The Impact of Co-occurring ADHD on Core Symptoms and Treatment Among Youth with Autism Spectrum Disorder

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Project Overview

Individuals with autism spectrum disorder (ASD) constitute an extremely heterogeneous group with highly variable clinical and psychological features. In the nearly eight decades since Leo Kanner's earliest descriptions of infantile autism (1943) and Hans Asperger's original report (1944), there have been significant changes in the way autism is conceptualized, diagnosed, and treated. These changes are the product of the myriad empirical investigations that have informed understanding of autism, multiple revisions of the Diagnostic and Statistical Manual, and theory-driven approaches to ameliorating symptoms associated with the disorder. Despite this progress, the immense heterogeneity that characterizes the autism spectrum contributes to challenges in diagnostic and treatment efforts. One critical source of such heterogeneity is psychiatric comorbidity, as the presence of co-occurring symptoms and disorders can impact symptom presentation and complicate treatment efforts. The comorbidity of autism and attention-deficit/ hyperactivity disorder (ADHD) is of particular interest, given its high prevalence, suspected impact on several domains of functioning, and its potential to pejoratively impact developmental outcomes. Increased knowledge about this comorbidity will contribute to our understanding of the observed heterogeneity within the autism spectrum. This understanding may drive identification of subgroups within autism that will allow us to tailor treatments to groups that may be best responders. Thus, it is critical to understand the history and current state of the evidence regarding the comorbidity of autism and ADHD. This three-manuscript dissertation series explores the ASD/ADHD comorbidity, the relationship between ADHD symptoms and core social and sensory symptoms in autism, and evaluates the impact of ADHD symptoms on treatment outcomes for a social competence intervention for youth with ASD.

Autism as a Disorder: From Past to Present

Autism was first introduced as a disorder in the third edition of Diagnostic and Statistical Manual (DSM-III; American Psychiatric Association, 1980) as "infantile autism" and was characterized by the pervasive lack of social responsiveness described by Kanner. The disorder was monothetic (e.g., required that all criteria be met) and considered to be rare, with an estimated prevalence of 3 in 10,000 (Treffert, 1970). By 1985 nearly 1000 research papers on autism had been published and many indicated concern about the inflexibility of the diagnostic criteria in light of evidence that the presentation of the disorder could change with intervention and throughout the lifespan (Rosen et al., 2021). These findings prompted the shift to a developmentally-oriented, polythetic set of 16 criteria in the revision of the DSM (DSM-III-R, American Psychiatric Association, 1987) for what became called "autistic disorder." The 16 criteria were grouped into three domains including, (1) qualitative impairments in reciprocal social interaction, (2) impairments in communication, and (3) restricted interests/resistance to change and repetitive movements, and diagnosis required at least eight symptoms, with two from the social domain and one from each of the others. Individuals who met some, but not all of these criteria, fell into a subcategory called Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS). Following publication of the revision, several studies suggested that the concept of PDD-NOS was too broad and the World Health Organization opted to include "subcategories" of autism in the 10th edition of International Classification of Diseases (ICD-10; World Health Organization 1992). These subcategories (e.g., Rett's disorder, childhood disintegrative disorder, Asperger's) were not included in DSM-III-R and differing diagnostic systems held the potential to hinder research efforts. Thus, international field trials were conducted to rigorously test the diagnostic criteria (Spitzer & Siegel, 1990; Volkmar et al.,

1994). Results confirmed that the classification system was overly broad and supported subcategories of Asperger's disorder and PDD-NOS within the three-domain diagnostic model that were included in DSM-IV (American Psychiatric Association, 1994).

The years following publication of DSM-IV were characterized by immense research efforts that ultimately highlighted problems with the diagnostic subgroups and three-domain diagnostic model. There was significant variability in the quantity and severity of symptoms within and between diagnostic subcategories with similar presentations (Fernell et al., 2010; Snow & Lecavalier, 2011) and poor diagnostic clarity and compromised diagnostic reliability (Lord et al., 2012; Lord et al., 2000). Such issues prompted a thorough review of the literature that revealed limited empirical support for a categorical conceptualization of autism and an inconsistent relationship between the core social, language, and behavioral features (Mandy & Skuse, 2008). Clinical and theoretical perspectives on autism suggested that core social symptoms of autism were related to issues of communication and reciprocity, rather than disorder-specific language deficits (Baird et al., 2008; Gotham et al., 2007). Additionally, sensory problems were commonly observed in autism and research suggested that sensory differences may differentiate autism from other disorders (Billstedt et al., 2007; Wiggins et al., 2009). These perspectives motivated further study of the diagnostic model of autism and several factor analytic studies were conducted. Results indicated that a two-factor diagnostic model, comprised of a social communication factor and repetitive/restricted behavior factor, was superior to other diagnostic models (Frazier et al., 2012; Mandy et al., 2012; Mandy & Skuse, 2008). These studies also supported the removal of delayed language as a diagnostic criteria, the conceptualization of stereotyped language as a repetitive/restricted behavior, and the consolidation of the social interaction and communication domains (Frazier et al., 2012; Mandy

et al., 2012; Mandy & Skuse, 2008). Additionally, research supported the notion of conceptualizing sensory abnormalities under the repetitive/restricted behavior domain (Chen et al., 2009) and factor analytic studies confirmed this and revealed improved diagnostic sensitivity with its inclusion (Frazier et al., 2012; Mandy et al., 2012). Taken together, these efforts and associated findings catalyzed the most significant revision in the diagnostic criteria to date, and "autism spectrum disorder" became conceptualized as a single condition within a dimensional framework defined by two symptom domains.

At present, ASD is considered a lifelong disorder that affects one in 54 individuals (Maenner et al., 2020) and is defined by core impairments in social communication and social interaction, and the presence of restricted, repetitive behaviors, interests, or activities (American Psychiatric Association, 2013). While the dimensional approach of DSM-5 achieved increased sensitivity and specificity regarding core symptoms of ASD, the disorder remains characterized by significant heterogeneity. This heterogeneity is observed at various levels including genetics, neural systems, cognition, language, behavior, and development (Bernard Paulais et al., 2019), and complicates assessment, differential diagnosis, and treatment provision.

Cognitive abilities in ASD are highly variable, as 30-40% of individuals meet criteria for an intellectual disability (ID; Bernard Paulais et al., 2019; Brown et al., 2017; Christensen et al., 2016) and others show superior cognitive abilities (Crespi, 2016). There is a strong relationship between ASD symptom severity and IQ (Gotham et al., 2007), and individuals with ID may have fewer strategies to compensate for the specific deficits due to ASD (Lord & Jones, 2012). Similarly, language development is extremely variable is autism, as many individuals are fluent speakers and 25-35% of individuals remain minimally- or nonverbal throughout the lifespan (Boucher, 2012; Rose et al., 2016). Language abilities are associated with both ASD symptom

severity and cognitive ability (Lord & Jones, 2012). Co-occurring psychiatric disorders serve to further complicate the picture of autism and influence clinical presentations, developmental trajectories, treatment planning, and outcomes. They are common among individuals with ASD and estimates suggests that 63–78% of individuals with ASD have at least one co-occurring psychiatric condition (Simonoff et al., 2008). The most common co-occurring conditions are ADHD, anxiety disorders, depressive disorders, and conduct-related disorders (Hollocks et al., 2019; Lugo-Marín et al., 2019; Simonoff et al., 2008).

ADHD is one of the most common comorbid disorders in ASD and it has been estimated that as many as 85% of children and adolescents with ASD meet criteria for ADHD (Lecavalier et al., 2019; Murray, 2010; Van Der Meer et al., 2012). Both ADHD (Visser et al., 2014) and ASD (Baio et al., 2018) are increasing in prevalence and the symptoms and impairments of both conditions often persist into adulthood. The relationship between ASD and ADHD has been complicated as a result of the changing conceptualization and diagnostic practices of autism over the last few decades. The comorbidity holds far-reaching implications for research, diagnostic, and treatment efforts.

ASD and ADHD: From Mutual Exclusivity to High Comorbidity

In previous version of the DSM up until publication of DSM-5, a comorbid diagnosis of ADHD in autism was precluded. These now highly comorbid neurodevelopmental disorders were studied separately for many years, despite the significant overlap in behavioral presentations associated with the disorders. Thus, most research on the comorbidity has occurred over the last decade and findings suggest big implications and even bigger remaining questions.

ASD and ADHD are the most common neurodevelopmental disorders and are defined by distinct diagnostic criteria that do not overlap. Despite the differences in the core symptoms,

several studies have reported elevated levels of autistic symptoms in youth with ADHD (Grzadzinski et al., 2011, 2016; Martin et al., 2014) and vice versa (Gadow et al., 2006; Simonoff et al., 2008; Yerys et al., 2009). Both disorders are associated with attention problems and hyperactivity/impulsivity (Ghirardi et al., 2019; Taylor et al., 2015), social problems and peer difficulties (Avni et al., 2018; Kern et al., 2015), and atypical sensory processing (Ahmad Ghanizadeh, 2011; Panagiotidi et al., 2018). It has been suggested that when the disorders co-occur, there is an additive effect on symptom expression (Ames & White, 2011; Antshel et al., 2016; Gargaro et al., 2011; Goldstein & Schwebach, 2004; Matson et al., 2010). Research has shown that individuals affected by the ASD/ADHD comorbidity display more severe behavior problems (Goldin et al., 2013; Guttmann-Steinmetz et al., 2009; Jang et al., 2013; Mulligan et al., 2009), lower adaptive functioning (Rao & Landa, 2014; Sikora et al., 2012), worse executive functioning (Yerys et al., 2010), and more severe symptoms of autism compared to either disorder alone (Sprenger et al., 2013).

The ASD/ADHD Comorbidity and Social Impairment

While it has been suggested that youth with the ASD/ADHD comorbidity display greater social problems compared to youth with ASD alone, this has not been consistently demonstrated in the literature. Studies comparing individuals with ASD + ADHD to those with ASD or ADHD alone have yielded contradictory results. Some have found greater global impairment across social domains (Rao & Landa, 2014), particular problems with social communication and social awareness (Factor et al., 2017), and worse social adaptation (Avni et al., 2018). Conversely, others have not revealed significant differences between youth with ASD and those with ASD + ADHD (Dellapiazza, Audras-Torrent, et al., 2021; Salley et al., 2015).

In light of the mixed findings on social impairment amidst the ASD/ADHD comorbidity, the first paper is this dissertation series investigated social impairment using a multi-informant, multi-method approach among 282 children diagnosed with either ASD, ADHD, or ASD + ADHD. No significant differences in social impairment were found between the ASD and ASD + ADHD groups on either measure. This study contributes to the mixed findings in regard to social functioning amidst the ASD + ADHD comorbidity and suggests that differences in sample characteristics and measurement approaches contribute to inconsistent findings. Another explanation for mixed findings is that the executive functioning deficits observed in both ASD and ADHD may drive social performance-based difficulties and account for some inconsistency. An additional hypothesis regarding the possible additive effect of ADHD on social impairment in ASD proposes that the inattentive and hyperactive/impulsive symptoms in ADHD, and shared theory of mind deficits, contribute to social problems (Kern et al., 2015; Leitner, 2014; Sokolova et al., 2017). Thus, differences in the type and severity of ADHD symptoms may account for differential findings in regards to social impairment.

