain the consistency of the scale. The Y-axis contains residuals of Log (Number of Co-Morbid Diagnoses +1) partialling out Mental Age and ADHD Severity with the mean Log (Number of Co-Morbid Diagnoses +1) added to maintain the consistency of the scale. The slope of the line (-0.002) is equal to the partial slope in the multiple regression analysis.

Figure 3.

Partial plot of the relationship between ADHD Severity and CBCLTotal. The X-axis contains residuals of ADHD Severity partialling out Mental Age and ASD Severity with the mean ADHD Severity added to maintain the consistency of the scale. The Y-axis contains residuals of CBCL total score partialling out Mental Age and ASD Severity with the mean CBCL total score added to maintain the consistency of the scale. The slope of the line (2.66) is equal to the partial slope in the multiple regression analysis.

Figure 4.

Partial plot of the relationship between ASD Severity and CBCLTotal. The X-axis contains residuals of ASD Severity partialling out Mental Age and ADHD Severity with the mean ASD Severity added to maintain the consistency of the scale. The Y-axis contains residuals of CBCL total score partialling out Mental Age and ADHD Severity with the mean CBCL total score added to maintain the consistency of the scale. The slope of the line (0.375) is equal to the partial slope in the multiple regression analysis.

Table 1

Participant Characteristics

Characteristics	n	%
Gender		
Male	78	78.8
Female	21	21.2
Autism Diagnosis		
Autistic Disorder	60	60.6
Asperger's	18	18.2
PDD-NOS	21	21.2
Race/ethnicity		
Caucasian	60	60.6
African American	16	16.2
Hispanic	17	17.2
Asian	5	5.1
"Other" or no data provided	1	1.0
	<i>Mean (range)</i>	<i>SD</i>
Age (years)	9.37 (6.67–13.5)	1.8
SB5 FSIQ	83.74 (46–128)	20.1
SB5 FS AE (mental age in years)	7.88 (3.1–21)	3.3
ADI-R Sum of Subscales	47.83 (23–66)	11.0
CPRS Global Index T Score	68.72 (37–90)	13.3
CTRS Global Index T Score	67.76 (45–90)	

Note. Total sample: n=99.

Table 2

Comorbid Diagnoses Assessed

Disorder/Subtype	n	%
ADHD	85	86
Predominantly Inattentive Subtype	21	21
Predominantly Hyperactive-Impulsive Subtype	1	1
Combined Subtype	63	64
Specific Phobia	33	33
Oppositional Defiant Diagnosis	21	21
Obsessive Compulsive Disorder	15	15
Enuresis	11	11
Social Phobia	6	6
Encopresis	5	5
Dysthymic Disorder	3	3
Conduct Disorder	2	2
Generalized Anxiety Disorder	2	2
Major Depressive Disorder	1	1
Separation Anxiety Disorder	1	1
Anxiety Disorder-Not Otherwise Specified	1	1
Anorexia Nervosa	1	1
Panic Disorder	0	0
Post-Traumatic Stress Disorder	0	0
Somatization Disorder	0	0
Bulimia Nervosa	0	0

Note. Total sample: n=99.

Table 3

Frequency of Comorbid Diagnoses

Number of Comorbid Diagnoses Present	n	%
0	5	5%
1	94	95%
2	56	57%
3	22	22%
4	12	12%
5	4	4%

Note. Total sample: n=99.

Table 4

Correlations Matrix with Transformed Comorbidities, ADHD and ASD Severity Scales, and Transformed Mental Age

Variable	Number of Comorbid Diagnoses (Transformed)	ADHD Severity	ASD Severity	Mental Age (Transformed)
Number of Comorbid Diagnoses (Transformed)	1.00	.28 *	-.10	.22 *
ADHD Severity	.28 *	1.00	-.03	-.02
ASD Severity	-.10	-.03	1.00	-.22 *
Mental Age (Transformed)	.22 *	-.02	-.22 *	1.00

Note.

*
p=.03,

**
p<.01.

Table 5
Correlations Matrix with CBCL Variables, Transformed Comorbidities, ADHD and Autism Severity, and Transformed Mental Age

	CBCL Subscales							
Variable	Anxious/ Depressed	Withdrawn/ Depressed	Somatic Complaints	Social Problems	Thought Problems	Attention Problems	Rule Breaking Behaviors	Aggressive Behavior
Number of Comorbid Diagnoses (Transformed)	.40**	.29*	.24*	.29**	.33**	.08	.32**	.29**
ADHD Severity	.35**	.19	.33**	.56**	.47**	.67**	.51**	.72**
ASD Severity	-.04	.08	.12	-.08	.13	.07	-.11	-.08
Mental Age (Transformed)	.38**	.10	.15	.25*	.01	-.06	.02	.08

Note.

* p<.02,

** p<0.0