This study provides an important contribution to the growing body of literature on the impact of ADHD symptoms on core social symptoms of ASD. While research investigating the impact of the ASD/ADHD comorbidity within the social communication domain has been marked by inconsistencies, research within behavioral domain is characterized by more robust findings. Several prior studies have demonstrated a relationship between co-occurring ADHD symptoms and some of the core behavioral features of ASD. The hyperactive symptoms of ADHD are associated with increased stereotyped and repetitive behaviors (Avni et al., 2018; Polderman et al., 2013, 2014; Ronald et al., 2014; Sokolova et al., 2017; Zachor & Ben-Itzchak, 2013) and youth with ASD + ADHD have shown greater frequency and severity of repetitive and

restricted behaviors (Wodka et al., 2021). When considering findings regarding the impact of ADHD symptoms on core behavioral features of ASD, it is important to note that little research has focused on the sensory features that now fall within this domain. While there is a clear relationship between sensory symptoms and repetitive behaviors and restricted interests, the role of ADHD symptoms in the manifestation of sensory challenges remains largely unstudied. Research on the associations between ADHD symptoms and specific sensory symptoms is necessary to understand how the ASD/ADHD comorbidity impacts the full range of behavioral symptoms core to ASD.

ADHD and Sensory Processing in ASD

While sensory problems have long been associated with autism, it was not until DSM-5 that sensory problems were added to the diagnostic criteria for ASD (American Psychiatric Association, 2013). Sensory problems are among the most common complaints from individuals on the spectrum (Grandin, 2009; Gray et al., 2021) and are also quite common in ADHD. It is estimated that 50% of individuals with ADHD have sensory differences (Mimouni-Bloch et al., 2018) and that sensory problems are not associated with a specific subtype of ADHD (Engel-Yeger & Ziv-On, 2011; Pfeiffer et al., 2015). As sensory problems were not formally recognized as a core symptom of autism, and ADHD and autism were conceptualized at categorically distinct disorders without co-occurrence until DSM-5, there is a dearth of research on the relationship between ADHD symptoms, autism, and atypical sensory processing (SP).

Atypical SP has downstream effects on the development of attention (Baranek et al., 2018; Cascio et al., 2016; Dellapiazza et al., 2021), social skills (Baranek et al., 2013b; Thye et al., 2018), and on cognitive, emotional, and behavioral functioning (Glod et al., 2015) in individuals with ASD. In ADHD, atypical SP has been associated with differences in visual,

auditory, tactile, olfactory, and vestibular/proprioceptive processing (Ahmad Ghanizadeh, 2011; Keating et al., 2021). The limited research to date that has investigated the relationship between ADHD and atypical SP in autism suggests a definite relationship between ADHD symptoms and greater atypical SP, though the sensory domains affected differ. The relationship between ADHD symptoms and atypical SP in autism has most robustly been demonstrated within the auditory domain (Ashburner et al., 2008; Dellapiazza et al., 2021; Sanz-Cervera et al., 2017), though symptoms have also been associated with tactile SP (Ashburner et al., 2008), under-responsivity and sensory-seeking (Ashburner et al., 2008; Liss et al., 2006), vestibular and proprioceptive SP (Sanz-Cervera et al., 2017), and multisensory processing (Dellapiazza et al., 2021). Among the few studies conducted, different measures of SP and different theoretical models of SP contribute to differential findings. Additionally, studies have inconsistently included important covariates known to impact SP, including demographic (e.g., age, gender) and clinical characteristics (e.g., IQ, ASD severity, anxiety symptoms). The role of ADHD symptoms in sensory processing in autism when accounting for all of these factors has not been previously studied.

To address this gap in the literature, the second paper in this dissertation series investigated the relationship between ADHD symptoms and types of atypical SP among 2108 children and adolescents with ASD. The large study sample was characterized by diversity of age, gender, autism symptom severity, cognitive ability, and comorbid ADHD and anxiety symptom severity. This well-characterized sample allowed for the inclusion of covariates known to impact atypical SP, including age, gender, IQ, ASD symptom severity, and anxiety symptoms, within a multiple regression framework. Interactions between age and ADHD symptoms, and IQ and ADHD symptoms were evaluated in all models to determine if the effect of ADHD symptoms on different types of atypical SP varies by age or IQ,

ADHD symptoms, measured continuously, significantly predicted tactile sensitivity, taste/smell sensitivity, under-responsivity and sensory seeking, auditory filtering, and visual/auditory sensitivity, and overall atypical SP, even after controlling for relevant covariates. Age significantly moderated the relationship between ADHD symptoms and tactile sensitivity and taste/smell sensitivity, which suggests there may be important age-related differences between symptoms of ADHD and sensory problems among youth with autism.

The moderating role of age in the relationship between ADHD symptoms and tactile sensitivity suggests that these symptoms may be most strongly linked among younger children, as compared to older children. The relationship between ADHD symptoms and taste/smell sensitivity among youth with autism is novel, and consistent with studies demonstrating that youth with ADHD displayed more atypical SP within this domain (Cheung & Siu, 2009; Machado et al., 2016; Mimouni-Bloch et al., 2018). ADHD symptoms were most strongly associated with taste/smell sensitivity during early childhood and puberty. Both of these developmental periods are associated with emotional and behavioral regulation challenges, which may be linked to increased sensory reactivity. Additionally, this study provided new information about the specific relationship between ADHD symptoms and visual/auditory over-responsivity and builds on prior literature that has indicated a relationship with visual and auditory processing more broadly (Dellapiazza et al., 2021; Sanz-Cervera et al., 2017).

Notably, two sensory domains, low energy/weakness and movement sensitivity, were not significantly associated with ADHD symptoms in the autistic sample. One hypothesis of atypical SP in autism suggests that individuals falls into two clusters; one is explained by hyperactivity and characterized by sensory seeking, externalizing, and poor social behaviors, and the other explained by movement sensitivity and characterized by withdrawal and low energy/weak

behaviors (James et al., 2011). Results from this study suggest that ADHD symptoms may drive symptoms associated with the first cluster, and thus may not predict symptoms consistent with the second cluster. Further research on the relationship between ADHD symptoms and atypical SP in autism using cluster analysis is necessary to confirm this possible explanation.

The associations between ADHD symptoms and core symptoms of ASD may have important implications for treatment efforts. While evidence for treatments of the sensory symptoms observed in ASD is lacking (see Weitlauf et al., 2017 for review of evidence for sensory interventions), there are many established interventions with good empirical support that target the social behavioral difficulties that are core to ASD (Wolstencroft et al., 2018; Zheng et al., 2021). However, little is known about how ADHD affects treatment outcomes for youth with ASD. It has been suggested that youth with ASD + ADHD may benefit less from social interventions (Antshel et al., 2011; Barkley, 1997), but this is an area that is largely unstudied.

Treatment in the Context of the ASD/ADHD Comorbidity

Despite research supporting the notion that youth with ASD + ADHD display more severe ASD symptoms and poorer developmental outcomes across domains than those with ASD only (Guttmann-Steinmetz et al., 2009; Leitner, 2014; Rao & Landa, 2014; Sinzig et al., 2008; Sokolova et al., 2017; Yerys et al., 2010), very few studies have evaluated the effect of the comorbidity on treatment response. There are only two studies to date on this topic and results are conflicting. Antshel et al. (2011) found that youth 8-12 years-old with ASD + ADHD did not improve as a result of social skills treatment, while the other ASD treatment groups (i.e., ASD only and ASD + Anxiety) showed significant improvement following the 10-session social skills intervention. Conversely, Deckers et al. (2016) revealed that a naturalistic social skills training program produced significant improvement per parent and teacher report for youth age 8-12 with

ASD + ADHD and that ADHD symptoms did not moderate treatment outcomes. These conflicting findings may be attributed to the differences in intervention components and delivery method, participant characteristics (e.g., symptom level), or measurement approach for ADHD symptoms. These studies are limited by reliance on a single measure of social improvement that is solely based on parent or teacher and the lack of baseline comparisons of social symptoms.

Studies on social functioning and response to social intervention in the presence of the ASD/ADHD comorbidity have been mixed. To address the inconsistent findings regarding the impact of comorbid ADHD on social impairment in ASD, and the potential impact of the ASD/ADHD comorbidity on social treatment outcomes, the third paper in this dissertation series sought to accomplish two aims. The first aim to was to compare social functioning among youth with ASD and ASD + ADHD using several measures of social impairment to determine which measurement tools may be appropriate for detecting social differences attributed to the ASD/ADHD comorbidity. The second aim was to determine if youth with ASD and ASD + ADHD demonstrate similar treatment gains following a social skills intervention. Results from the first aim indicated that youth with ASD and ASD + ADHD displayed comparable social impairments at baseline in many domains. The ASD + ADHD group showed more severe impairments on a measure of social awareness, but not on other measures. The ASD group also showed more severe symptoms within the social communication domain of a diagnostic tool. This finding is in contrast to the results from the first paper in this dissertation series and may related to differences in sample characteristics. The study sample in this third paper was restricted to youth age 6-14 without intellectual disability (IQ $\geq$ 75) with solid language abilities. Conversely, the sample in my first paper included individuals age 2-17 with variable cognitive abilities (*M* IQ = 77.69) who had been referred for an autism diagnostic evaluation. This sample

may have presented with more cognitive and language deficits and functional impairments than the sample in my third paper. This may explain the lack of significant group differences in social functioning between the ASD and ASD + ADHD groups. Further research is needed to understand how age, IQ, language abilities, and level of co-occurring symptoms contribute to degree and quality of social impairment.

Results from the second aim of the third paper indicated that both youth with ASD and ASD + ADHD demonstrated significant improvement following a social competence intervention. Improvements were observed on global measures of social functioning, and specific measures of social communication, peer interaction, social reciprocity, social awareness, social cognition, and social motivation. No meaningful differences were observed in the level of social gains achieved by ASD versus ASD + ADHD groups, which suggests that youth with co-occurring ADHD may benefit similarly from this social competence intervention. As the intervention employed has been associated with meaningful improvements in executive functioning (Stichter et al., 2016), the structured, scaffolded teaching approach and recurring practice opportunities may be particularly appropriate for youth with the ASD/ADHD co-occurrence.

Implications of Three-Paper Dissertation Series

This three-paper dissertation examines several important gaps in the research literature on the comorbidity of ASD and ADHD and the impact it has on affected individuals. The findings from these investigations will provide important information to researchers and clinicians regarding the role that ADHD symptoms play in the presentation of core symptoms of ASD. These findings will aid the collective endeavor among professionals to parse out heterogeneity in efforts to match individuals with the most appropriate treatments based on the presentation of

their symptoms. Treatment appropriateness is influenced by the presence of comorbid disorders. As ADHD is among the most common comorbid disorders in ASD, we must determine the role that associated symptoms play in the presentation and treatment of autism.

The first paper in this series introduced the idea that measurement approaches are implicated in the inconsistent findings regarding how the ASD/ADHD comorbidity affects social impairment. The second paper determined that ADHD symptoms play a role in the presentation and severity of sensory symptoms, and that ADHD symptoms differentially impact sensory modalities and type of response to sensory stimuli. The third paper revealed that youth with ASD + ADHD display more severe impairments in social awareness, but may appear comparable in many other social domains. By contrast, youth with ASD without ADHD demonstrated greater impairment on the social communication domain of a diagnostic tool, which conflicts with results from the first paper in this series. Sample characteristics, such as age, IQ, language level, and degree of functional impairment may account for inconsistencies in findings regarding social impairment in youth with ASD and ASD + ADHD. Younger individuals with ASD or ASD + ADHD with cognitive and language limitations may present with similar social communication difficulties on the gold-standard diagnostic tool. In contrast, older individuals with ASD with solid cognitive and language skills may show more social communication problems than their counterparts with co-occurring ADHD on this measure of core autism symptoms. This third paper also showed that youth with ASD and ASD + ADHD both benefitted from a social competence intervention, as evidenced by significant improvement on several global and specific social measures. Co-occurring ADHD was not associated with poorer treatment response, which is promising.

Overall, the ASD/ADHD comorbidity may be associated with compounded social difficulties in the area of social awareness among school-age youth. Symptoms associated with ADHD may contribute to performance challenges in other social areas, and to over- and under-sensory responsivity within the tactile, auditory, visual, and gustatory/olfactory systems. Nonetheless, youth affected by the ASD/ADHD comorbidity appear to benefit from structured social interventions, similar to youth with ASD only.

References

Ames, C. S., & White, S. J. (2011). Brief report: Are ADHD traits dissociable from the autistic profile? Links between cognition and behaviour. *Journal of Autism and Developmental Disorders*, *41*(3), 357–363. https://doi.org/10.1007/s10803-010-1049-0

American Psychiatric Association (APA). (1980). Diagnostic and Statistical Manual of Mental Disorders, 3rd edition (DSM-III). Washington, DC: American Psychiatric Press.

American Psychiatric Association (APA). (1987). Diagnostic and Sta- tistical Manual of Mental Disorders, 3rd edition revised (DSM- III-R). Washington, DC: American Psychiatric Publishing.

American Psychiatric Association (APA). (1994). Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV). Washington, DC: American Psychiatric Publishing.

American Psychiatric Association (APA). (2013). Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5). Washington, DC: American Psychiatric Publishing.

Antshel, K. M., Polacek, C., McMahon, M., Dygert, K., Spenceley, L., Dygert, L., Miller, L., & Faisal, F. (2011). Comorbid ADHD and anxiety affect social skills group intervention treatment efficacy in children with autism spectrum disorders. *Journal of Developmental and Behavioral Pediatrics*, *32*(6), 439–446. https://doi.org/10.1097/DBP.0b013e318222355d

Antshel, K. M., Zhang-James, Y., Wagner, K. E., Ledesma, A., & Faraone, S. V. (2016). An update on the comorbidity of ADHD and ASD: a focus on clinical management. *Expert Review of Neurotherapeutics*, *16*(3), 279–293. https://doi.org/10.1586/14737175.2016.1146591

Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional,

behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy*, *62*(5), 564–573. https://doi.org/10.5014/ajot.62.5.564

Asperger, H. (1944). Die “autistichen Psychopathen” im Kinder- salter. Archive fur psychiatrie und Nervenkrankheiten, 117, 76–136.

Avni, E., Ben-itzchak, E., & Zachor, D. A. (2018). *The Presence of comorbid ADHD and anxiety symptoms in autism spectrum disorder : Clinical presentation and predictors*. *9*(December), 1–12. https://doi.org/10.3389/fpsyt.2018.00717

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., Kurzius-Spencer, M., Zahorodny, W., Robinson, C., Rosenberg, T., White, T., Durkin, M. S., Imm, P., Nikolaou, L., Yeargin-Allsopp, M., Lee, L.-C., Harrington, R., Lopez, M., Fitzgerald, R. T., … Dowling, N. F. (2018). Prevalence of autism spectrum disorder among children aged 8 years — Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2014. *MMWR. Surveillance Summaries*, *67*(6), 1–23. https://doi.org/10.15585/mmwr.ss6706a1

Baird, G., Charman, T., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., Carcani-Rathwell, I., Serkana, D., & Simonoff, E. (2008). Regression, developmental trajectory and associated problems in disorders in the autism spectrum: The SNAP study. *Journal of Autism and Developmental Disorders*, *38*(10), 1827–1836. https://doi.org/10.1007/s10803-008-0571-9

Baranek, G. T., Watson, L. R., Boyd, B. A., Poe, M. D., David, F. J., & McGuire, L. (2013). Hyporesponsiveness to social and nonsocial sensory stimuli in children with autism, children with developmental delays, and typically developing children. *Development and Psychopathology*, *25*(2), 307–320. https://doi.org/10.1017/S0954579412001071

Baranek, G. T., Woynaroski, T. G., Nowell, S., Turner-Brown, L., DuBay, M., Crais, E. R., &

Watson, L. R. (2018). Cascading effects of attention disengagement and sensory seeking on social symptoms in a community sample of infants at-risk for a future diagnosis of autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*, 30–40. https://doi.org/10.1016/j.dcn.2017.08.006

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Bernard Paulais, M. A., Mazetto, C., Thiébaut, E., Nassif, M. C., Costa Coelho De Souza, M. T., Stefani, A. P., Blanc, R., Gattegno, M. P., Aiad, F., Sam, N., Belal, L., Fekih, L., Kaye, K., Contejean, Y., Wendland, J., Barthelemy, C., Bonnet-Brilhault, F., & Adrien, J. L. (2019). Heterogeneities in cognitive and socio-emotional development in children with autism spectrum disorder and severe intellectual disability as a comorbidity. In *Frontiers in Psychiatry* (Vol. 10, Issue JUN, p. 508). Frontiers. https://doi.org/10.3389/fpsyt.2019.00508

Billstedt, E., Carina Gillberg, I., & Gillberg, C. (2007). Autism in adults: Symptom patterns and early childhood predictors. Use of the DISCO in a community sample followed from childhood. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(11), 1102–1110. https://doi.org/10.1111/j.1469-7610.2007.01774.x

Boucher, J. (2012). Research review: Structural language in autistic spectrum disorder - Characteristics and causes. In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 53, Issue 3, pp. 219–233). J Child Psychol Psychiatry. https://doi.org/10.1111/j.1469-7610.2011.02508.x

Brown, A. C., Chouinard, P. A., & Crewther, S. G. (2017). Vision research literature may not represent the full intellectual range of autism spectrum disorder. In *Frontiers in Human*

Neuroscience (Vol. 11, p. 57). Frontiers. https://doi.org/10.3389/fnhum.2017.00057

Cascio, C. J., Woynaroski, T., Baranek, G. T., & Wallace, M. T. (2016). Toward an interdisciplinary approach to understanding sensory function in autism spectrum disorder. In *Autism Research* (Vol. 9, Issue 9, pp. 920–925). John Wiley and Sons Inc. https://doi.org/10.1002/aur.1612

Chen, Y. H., Rodgers, J., & McConachie, H. (2009). Restricted and repetitive behaviours, sensory processing and cognitive style in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(4), 635–642. https://doi.org/10.1007/s10803-008-0663-6

Cheung, P. P. P., & Siu, A. M. H. (2009). A comparison of patterns of sensory processing in children with and without developmental disabilities. *Research in Developmental Disabilities*, *30*(6), 1468–1480. https://doi.org/10.1016/j.ridd.2009.07.009

Christensen, D. L., Baio, J., Van Naarden Braun, K., Bilder, D., Charles, J., Constantino, J. N., Daniels, J., Durkin, M. S., Fitzgerald, R. T., Kurzius-Spencer, M., Lee, L. C., Pettygrove, S., Robinson, C., Schulz, E., Wells, C., Wingate, M. S., Zahorodny, W., & Yeargin-Allsopp, M. (2016). Prevalence and characteristics of autism spectrum disorder among children aged 8 years - Autism and developmental disabilities monitoring network, 11 sites, United States, 2012. *MMWR Surveillance Summaries*, *65*(3), 1–23. https://doi.org/10.15585/mmwr.ss6503a1

Crespi, B. J. (2016). Autism as a disorder of high intelligence. *Frontiers in Neuroscience*, *10*(JUN). https://doi.org/10.3389/fnins.2016.00300

Dellapiazza, F., Audras-Torrent, L., Michelon, C., Baghdadli, A., & Baghdadli, A. (2021). Clinical characteristics of children with ASD and comorbid ADHD: Association with social

impairment and externalizing and internalizing behaviours. *Research in Developmental Disabilities*, *113*, 103930. https://doi.org/10.1016/j.ridd.2021.103930

Dellapiazza, F., Michelon, C., Vernhet, C., Muratori, F., Blanc, N., Picot, M. C., Baghdadli, A., Baghdadli, A., Chabaux, C., Chatel, C., Cohen, D., Damville, E., Geoffray, M. M., Gicquel, L., Jardri, R., Maffre, T., Novo, A., Odoyer, R., Oreve, M. J., … Vespirini, S. (2021). Sensory processing related to attention in children with ASD, ADHD, or typical development: results from the ELENA cohort. *European Child and Adolescent Psychiatry*, *30*(2), 283–291. https://doi.org/10.1007/s00787-020-01516-5

Engel-Yeger, B., & Ziv-On, D. (2011). The relationship between sensory processing difficulties and leisure activity preference of children with different types of ADHD. *Research in Developmental Disabilities*, *32*(3), 1154–1162. https://doi.org/10.1016/j.ridd.2011.01.008

Factor, R. S., Ryan, S. M., Farley, J. P., Ollendick, T. H., & Scarpa, A. (2017). Does the presence of anxiety and ADHD symptoms add to social impairment in children with autism spectrum disorder? *Journal of Autism and Developmental Disorders*, *47*(4), 1122–1134. https://doi.org/10.1007/s10803-016-3025-9

Fernell, E., Hedvall, Å., Norrelgen, F., Eriksson, M., Höglund-Carlsson, L., Barnevik-Olsson, M., Svensson, L., Holm, A., Westerlund, J., & Gillberg, C. (2010). Developmental profiles in preschool children with autism spectrum disorders referred for intervention. *Research in Developmental Disabilities*, *31*(3), 790–799. https://doi.org/10.1016/j.ridd.2010.02.003

Frazier, T. W., Youngstrom, E. A., Speer, L., Embacher, R., Law, P., Constantino, J., Findling, R. L., Hardan, A. Y., & Eng, C. (2012). Validation of proposed DSM-5 criteria for autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(1), 28–40. https://doi.org/10.1016/j.jaac.2011.09.021

Gadow, K. D., DeVincent, C. J., & Pomeroy, J. (2006). ADHD symptom subtypes in children with pervasive developmental disorder. *Journal of Autism and Developmental Disorders*, *36*(2), 271–283. https://doi.org/10.1007/s10803-005-0060-3

Gargaro, B. A., Rinehart, N. J., Bradshaw, J. L., Tonge, B. J., & Sheppard, D. M. (2011). Autism and ADHD: How far have we come in the comorbidity debate? *Neuroscience and Biobehavioral Reviews*, *35*(5), 1081–1088. https://doi.org/10.1016/j.neubiorev.2010.11.002

Ghanizadeh, A. (2011). Sensory processing problems in children with ADHD, a systematic review. *Psychiatry Investigation*, *8*(2), 89–94. https://doi.org/10.4306/pi.2011.8.2.89

Ghirardi, L., Pettersson, E., Taylor, M. J., Freitag, C. M., Franke, B., Asherson, P., Larsson, H., & Kuja-Halkola, R. (2019). Genetic and environmental contribution to the overlap between ADHD and ASD trait dimensions in young adults: A twin study. *Psychological Medicine*, *49*(10), 1713–1721. https://doi.org/10.1017/S003329171800243X

Glod, M., Riby, D. M., Honey, E., & Rodgers, J. (2015). Psychological correlates of sensory processing patterns in individuals with autism spectrum disorder: A systematic review. *Review Journal of Autism and Developmental Disorders*, *2*(2), 199–221. https://doi.org/10.1007/s40489-015-0047-8

Goldin, R. L., Matson, J. L., Tureck, K., Cervantes, P. E., & Jang, J. (2013). A comparison of tantrum behavior profiles in children with ASD, ADHD and comorbid ASD and ADHD. *Research in Developmental Disabilities*, *34*(9), 2669–2675. https://doi.org/10.1016/j.ridd.2013.04.022

Goldstein, S., & Schwebach, A. J. (2004). The comorbidity of pervasive developmental disorder and attention deficit hyperactivity disorder: Results of a retrospective chart review. *Journal of Autism and Developmental Disorders*, *34*(3), 329–339.

https://doi.org/10.1023/B:JADD.0000029554.46570.68

Gotham, K., Risi, S., Pickles, A., & Lord, C. (2007). The autism diagnostic observation schedule: Revised algorithms for improved diagnostic validity. In *Journal of Autism and Developmental Disorders* (Vol. 37, Issue 4, pp. 613–627). J Autism Dev Disord. https://doi.org/10.1007/s10803-006-0280-1

Grandin, T. (2009). Visual Abilities and Sensory Differences in a Person with Autism. *Biological Psychiatry*, *65*(1), 15–16. https://doi.org/10.1016/j.biopsych.2008.11.005

Gray, S., Kirby, A. V., & Holmes, L. G. (2021). Autistic Narratives of Sensory Features, Sexuality, and Relationships. *Https://Home.Liebertpub.Com/Aut*. https://doi.org/10.1089/AUT.2020.0049

Grzadzinski, R., Di Martino, A., Brady, E., Mairena, M. A., O'Neale, M., Petkova, E., Lord, C., & Castellanos, F. X. (2011). Examining autistic traits in children with ADHD: Does the Autism Spectrum Extend to ADHD? *Journal of Autism and Developmental Disorders*, *41*(9), 1178–1191. https://doi.org/10.1007/s10803-010-1135-3

Grzadzinski, R., Dick, C., Lord, C., & Bishop, S. (2016). Parent-reported and clinician-observed autism spectrum disorder (ASD) symptoms in children with attention deficit/hyperactivity disorder (ADHD): Implications for practice under DSM-5. *Molecular Autism*, *7*(1). https://doi.org/10.1186/s13229-016-0072-1

Guttmann-Steinmetz, S., Gadow, K. D., & DeVincent, C. J. (2009). Oppositional defiant and conduct disorder behaviors in boys with autism spectrum disorder with and without attention-deficit hyperactivity disorder versus several comparison samples. *Journal of Autism and Developmental Disorders*, *39*(7), 976–985. https://doi.org/10.1007/s10803-009-0706-7

Hollocks, M. J., Lerh, J. W., Magiati, I., Meiser-Stedman, R., & Brugha, T. S. (2019). Anxiety and depression in adults with autism spectrum disorder: A systematic review and meta-analysis. In *Psychological Medicine* (Vol. 49, Issue 4, pp. 559–572). https://doi.org/10.1017/S0033291718002283

James, K., Miller, L. J., Schaaf, R., Nielsen, D. M., & Schoen, S. A. (2011). Phenotypes within sensory modulation dysfunction. *Comprehensive Psychiatry*, *52*(6), 715–724. https://doi.org/10.1016/j.comppsych.2010.11.010

Jang, J., Matson, J. L., Williams, L. W., Tureck, K., Goldin, R. L., & Cervantes, P. E. (2013). Rates of comorbid symptoms in children with ASD, ADHD, and comorbid ASD and ADHD. *Research in Developmental Disabilities*, *34*(8), 2369–2378. https://doi.org/10.1016/j.ridd.2013.04.021

Kanner, L. (1943). Autistic disturbances of affective contact. Nerv- ous Child, 2(3), 217–250.

Keating, J., Gaffney, R., Bramham, J., & Downes, M. (2021). Sensory modulation difficulties and assessment in children with attention deficit hyperactivity disorder: A systematic review. In *European Journal of Developmental Psychology*. Routledge. https://doi.org/10.1080/17405629.2021.1889502

Kern, J. K., Geier, D. A., Sykes, L. K., Geier, M. R., & Deth, R. C. (2015). Are ASD and ADHD a Continuum? A Comparison of Pathophysiological Similarities Between the Disorders. *Journal of Attention Disorders*, *19*(9), 805–827. https://doi.org/10.1177/1087054712459886

Lecavalier, L., McCracken, C. E., Aman, M. G., McDougle, C. J., McCracken, J. T., Tierney, E., Smith, T., Johnson, C., King, B., Handen, B., Swiezy, N. B., Eugene Arnold, L., Bearss, K., Vitiello, B., & Scahill, L. (2019). An exploration of concomitant psychiatric disorders in children with autism spectrum disorder. *Comprehensive Psychiatry*, *88*, 57–64.

https://doi.org/10.1016/j.comppsych.2018.10.012

Leitner, Y. (2014). The Co-occurrence of autism and attention deficit hyperactivity disorder in children: What do we know? *Frontiers in Human Neuroscience*, *8*(April), 1–8. https://doi.org/10.3389/fnhum.2014.00268

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006). Sensory and attention abnormalities in autistic spectrum disorders. *Autism*, *10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Lord, C., & Jones, R. M. (2012). Annual research review: Re-thinking the classification of autism spectrum disorders. In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 53, Issue 5, pp. 490–509). J Child Psychol Psychiatry. https://doi.org/10.1111/j.1469-7610.2012.02547.x

Lord, C., Petkova, E., Hus, V., Gan, W., Lu, F., Martin, D. M., Ousley, O., Guy, L., Bernier, R., Gerdts, J., Algermissen, M., Whitaker, A., Sutcliffe, J. S., Warren, Z., Klin, A., Saulnier, C., Hanson, E., Hundley, R., Piggot, J., … Risi, S. (2012). A multisite study of the clinical diagnosis of different autism spectrum disorders. *Archives of General Psychiatry*, *69*(3), 306–313. https://doi.org/10.1001/archgenpsychiatry.2011.148

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., Dilavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism Diagnostic Observation Schedule-Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, *30*(3), 205–223. https://doi.org/10.1023/A:1005592401947

Lugo-Marín, J., Magán-Maganto, M., Rivero-Santana, A., Cuellar-Pompa, L., Alviani, M., Jenaro-Rio, C., Díez, E., & Canal-Bedia, R. (2019). Prevalence of psychiatric disorders in

adults with autism spectrum disorder: A systematic review and meta-analysis. In *Research in Autism Spectrum Disorders* (Vol. 59, pp. 22–33). Elsevier. https://doi.org/10.1016/j.rasd.2018.12.004

Machado, B. C., Dias, P., Lima, V. S., Campos, J., & Gonçalves, S. (2016). Prevalence and correlates of picky eating in preschool-aged children: A population-based study. *Eating Behaviors*, *22*, 16–21. https://doi.org/10.1016/j.eatbeh.2016.03.035

Maenner, M. J., Shaw, K. A., Baio, J., Washington, A., Patrick, M., DiRienzo, M., Christensen, D. L., Wiggins, L. D., Pettygrove, S., Andrews, J. G., Lopez, M., Hudson, A., Baroud, T., Schwenk, Y., White, T., Rosenberg, C. R., Lee, L. C., Harrington, R. A., Huston, M., … Dietz, P. M. (2020). Prevalence of autism spectrum disorder among children aged 8 Years-Autism and developmental disabilities monitoring network, 11 Sites, United States, 2016. *MMWR Surveillance Summaries*, *69*(4), 1–12. https://doi.org/10.15585/MMWR.SS6904A1

Mandy, W. P., Charman, T., & Skuse, D. H. (2012). Testing the construct validity of proposed criteria for DSM-5 autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(1), 41–50. https://doi.org/10.1016/j.jaac.2011.10.013

Mandy, W. P. L., & Skuse, D. H. (2008). Research Review: What is the association between the social-communication element of autism and repetitive interests, behaviours and activities? In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 49, Issue 8, pp. 795–808). https://doi.org/10.1111/j.1469-7610.2008.01911.x

Martin, J., Hamshere, M. L., O'Donovan, M. C., Rutter, M., & Thapar, A. (2014). Factor structure of autistic traits in children with ADHD. *Journal of Autism and Developmental Disorders*, *44*(1), 204–215. https://doi.org/10.1007/s10803-013-1865-0

Matson, J. L., Mahan, S., Hess, J. A., Fodstad, J. C., & Neal, D. (2010). Progression of

challenging behaviors in children and adolescents with Autism Spectrum Disorders as measured by the Autism Spectrum Disorders-Problem Behaviors for Children (ASD-PBC). *Research in Autism Spectrum Disorders*, *4*(3), 400–404. https://doi.org/10.1016/j.rasd.2009.10.010

Mimouni-Bloch, A., Offek, H., Rosenblum, S., Posener, I., Silman, Z., & Engel-Yeger, B. (2018). Association between sensory modulation and daily activity function of children with attention deficit/hyperactivity disorder and children with typical development. *Research in Developmental Disabilities*, *83*, 69–76. https://doi.org/10.1016/j.ridd.2018.08.002

Mulligan, A., Anney, R. J. L., O'Regan, M., Chen, W., Butler, L., Fitzgerald, M., Buitelaar, J., Steinhausen, H. C., Rothenberger, A., Minderaa, R., Nijmeijer, J., Hoekstra, P. J., Oades, R. D., Roeyers, H., Buschgens, C., Christiansen, H., Franke, B., Gabriels, I., Hartman, C., … Gill, M. (2009). Autism symptoms in attention-deficit/hyperactivity disorder: A familial trait which correlates with conduct, oppositional defiant, language and motor disorders. *Journal of Autism and Developmental Disorders*, *39*(2), 197–209. https://doi.org/10.1007/s10803-008-0621-3

Murray, M. J. (2010). Attention-deficit/Hyperactivity Disorder in the Context of Autism Spectrum Disorders. *Current Psychiatry Reports 2010 12:5*, *12*(5), 382–388. https://doi.org/10.1007/S11920-010-0145-3

Panagiotidi, M., Overton, P. G., & Stafford, T. (2018). The relationship between ADHD traits and sensory sensitivity in the general population. *Comprehensive Psychiatry*, *80*, 179–185. https://doi.org/10.1016/j.comppsych.2017.10.008

Pfeiffer, B., Daly, B. P., Nicholls, E. G., & Gullo, D. F. (2015). Assessing sensory processing problems in children with and without attention deficit hyperactivity disorder. *Physical and*

Occupational Therapy in Pediatrics, *35*(1), 1–12. https://doi.org/10.3109/01942638.2014.904471

Polderman, T. J. C., Hoekstra, R. A., Posthuma, D., & Larsson, H. (2014). The co-occurrence of autistic and ADHD dimensions in adults: An etiological study in 17 770 twins. *Translational Psychiatry*, *4*(9), e435. https://doi.org/10.1038/tp.2014.84

Polderman, T. J. C., Hoekstra, R. A., Vinkhuyzen, A. A. E., Sullivan, P. F., Van Der Sluis, S., & Posthuma, D. (2013). Attentional switching forms a genetic link between attention problems and autistic traits in adults. *Psychological Medicine*, *43*(9), 1985–1996. https://doi.org/10.1017/S0033291712002863

Rao, P. A., & Landa, R. J. (2014). Association between severity of behavioral phenotype and comorbid attention deficit hyperactivity disorder symptoms in children with autism spectrum disorders. *Autism*, *18*(3), 272–280. https://doi.org/10.1177/1362361312470494

Ronald, A., Larsson, H., Anckarsäter, H., & Lichtenstein, P. (2014). Symptoms of autism and ADHD: A Swedish twin study examining their overlap. *Journal of Abnormal Psychology*, *123*(2), 440–451. https://doi.org/10.1037/a0036088

Rose, V., Trembath, D., Keen, D., & Paynter, J. (2016). The proportion of minimally verbal children with autism spectrum disorder in a community-based early intervention programme. *Journal of Intellectual Disability Research*, *60*(5), 464–477. https://doi.org/10.1111/jir.12284

Rosen, N. E., Lord, C., & Volkmar, F. R. (2021). The Diagnosis of Autism: From Kanner to DSM-III to DSM-5 and Beyond. In *Journal of Autism and Developmental Disorders* (pp. 1–18). Springer. https://doi.org/10.1007/s10803-021-04904-1

Salley, B., Gabrielli, J., Smith, C. M., & Braun, M. (2015). Do communication and social

interaction skills differ across youth diagnosed with autism spectrum disorder, attention-deficit/hyperactivity disorder, or dual diagnosis? *Research in Autism Spectrum Disorders*, *20*, 58–66. https://doi.org/10.1016/j.rasd.2015.08.006

Sanz-Cervera, P., Pastor-Cerezuela, G., González-Sala, F., Tárraga-Mínguez, R., & Fernández-Andrés, M. I. (2017). Sensory processing in children with autism spectrum disorder and/or attention deficit hyperactivity disorder in the home and classroom contexts. *Frontiers in Psychology*, *8*, 1772. https://doi.org/10.3389/fpsyg.2017.01772

Sikora, D. M., Vora, P., Coury, D. L., & Rosenberg, D. (2012). Attention-deficit/hyperactivity disorder symptoms, adaptive functioning, and quality of life in children with autism spectrum disorder. *Pediatrics*, *130*(Supplement 2), S91–S97. https://doi.org/10.1542/peds.2012-0900G

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008a). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008b). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f

Sinzig, J., Morsch, D., & Lehmkuhl, G. (2008). Do hyperactivity, impulsivity and inattention have an impact on the ability of facial affect recognition in children with autism and

ADHD? *European Child & Adolescent Psychiatry*, *17*(2), 63–72. https://doi.org/10.1007/s00787-007-0637-9

Snow, A. V., & Lecavalier, L. (2011). Comparing autism, PDD-NOS, and other developmental disabilities on parent-reported behavior problems: Little evidence for ASD subtype validity. *Journal of Autism and Developmental Disorders*, *41*(3), 302–310. https://doi.org/10.1007/s10803-010-1054-3

Sokolova, E., Oerlemans, A. M., Rommelse, N. N., Groot, P., Hartman, C. A., Glennon, J. C., Claassen, T., Heskes, T., & Buitelaar, J. K. (2017). A Causal and Mediation Analysis of the Comorbidity Between Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). *Journal of Autism and Developmental Disorders 2017 47:6*, *47*(6), 1595–1604. https://doi.org/10.1007/S10803-017-3083-7

Spitzer, R., & Siegel, B. (1990). The DSM-III-R Field Trial of Pervasive Developmental Disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *29*(6), 855–862. https://doi.org/10.1097/00004583-199011000-00003

Sprenger, L., Bühler, E., Poustka, L., Bach, C., Heinzel-Gutenbrunner, M., Kamp-Becker, I., & Bachmann, C. (2013). Impact of ADHD symptoms on autism spectrum disorder symptom severity. *Research in Developmental Disabilities*, *34*(10), 3545–3552. https://doi.org/10.1016/j.ridd.2013.07.028

Stichter, J. P., Christ, S. E., Herzog, M. J., O'Donnell, R. M., & O'Connor, K. V. (2016). Exploring the role of executive functioning measures for social competence research. *Assessment for Effective Intervention*, *41*(4), 243–254. https://doi.org/10.1177/1534508416644179

Taylor, M. J., Charman, T., & Ronald, A. (2015). Where are the strongest associations between

autistic traits and traits of ADHD? evidence from a community-based twin study. *European Child and Adolescent Psychiatry*, *24*(9), 1129–1138. https://doi.org/10.1007/s00787-014-0666-0

Thye, M. D., Bednarz, H. M., Herringshaw, A. J., Sartin, E. B., & Kana, R. K. (2018). The impact of atypical sensory processing on social impairments in autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*(September 2016), 151–167. https://doi.org/10.1016/j.dcn.2017.04.010

Van Der Meer, J. M. J., Oerlemans, A. M., Van Steijn, D. J., Lappenschaar, M. G. A., De Sonneville, L. M. J., Buitelaar, J. K., & Rommelse, N. N. J. (2012). NEW RESEARCH Are Autism Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder Different Manifestations of One Overarching Disorder? Cognitive and Symptom Evidence From a Clinical and Population-Based Sample. *JAAC*, *51*(11), 1160-1172.e3. https://doi.org/10.1016/j.jaac.2012.08.024

Visser, S. N., Danielson, M. L., Bitsko, R. H., Holbrook, J. R., Kogan, M. D., Ghandour, R. M., Perou, R., & Blumberg, S. J. (2014). NEW RESEARCH Trends in the Parent-Report of Health Care Provider-Diagnosed and Medicated Attention-Deficit/Hyperactivity Disorder: United States, 2003-2011. *J. Am. Acad. Child Adolesc. Psychiatry*, *53*(1), 34–46. www.jaacap.org

Volkmar, F. R., Klin, A., Siegel, B., Szatmari, P., Lord, C., Campbell, M., Freeman, B. J., Cicchetti, D. V., Rutter, M., Kline, W., Buitelaar, J., Hattab, Y., Fombonne, E., Fuentes, J., Werry, J., Stone, W., Kerbeshian, J., Hoshino, Y., & Bregman, J. (1994). Field trial for autistic disorder in DSM-IV. *American Journal of Psychiatry*, *151*(9), 1361–1367. https://doi.org/10.1176/ajp.151.9.1361

Weitlauf, A. S., Sathe, N., McPheeters, M. L., & Warren, Z. E. (2017). Interventions targeting sensory challenges in autism spectrum disorder: A systematic review. In *Pediatrics* (Vol. 139, Issue 6, p. 2021). American Academy of Pediatrics. https://doi.org/10.1542/peds.2017-0347

Wiggins, L. D., Robins, D. L., Bakeman, R., & Adamson, L. B. (2009). Breif report: Sensory abnormalities as distinguishing symptoms of autism spectrum disorders in young children. *Journal of Autism and Developmental Disorders*, *39*(7), 1087–1091. https://doi.org/10.1007/s10803-009-0711-x

Wodka, E. L., Parish-Morris, J., Annett, R. D., Carpenter, L., Dillon, E., Michaelson, J., Kim, S. H., Landa, R., & Kanne, S. (2021). Co-occurring attention-deficit/hyperactivity disorder and anxiety disorders differentially affect males and females with autism. *The Clinical Neuropsychologist*, 1–25. https://doi.org/10.1080/13854046.2021.1942554

Wolstencroft, J., Robinson, L., Srinivasan, R., Kerry, E., Mandy, W., & Skuse, D. (2018). A Systematic Review of Group Social Skills Interventions, and Meta-analysis of Outcomes, for Children with High Functioning ASD. *Journal of Autism and Developmental Disorders*, *48*(7), 2293–2307. https://doi.org/10.1007/s10803-018-3485-1

Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2009). Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders. *Autism Research*, *2*(6), 322–333. https://doi.org/10.1002/aur.103

Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2010). *Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders*. *2*(6), 322–333. https://doi.org/10.1002/aur.103

Zheng, S., Kim, H., Salzman, E., Ankenman, K., & Bent, S. (2021). Improving Social Knowledge and Skills among Adolescents with Autism: Systematic Review and Meta-Analysis of UCLA PEERS® for Adolescents. *Journal of Autism and Developmental Disorders*, 1–16. https://doi.org/10.1007/s10803-021-04885-1

Abstracts

Manuscript One: The Impact of the Comorbidity of ASD and ADHD on Social Impairment

Children with autism spectrum disorder (ASD) and children with attention deficit/hyperactivity disorder (ADHD) both experience behavioral and social difficulties. Prior research has shown that when these disorders co-occur, behavioral symptoms associated with both disorders may be more severe. There is only limited research on the impact of ASD + ADHD comorbidity on social functioning. The present study investigated social impairment in 282 children diagnosed with ASD, ADHD, or ASD + ADHD. No significant differences in social impairment were found between the ASD and ASD + ADHD groups. This study contributes to extant literature indicating mixed findings in regard to social functioning amidst the ASD + ADHD comorbidity.

Manuscript Two: The Association Between ADHD Symptoms and Atypical Sensory Processing in Individuals with Autism Spectrum Disorder

Atypical sensory processing (SP) is common among individuals with autism spectrum disorder (ASD) and sensory problems are a core feature of the disorder. Differences in SP are also observed in individuals with attention deficit/hyperactivity disorder (ADHD) and up to 70% of children with ASD also have co-occurring symptoms of ADHD. Prior research has suggested that ADHD symptoms may be associated with increased problems related to SP. The present study investigated the relationship between ADHD symptoms and types of atypical SP in 2108 youth diagnosed with ASD, controlling for demographic and clinical characteristics. Results indicate that ADHD symptoms significantly predicted several types of atypical SP, but not

movement sensitivity or low energy/weakness. Findings suggest that ADHD symptoms may differentially impact types of atypical SP among youth with autism.

Manuscript Three: The Impact of Co-occurring ADHD on Social Intervention Outcomes in Youth with Autism Spectrum Disorder

The co-occurrence of autism spectrum disorder (ASD) and attention deficit/hyperactivity disorder (ADHD) is significant and has been associated with a host of negative outcomes. Studies investigating social functioning in the presence of the ASD/ADHD co-occurrence have produced mixed findings. The present study further evaluated the impact of the ASD/ADHD co-occurrence on social functioning and compared treatment response to a social competence intervention between youth with ASD and ASD + ADHD. Youth affected by the co-occurring ADHD displayed more impairments related to social awareness, but not in other social areas. Participants in both the ASD and ASD + ADHD groups demonstrated significant improvement following a social competence intervention. Co-occurring ADHD was not significantly associated with poorer treatment response.

Manuscript One

The Impact of the Comorbidity of ASD and ADHD on Social Impairment

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Abstract

Children with autism spectrum disorder (ASD) and children with attention deficit/hyperactivity disorder (ADHD) both experience behavioral and social difficulties. Prior research has shown that when these disorders co-occur, behavioral symptoms associated with both disorders may be more severe. There is only limited research on the impact of ASD + ADHD comorbidity on social functioning. The present study investigated social impairment in 282 children diagnosed with ASD, ADHD, or ASD + ADHD. No significant differences in social impairment were found between the ASD and ASD + ADHD groups. This study contributes to extant literature indicating mixed findings in regard to social functioning amidst the ASD + ADHD comorbidity.

Keywords: autism, autism spectrum disorder, ADHD, social impairment, comorbidity

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by impairment in social communication, social interaction, and restricted, repetitive behaviors, interests, or activities (American Psychiatric Association, 2013). The core deficit in social interaction is a hallmark feature of ASD and the presence of comorbid psychopathology may serve to compound social impairment. Attention deficit/hyperactivity disorder (ADHD) symptoms are among the most common mental health concerns for individuals with ASD (McClain et al., 2017) with prevalence rates of ADHD symptoms in ASD ranging from 28.2% to 87% (Ames & White, 2011; Amr et al., 2012; Frazier et al., 2001; Stevens et al., 2016). Social deficits are well-documented in neurotypical individuals with ADHD (Barkley, 1998; Clark et al., 1999; Corbett & Constantine, 2006; Demopoulos et al., 2013; Wehmeier et al., 2010) and 15 to 25% of children with ADHD have ASD-like social difficulties (Grzadzinski et al., 2016; Kotte et al., 2013). The comorbidity of ASD and ADHD may exacerbate social impairment beyond what is observed in ASD alone and produce a different manifestation of social deficits (Factor et al., 2017). As will be discussed, increased social impairment can contribute to problems across home, school, and community contexts and have important implications for diagnostic and treatment efforts.

Diagnostic and Clinical Characteristics of ASD and ADHD

ASD and ADHD are two of the most commonly diagnosed childhood neurodevelopmental disorders. Core diagnostic symptoms of ASD and ADHD do not overlap (American Psychiatric Association, 2013), but core features associated with both can manifest similarly. A considerable body of research has identified the overlap in features between ASD and ADHD (Corbett & Constantine, 2006; Goldstein & Schwebach, 2004; Leyfer et al., 2006). Both disorders can include difficulties in attention, impulsivity, and various degrees of

hyperactivity (Corbett & Constantine, 2006; Goldstein & Schwebach, 2004; Leitner, 2014; Yerys et al., 2010), in addition to difficulties with conversation, peer relationships, and recognizing social cues (Ames & White, 2011; Grzadzinski et al., 2011b; Hartley & Sikora, 2009). These transdiagnostic commonalities present differential diagnostic challenges, and a diagnosis of ASD is often delayed or initially misdiagnosed as ADHD (Hartley & Sikora, 2009). The degree of social communication deficits observed often differentiates the two disorders, but these deficits can be difficult to objectively categorize in an evaluation, as they may result from the core impairment associated with either ASD or ADHD (Salley et al., 2015).

The Comorbidity of ASD and ADHD

Diagnosis may be more challenging when ASD and ADHD co-occur (Gargaro et al., 2011). Previous versions of the Diagnostic and Statistical Manual of Mental Disorders (DSM) precluded a diagnosis of ADHD in individuals with ASD, but the DSM-5 (American Psychiatric Association, 2013) now acknowledges the co-occurrence of ASD and ADHD. Some research suggests that individuals with ASD + ADHD may have qualitatively different profiles than those with ASD alone (Antshel et al., 2016; Colombi & Ghaziuddin, 2017; Factor et al., 2017; Leitner, 2014; Sokolova et al., 2017).

Individuals with ASD and individuals with ADHD appear to display some distinct and overlapping profiles, and symptoms associated with either can cause significant behavioral, social, and adaptive problems (Rich et al., 2009). The comorbidity is associated with increased autistic symptoms and maladaptive behaviors (Sprenger et al., 2013a; Yerys et al., 2010) and more social and family problems (Rao & Landa, 2014). The deficits observed at the intersection of the disorders may occur out of proportion to what is attributed to ASD or ADHD alone. The comorbidity is associated with an additive effect on symptom expression compared to either

disorder when it occurs alone (Ames & White, 2011; Antshel et al., 2016; Gargaro et al., 2011; Goldstein & Schwebach, 2004). This has been robustly demonstrated in research on tantrums which shows that individuals with ASD + ADHD display more severe tantrums than those with ASD or ADHD alone (Goldin et al., 2013; Guttmann-Steinmetz et al., 2009; Jang et al., 2013; Mulligan et al., 2009). This additive effect expands into other domains of functioning, as Sikora, Vora, Coury, and Rosenberg (2012) found that children with ASD + ADHD had significantly greater delays in adaptive functioning and lower health-related quality of life than individuals with ASD only. Similarly, Rao and Landa (2014) found that young children affected by this comorbidity were more cognitively, socially, and adaptively impaired than individuals with ASD alone.

Less research has focused on the specific impact of the ASD + ADHD comorbidity on social functioning. Similarities and differences in social profiles of individuals with ASD versus ADHD point to some overlapping and divergent treatment implications for these populations. Furthermore, there may be specific treatment considerations warranted for individuals affected by ASD + ADHD, as they may display a different social profile altogether.

Social Profiles in ASD and ADHD

Significant social problems have been observed in individuals with ADHD (de Boo & Prins, 2007; Luteijn et al., 2000) and have been reported in 52 to 82% of affected children (Barkley et al., 1990; Landau et al., 1998; Staikova et al., 2013). Children with ADHD are often rejected by their peers and have few friends (Hoza et al., 2005; Mikami, 2011). Inattentiveness may result in missed social cues, impulsive behavior may upset peers, and hyperactivity can hinder social participation (Leitner, 2014). It is estimated that 50 to 60% of children with ADHD experience peer rejection (Barkley et al., 1990) and are often disliked within minutes of initial

interactions (Pelham, 1989). Specific play behaviors have been linked to peer rejection and include being controlling, annoying, explosive, easily frustrated, inattentive during group activities/sports, and violating rules in games (Guevremont & Dumas, 1994; Klassen, 2004; Pelham et al., 1990; Whalen & Henker, 1985). The core symptoms of ADHD can impede the formation of peer relationships and limit social opportunities, and thus contribute to the manifestation of social problems across contexts.

This social profile differs from that observed in individuals with ASD, in which social problems range from difficulties with rudimentary aspects of social interaction (e.g., eye contact, joint attention) to more complex social processes, including understanding social contexts and establishing and maintaining friendships (Cervantes et al., 2013; Kjellmer et al., 2012; Matson & Wilkins, 2007). The core social-cognitive deficits seen in ASD result in impaired social-emotional reciprocity and nonverbal communication that manifest in absent or abnormal social initiations, responses, and communication. Individuals with ASD may demonstrate atypical social approach (e.g., intrusive touching), fail to respond to peers (e.g., lack of social smile or shared enjoyment), and have impairments in eye contact, body language, and speech production (American Psychiatric Association, 2013). They may have difficulty associating with peers, feeling empathy for others, and picking up on social cues (Luteijn et al., 2000). These deficits and corresponding behaviors can hinder development and maintenance of appropriate peer relationships, and many individuals with ASD lack interest in others or the skills necessary to play cooperatively or establish friendships. While this is not true of all individuals with ASD, many withdraw and prefer solitary activities and avoid interactions with others. Taken together, the social-cognitive and affective deficits observed in ASD manifest in an array of social impairments that create immense challenges for affected individuals in social contexts.

While individuals with ASD and ADHD exhibit somewhat distinct social profiles, the deficits observed in the presence of both disorders impede the formation of peer relationships and affect social skill performance. The similarities and differences in social functioning among children with ADHD versus ASD result in some overlapping and also some distinct implications, thus underscoring the clinical significance of social impairment and the relevance of understanding transdiagnostic and diagnosis-specific processes related to social functioning.

ASD + ADHD Comorbidity and Social Functioning

There is a paucity of research on the social impairment observed in the presence of ASD +ADHD comorbidity, but some studies have indicated an additive effect on social deficits. Rao and Landa (2014) investigated social impairment associated with the comorbidity in a community-based sample of young children (age 4-8) using the Social Responsiveness Scale, 2nd Edition (SRS-2; Constantino & Gruber, 2012), a parent-report measure of ASD symptoms. They found that individuals with ASD + ADHD scored significantly higher, indicating greater impairment, on all subscales of the SRS-2 than did individuals with ASD only. Also using the SRS-2, Factor et al. (2017) investigated social impairment in children (age 3-17) with ASD and ASD + ADHD recruited from a university center serving the local community. They similarly found that the ASD + ADHD group had significantly higher scores on the Social Awareness and Social Communication subscales than did individuals with ASD only. The finding that ADHD symptoms increased social communication difficulties in ASD is consistent with research on ADHD that indicates pragmatic language skills mediate the relationship between ADHD symptoms and impaired social skills (Staikova et al., 2013). Contrary to the findings in Rao and Landa (2014), the authors found no significant differences between the ASD and ASD + ADHD groups on SRS-2 Total Score in a group of children ages 3 to 17. Differential results may be age-

related, as ADHD symptoms may be more pronounced in younger children and may have greater impact on social functioning. This suggests that developmental differences in ADHD symptoms may impact the quality or degree of social impairment observed in individuals with ASD + ADHD. However, neither of the aforementioned studies included an ADHD-only group, which may have further explained the impact of ADHD symptoms on social impairment and highlighted age-related differences in symptom expression.

One study investigated social impairment across individuals with ASD, ADHD, and ASD + ADHD (age 3-18) seen at a specialty clinic for neurodevelopmental disorders. Salley et al. (2015) evaluated communication and social interaction skills across these groups using the Autism Diagnostic Observation Schedule (ADOS, Lord et al., 2000), a standardized behavioral observation assessing core features of ASD for diagnostic purposes. Comparison of ADOS communication and social interaction scores across groups revealed that the ASD group displayed the highest level of social impairment, followed by the ASD + ADHD and ADHD groups, respectively. This finding is in contrast to that of Rao and Landa (2014) and Factor et al. (2017) and may be related to study sample characteristics and differences in measurement type and approach, as the SRS-2 is a parent report measure and the ADOS is an observational assessment. The sample in Salley et al. (2015) consisted of clinically-referred individuals that likely presented with higher levels of ASD symptoms than may be observed in community samples, like that of Rao and Landa (2014) and Factor et al. (2017). The lack of a significant mean difference observed in social impairment between the ASD and ASD + ADHD groups suggests that these groups may appear comparable in social and communication impairment when using the ADOS as an evaluative measure of social impairment. The authors acknowledged an unbalanced distribution of ADOS modules administered to individuals in the

ASD + ADHD group, indicating that the overall scores may have been suppressed for this group and may have impacted findings (Salley et al., 2015).

In summary, those few studies that have investigated social impairment across individuals with ASD, ADHD, and ASD + ADHD have reported rather inconsistent findings. It remains unclear which measurement tools may be most appropriate for detecting potential differences in the social presentations of children with ASD versus ASD + ADHD. Previous studies have relied on either parent or clinician report, but no study has investigated group differences using information from both parents and clinicians. The ADOS was designed to maximize diagnostic sensitivity and specificity for ASD, and may be more capable of capturing social differences among these populations than ASD screening tools. Additionally, other parent-report measures of social symptoms could provide useful information about social differences between these populations.

The aim of the present study is to evaluate group differences in social impairment among a large, well-characterized, sample of children with ASD, ADHD, and ASD + ADHD referred for an autism diagnostic evaluation. The present study will assess social deficits using two assessment tools, clinician- and parent-informed, to further examine the impact of the ASD + ADHD comorbidity on social functioning. In concordance with prior literature suggesting an additive effect on symptom expression in the presence of the ASD + ADHD comorbidity (Factor et al., 2017; Goldin et al., 2013; Mulligan et al., 2009; Rao & Landa, 2014), we hypothesized that the ASD + ADHD group would present with the highest degree of social impairment, followed by the ASD only and ADHD only groups, respectively.

Methods

Participants and Procedures

Data were utilized from a previously completed study focused on comparison of DSM-IV and DSM-5 criteria for ASD (Mazurek et al., 2017). The complete sample consisted of 439 children and adolescents (age 2-17 years) who were referred for ASD evaluation and received a comprehensive diagnostic evaluation by autism specialists (e.g., psychologists, physicians, and/or interdisciplinary teams) at one of six autism centers affiliated with the Autism Treatment Network (ATN): Children's Hospital Los Angeles, Cincinnati Children's Hospital Medical Center, Nationwide Children's Hospital, University of Missouri, University of Pittsburgh, and Vanderbilt University Medical Center. Each assessment was conducted in accordance with the standard ATN diagnostic process (as described in detail in Mazurek et al., 2017), which includes a review of records, standardized observation using the ADOS-2 (Lord et al., 2012), cognitive assessment, assessment of behavioral functioning, and additional measures deemed necessary for diagnostic determination. Families of eligible children (i.e., those referred for an ASD evaluation, and between the ages of 2 years and 17 years, 11 months) were recruited for participation prior to the child's evaluation, and informed consent was obtained prior to participation. Recruitment continued until the target sample size for the original study was met. Participants were enrolled and evaluated from December 2014 through February 2016.

Participants who received a clinical diagnosis according to DSM-5 criteria of ASD (without ADHD), ADHD (without ASD), or ASD + ADHD and who had completed comprehensive (full scale) IQ testing were included in the current investigation. This resulted in a final sample of 282 children diagnosed with ASD (n = 151), ADHD (n = 82), or ASD + ADHD (n = 49). See Table 1 for sample characteristics.

[INSERT TABLE 1]

Measures

Demographics

Primary caregivers completed a demographic questionnaire which included information about the participant's age, sex, ethnicity, race, and household income.

Social Impairment

The ADOS-2 social affect calibrated severity score (SA-CSS; Esler et al., 2015; Gotham, Pickles, & Lord, 2009; Hus & Lord, 2014) served as a clinical observational method of measuring social impairment. The ADOS-2 is a standardized, semi-structured assessment of communication and social interaction, and repetitive behaviors and restricted interests. The SA-CSS is based on a 10-point scale: scores from 1 to 3 are in the ''Nonspectrum'' range; 4–5 are in the ''ASD'' range; and 6–10 in the ''Autism'' range. The CSS severity metric was found to have more uniform distributions across developmental groups than raw scores and to be less influenced by child characteristics such as verbal IQ, nonverbal IQ, age, and race (Gotham et al. 2009; Hus & Lord, 2014). The CSS has been employed in studies assessing participants across broad age ranges (Gotham et al., 2009; Shumway et al. 2012) and allows for comparison of symptoms severity across modules (Gotham et al., 2007; Gotham et al., 2009).

The Lethargy/Social Withdrawal subscale from the Aberrant Behavior Checklist (ABC; Aman & Singh, 1986) was included to assess caregiver-reported symptom severity in the social domain. The ABC is a 58-item caregiver-report questionnaire that measures current behavioral functioning. It comprises five subscales: Irritability, Lethargy/Social Withdrawal, Stereotypic Behavior, Hyperactivity/Noncompliance, and Inappropriate Speech; and it has shown strong psychometric properties (Aman et al., 1995). The ABC subscales have been widely used in individuals with ASD (Bagaiolo et al., 2019; Kaat et al., 2014; Sannar et al., 2018) and individuals with ADHD (Capone et al., 2016; Halvorsen et al., 2019; Miller et al., 2004). All

items are on a Likert scale ranging from 0 (i.e., not at all a problem) to 3 (i.e., the problem is severe in degree). Included in the current study, the Lethargy/Social Withdrawal subscale consists of 16 items that assess symptoms associated with social isolation, withdrawal, and impairment in social reciprocity. This subscale has the potential to index mood-related symptoms that impact social functioning and focuses more on the absence of appropriate social behavior, as opposed to the presence of inappropriate social behavior. Higher scores indicate more symptoms of social impairment.

Intellectual Ability

Full Scale IQ was assessed using one of a range of measures depending on an individual's age, verbal ability, and ability to participate in testing. IQ measures included the Stanford Binet Scales of Intelligence–5th Edition (Roid, 2003), the Wechsler Intelligence Scale for Children–Fourth Edition (Wechsler, 2003), the Wechsler Intelligence Scale for Children–Fifth Edition (Wechsler, 2014), the Wechsler Preschool and Primary Scale of Intelligence–Third Edition (Wechsler, 2002), the Wechsler Abbreviated Scale of Intelligence–Second Edition (Wechsler, 2011), Wechsler Adult Intelligence Scale—Fourth Edition (Wechsler, 2008), the Differential Ability Scales–Second Edition (Elliot, 2007). Additionally, the Bayley Scales of Infant and Toddler Development–Third Edition (Bayley, 2006) and the Mullen Scales of Early Learning (MSEL; Mullen, 1995) were used to assess emerging cognitive skills as a proxy for Full Scale IQ (FSIQ). For participants receiving the MSEL, the Early Learning Composite Standard Score was used.

Analytic Plan

All data were cleaned and examined for outliers, missing data, and distributional assumptions using SPSS Statistics Software, Version 25. Descriptive statistics were generated

for the ASD, ADHD, and ASD + ADHD groups. Correlational analyses were performed to address the inclusion of relevant covariates.

Data for variables of interest were transformed using a two-step transformation due to skewed distributions. Step 1 involved transforming the variable into a percentile rank, which resulted in uniformly distributed probabilities. Step 2 applied the inverse-normal transformation to the results of the first step to form a variable consisting of normally distributed z-scores (Templeton, 2011). More traditional data transformation methods were unable to produce normal distributions to meet the assumptions of normality. Multiple imputation was performed to replace missing data on measures of interest (27% missing on ABC Lethargy/Social Withdrawal subscale; 3.5% missing on SA-CSS) that was determined to be missing at random due to lack of association with any demographic variables. Five imputation data sets were used.

Groups were compared on demographic and sample characteristics using chi-square tests and one-way Analyses of Variance (ANOVA). For ANOVAs, Bonferroni corrections were performed to account for multiple comparisons. See Table 3 for group differences on study variables. Multivariate analysis of covariance (MANCOVA) was employed with adjustment for unequal sample sizes to determine the presence of mean differences across diagnostic groups on measures of social impairment while accounting for relevant covariates. Post-hoc (Bonferroni corrected) pairwise comparisons were conducted to determine what group comparisons were significant across variables of interest.

Results

Results of correlational analyses among study variables can be found in Table 2. All groups were compared on child age and IQ using one-way ANOVAs. A univariate ANOVA demonstrated that the three groups differed relative to age, $F(2,278)= 55.09$, $p <0.001$ and post-

hoc tests indicated that the ADHD and ASD + ADHD groups did not significantly differ from one another, but both were older than the ASD group at .001 level. Similarly, a univariate ANOVA revealed group differences in IQ, $F(2,278)= 23.50$, $p <0.001$ and post-hoc tests showed that ADHD and ASD + ADHD groups did not differ from each other and both had a significantly higher IQ than the ASD group at the .001 level. Thus, age and IQ were included as covariates. Chi square analyses demonstrated that the three diagnostic groups did not significantly differ by sex, $\chi^2(2)=.49$, $p =.79$ or household income, $\chi^2(10)=15.74$, $p =.11$ and these variables were not included as covariates. Results from univariate analyses for dependent variables and covariates can be found in Table 3.

[INSERT TABLE 2]

[INSERT TABLE 3]

The hypothesis that children with ASD + ADHD would show greater social impairment than children with ASD or ADHD alone was tested using MANCOVA. The independent variable was diagnostic group status, the dependent variables were the ADOS-2 SA-CSS and the ABC Lethargy/Social Withdrawal score, and covariates included age and IQ. Multivariate results were significant for diagnostic group status, $F(4,548)= 24.59$, $p < .001$, Wilks' $\Lambda = .719$, partial $\eta^2 = .152$ above the significant effect of age, $F(2,274)= 5.49$, $p < .001$, Wilks' $\Lambda = .961$, partial $\eta^2 = .039$. Multivariate results were not significant for IQ, $F(2,274)= 1.49$, $p =.227$, Wilks' $\Lambda = .989$, partial $\eta^2 = .011$. Post-hoc multiple pairwise comparisons (Bonferroni adjusted) found significant differences on only one measure of social functioning, the ADOS-2 SA-CSS, $F(2,275)= 50.79$, $p < .001$, partial $\eta^2 = .27$, with the ASD group scoring significantly higher than the ADHD group, and the ASD + ADHD group scoring higher than the ADHD group, both at

the .001 level. No significant differences on the ADOS-2 SA-CSS were observed between the ASD and ASD + ADHD groups.

Discussion and Implications

This study provides an additional contribution to research on social impairment among children with ASD, ADHD, and ASD + ADHD. Significant differences in social impairment were observed on a measure of social affect between the ASD and ADHD groups, as well as the ADHD and ASD + ADHD groups. However, contrary to our hypothesis, no differences in social impairment were observed on this measure between the ASD and ASD + ADHD groups, and no between group differences were indicated on the ABC Lethargy/Social Withdrawal subscale.

As expected, the ASD and ASD + ADHD groups both demonstrated significantly more social impairment on the ADOS-2 SA-CSS than the ADHD group, but no significant differences were observed between the ASD and ASD + ADHD groups. Notably, children in the ASD group were significantly younger and had lower IQ on average compared to the other groups. This finding is consistent with many other studies that have found that higher IQ and ADHD symptoms are associated with older age at ASD diagnosis (Frenette et al., 2013; Mazurek et al., 2014; Shattuck et al., 2009). As children with mild to moderate ADHD symptoms are typically diagnosed at a later age, the ASD + ADHD and ADHD groups may have presented with fewer functional limitations than younger children initially diagnosed with ASD. While studies employing the SRS-2 to investigate group differences in social impairment have produced different results, results from a previous study by Salley et al. (2015), revealed that the ASD group had higher scores on the ADOS communication/social interaction score than did the ASD + ADHD and ADHD groups in a similarly aged sample (M=7.39) of 209 youth. This may suggest that the ADOS social interaction and communication items are most sensitive to the

classic core deficits observed in ASD, rather than potential social performance differences that may be exhibited by children who present with both ASD and ADHD or just ADHD. The ADOS activities probe for the presence of foundational social behaviors (e.g., eye contact, emotion, affect, gestures) as well as the ability of a child to employ social behaviors (e.g., social overtures, conversational reciprocity) in context effectively during social activities toward a common goal (e.g., rapport, shared enjoyment). However, the ADOS pulls for these components within a contrived clinical setting with an unfamiliar adult. It is possible that ADOS is measuring different social constructs than parent-report symptom measures like the SRS-2. The SRS asks parents to assess frequency of atypical social behaviors or lack of social behaviors. Since it measures behaviors that occur outside of a controlled clinical environment, parent-report may be capturing global social performance and behaviors across a variety of contexts (e.g., peer, school, home). Consequently, it is unclear if the social constructs assessed on the SRS-2 are a manifestation of core deficits, a skill application problem in different contexts, or a social performance issue that might be attributed to other symptoms/behaviors (e.g., inattention to social cues, distractibility, interfering hyperactivity, preoccupation). For example, SRS-2 items "plays with others appropriately" or "offers comfort to others" could tap into the core social deficits attributed to ASD, but may also capture social performance challenges due to symptoms of ADHD. Additionally, the presence of internalizing and externalizing symptoms has been found to result in higher SRS-2 scores among children with and without ASD (Hus et al., 2013), which lends support to concerns that the measure may be susceptible to symptoms beyond those considered to be core features of ASD.

This is one possible explanation as to why studies using the SRS-2 have indicated that children with ASD + ADHD have more symptoms of social impairment than those with ASD

only (Factor et al., 2017; Rao & Landa, 2014). It is also possible that since the ADOS-2 was designed to be diagnostically sensitive to features of ASD, and not ADHD, it may not differentiate when additional and/or qualitatively different social difficulties are attributed to a comorbid diagnosis of ADHD.

Interestingly, no significant differences between diagnostic groups were observed on the ABC Lethargy/Social Withdrawal subscale. This may suggest this subscale is better able to capture the converging, rather than diverging social symptoms associated with ASD and ADHD (e.g., preoccupation, lack of response to structured activities, difficulty reaching). A recent study by Norris and colleagues found that the ABC Lethargy/Social Withdrawal subscale was highly and significantly correlated with the SRS-2 Total score, a measure that has yielded false positive endorsements of autism among children with ADHD (Reiersen et al. 2007). The ABC Lethargy/Social Withdrawal subscale may similarly be sensitive to social differences attributable to either ASD or ADHD, and may not be able to capture a qualitatively different social profile that may exist in ASD + ADHD. Further, this subscale did not significantly correlate with the ADOS-2 social affect score, which suggests that these measures are quantifying different symptoms of social impairment altogether.

Beyond differences that may be attributed to assessment tool selection, study sample characteristics may also contribute to inconsistent findings with regard to social functioning. For example, differences in sample size and recruitment methods could explain differences in findings. There may be additional clinical or demographic characteristics that were not accounted for (e.g., other comorbid symptoms, parental education level) that could have contributed to differences in samples. Diagnostic overshadowing in clinical assessment also poses concern to research on the ASD/ADHD comorbidity. Children who present to an

evaluation with significant difficulties associated with ASD and/or cognitive impairments may be less likely to be diagnosed with co-occurring ADHD or may be diagnosed at a later age. It is possible that symptom severity or functional limitations associated with a primary diagnosis of ASD masks co-occurring difficulties that may actually be attributable to ADHD or another comorbid diagnosis. The lack of comprehensive assessment data on co-occurring conditions and the lack of available IQ data for participants across studies investigating the ASD/ADHD may have contributed to differences in findings. Notably, the present study had the largest sample of children with ASD + ADHD in the literature to date and all participants had complete IQ data and were evaluated in accordance with the rigorous standards of the Autism Treatment Network. In addition, participants came from various racial/ethnic backgrounds and socioeconomic levels across several regions of the United States and are believed to be a fairly representative sample.

This study contributes to the small body of literature characterized by mixed findings on social functioning amidst the ASD + ADHD comorbidity. While an additive effect has been demonstrated in regard to behavior problems, it has been more difficult to illustrate the effect, if any, the comorbidity has on social problems. Social problems are a core feature of ASD, and are often present in ADHD, but research investigating the combination of the two disorders yields different results based on participant characteristics and assessment measures used to quantify deficits. Social difficulties are more pervasive and stable in ASD, but may be less consistent in ADHD. There is substantial heterogeneity of social skills in children with ADHD and research investigating the mechanism by which social difficulties present in ADHD has highlighted social performance problems/inconsistencies, rather than a skill acquisition problem (Aduen et al., 2018). Given these performance-based challenges and inconsistencies, it is possible that application of social skills in real-time places increased demands on executive functioning skills,

which are known to be impaired among children with ADHD. Executive functioning deficits are also well-documented in ASD and may be associated with social functioning (Freeman et al., 2017). Differences in executive functioning across children with ASD, ADHD, and ASD + ADHD could explain some of observed heterogeneity in social functioning across these groups.

Limitations and Future Directions

There are a number of limitations to note in the present study. First, a larger sample size may have allowed for more power and more balanced samples sizes across each diagnostic group. The variability in age of participants in this study may be another limitation given the role that developmental differences may play in the presentation of social deficits. There is also a possibility that differences across ADOS modules could have presented potentially different social demands that may have impacted results. While we attempted to account for this through use of the CSS, rather than raw score, future studies with participants matched on age, IQ, and ADOS module would be helpful to further investigate this possibility. Further, all children included in the present study were initially referred for ASD evaluation, suggesting that social impairment (even among the group receiving a final diagnosis of ADHD only) may have been more significant than what would be observed in the general ADHD population. Future studies would benefit from a more representative sample of children, potentially stratified by age to further explore age-related differences in symptoms of social problems. These studies should use a variety of different assessment methods (e.g., observational, interview, standardized protocols) and several informants (e.g., clinician, teacher, parent, peers) to collect more comprehensive social-behavioral data across contexts to further distinguish fundamental social impairments from social performance problems. It may also be important to include measures designed to assess symptoms of ADHD to further parse out what social challenges may be better attributed to

symptoms of ADHD. Furthermore, clinical information on ADHD subtype (e.g., predominately inattentive, hyperactive, combined) may provide useful information that could help researchers makes sense of the observed heterogeneity in social difficulties observed in the presence of ADHD.

Since the revision of the DSM-5 allowing the comorbid diagnoses of ASD and ADHD, researchers and clinicians have only just begun to make progress in understanding the ASD + ADHD phenotype. Prospective, longitudinal studies of social development and social symptoms associated with ASD and ADHD are needed in order to examine different symptoms manifestations or developmental trajectories produced by each disorder. This may be necessary in order to determine where potential differences in symptom presentation and manifestation exist amidst the ASD + ADHD comorbidity throughout the lifespan.

In conclusion, our findings suggest that children with ASD versus ASD + ADHD display similar profiles of social problems when using the ADOS-2 SA-CSS and the ABC Lethargy/Social Withdrawal subscale to assess social functioning. It is possible that the social presentations of children with ASD and ASD + ADHD are characterized similarly and that these groups do not differ by degree of social impairment. Perhaps the hallmark social difficulties observed in ASD are not significantly altered or worsened by the presence of ADHD. While further research is needed to clarify the mixed findings on the social impact of the ASD/ADHD comorbidity, it is possible that social interventions targeting the core social symptoms observed in ASD may similarly improve social functioning among individuals with and without the ADHD comorbidity.

Conclusion

This study contributes to the growing literature base on social functioning in the presence of the ASD/ADHD comorbidity. A multi-method, multi-informant approach was employed to assess social difficulties across diagnostic groups within a large, representative, and well-characterized sample. Our findings suggest that children diagnosed with ASD and those diagnosed with ASD + ADHD present with similar levels of social impairment when assessing social symptoms with the ADOS-2 SA-CSS. Additionally, the parent-completed ABC Lethargy/Social Withdrawal subscale yielded non-significant differences in scores across children with ASD, ADHD, and those with both disorders, which suggests the measure is capturing convergent social symptoms attributable to either ASD or ADHD. Study results underscore the importance of measurement tool selection and confirm the need to apply multiple assessment methods when assessing the social impact of ADHD symptoms in individuals with and without ASD. Given the mixed findings regarding social functioning in the presence of the ASD/ADHD comorbidity, further comprehensive research with a comprehensive multiple measure and developmental approach is necessary to identify potential differences in the clinical presentations of children with ASD versus children with ASD + ADHD.

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Aduen, P. A., Day, T. N., Kofler, M. J., Harmon, S. L., Wells, E. L., & Sarver, D. E. (2018). Social Problems in ADHD: Is it a Skills Acquisition or Performance Problem? *Journal of Psychopathology and Behavioral Assessment*, *40*(3), 440–451. https://doi.org/10.1007/s10862-018-9649-7

Aman, M., & Singh, N. (1986). *Aberrant behavior checklist: Manual.*

Ames, C. S., & White, S. J. (2011). Brief report: Are ADHD traits dissociable from the autistic profile? Links between cognition and behaviour. *Journal of Autism and Developmental Disorders*, *41*(3), 357–363. https://doi.org/10.1007/s10803-010-1049-0

Amr, M., Raddad, D., El-Mehesh, F., Bakr, A., Sallam, K., & Amin, T. (2012). Comorbid psychiatric disorders in Arab children with Autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(1), 240–248. https://doi.org/10.1016/j.rasd.2011.05.005

Antshel, K. M., Polacek, C., McMahon, M., Dygert, K., Spenceley, L., Dygert, L., Miller, L., & Faisal, F. (2011). Comorbid ADHD and anxiety affect social skills group intervention treatment efficacy in children with autism spectrum disorders. *Journal of Developmental and Behavioral Pediatrics*, *32*(6), 439–446. https://doi.org/10.1097/DBP.0b013e318222355d

Antshel, K. M., Zhang-James, Y., Wagner, K. E., Ledesma, A., & Faraone, S. V. (2016). An update on the comorbidity of ADHD and ASD: a focus on clinical management. *Expert Review of Neurotherapeutics*, *16*(3), 279–293. https://doi.org/10.1586/14737175.2016.1146591

Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy*, *62*(5), 564–573. https://doi.org/10.5014/ajot.62.5.564

Avni, E., Ben-itzchak, E., & Zachor, D. A. (2018). *The Presence of comorbid ADHD and anxiety symptoms in autism spectrum disorder : Clinical presentation and predictors*. *9*(December), 1–12. https://doi.org/10.3389/fpsyt.2018.00717

Bagaiolo, L. F., Bordini, D., Cunha, G. R. da, Sasaki, T. N. D., Nogueira, M. L. M., Pacífico, C. R., & Braido, M. (2019). Implementing a community-based parent training behavioral intervention for Autism Spectrum Disorder. *Psicologia - Teoria e Prática*, *21*(3). https://doi.org/10.5935/1980-6906/psicologia.v21n3p456-472

Bagby, M. S., Dickie, V. A., & Baranek, G. T. (2012). How sensory experiences of children with and without autism affect family occupations. *American Journal of Occupational Therapy*, *66*(1), 78–86. https://doi.org/10.5014/ajot.2012.000604

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., Kurzius-Spencer, M., Zahorodny, W., Robinson, C., Rosenberg, T., White, T., Durkin, M. S., Imm, P., Nikolaou, L., Yeargin-Allsopp, M., Lee, L.-C., Harrington, R., Lopez, M., Fitzgerald, R. T., … Dowling, N. F. (2018). Prevalence of autism spectrum disorder among children aged 8 years — Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2014. *MMWR. Surveillance Summaries*, *67*(6), 1–23. https://doi.org/10.15585/mmwr.ss6706a1

Baird, G., Charman, T., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., Carcani-Rathwell, I., Serkana, D., & Simonoff, E. (2008). Regression, developmental trajectory and associated problems in disorders in the autism spectrum: The SNAP study. *Journal of Autism and*

Developmental Disorders, *38*(10), 1827–1836. https://doi.org/10.1007/s10803-008-0571-9

Baranek, G. T., Watson, L. R., Boyd, B. A., Poe, M. D., David, F. J., & McGuire, L. (2013a). Hyporesponsiveness to social and nonsocial sensory stimuli in children with autism, children with developmental delays, and typically developing children. *Development and Psychopathology*, *25*(02), 307–320. https://doi.org/10.1017/s0954579412001071

Baranek, G. T., Watson, L. R., Boyd, B. A., Poe, M. D., David, F. J., & McGuire, L. (2013b). Hyporesponsiveness to social and nonsocial sensory stimuli in children with autism, children with developmental delays, and typically developing children. *Development and Psychopathology*, *25*(2), 307–320. https://doi.org/10.1017/S0954579412001071

Baranek, G. T., Woynaroski, T. G., Nowell, S., Turner-Brown, L., DuBay, M., Crais, E. R., & Watson, L. R. (2018). Cascading effects of attention disengagement and sensory seeking on social symptoms in a community sample of infants at-risk for a future diagnosis of autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*, 30–40. https://doi.org/10.1016/j.dcn.2017.08.006

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Barkley, R. A. (1998). Attention-deficit hyperactivity disorder. *Scientific American*, *279*(3), 66–71. https://doi.org/10.3928/0048-5713-19891101-08

Barkley, R. A., DuPaul, G. J., & McMurray, M. B. (1990). Comprehensive evaluation of attention deficit disorder with and without hyperactivity as defined by research criteria. *Journal of Consulting and Clinical Psychology*, *58*(6), 775–789. https://doi.org/10.1037/0022-006X.58.6.775

Barry, T. D., Klinger, L. G., Lee, J. M., Palardy, N., Gilmore, T., & Bodin, S. D. (2003). Examining the Effectiveness of an Outpatient Clinic-Based Social Skills Group for High-Functioning Children with Autism. *Journal of Autism and Developmental Disorders*, *33*(6), 685–701. https://doi.org/10.1023/B:JADD.0000006004.86556.e0

Batson, M., Elliott, S., Lam, G., Seimears, N., Batson, M., & Lam, G. (2017). *Social Skills Interventions for Adolescents with ASD , ADHD , and Other Comorbidities*. http://soundideas.pugetsound.edu/ot_capstone/24

Bayley, N. (2006). *Bayley scales of infant and toddler development.3rd ed.*

Ben-Sasson, A., Gal, E., Fluss, R., Katz-Zetler, N., & Cermak, S. A. (2019). Update of a meta-analysis of sensory symptoms in ASD: A new decade of research. *Journal of Autism and Developmental Disorders*, *49*(12), 4974–4996. https://doi.org/10.1007/s10803-019-04180-0

Bernard Paulais, M. A., Mazetto, C., Thiébaut, E., Nassif, M. C., Costa Coelho De Souza, M. T., Stefani, A. P., Blanc, R., Gattegno, M. P., Aiad, F., Sam, N., Belal, L., Fekih, L., Kaye, K., Contejean, Y., Wendland, J., Barthelemy, C., Bonnet-Brilhault, F., & Adrien, J. L. (2019). Heterogeneities in cognitive and socio-emotional development in children with autism spectrum disorder and severe intellectual disability as a comorbidity. In *Frontiers in Psychiatry* (Vol. 10, Issue JUN, p. 508). Frontiers. https://doi.org/10.3389/fpsyt.2019.00508

Billstedt, E., Carina Gillberg, I., & Gillberg, C. (2007). Autism in adults: Symptom patterns and early childhood predictors. Use of the DISCO in a community sample followed from childhood. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(11), 1102–1110. https://doi.org/10.1111/j.1469-7610.2007.01774.x

Boucher, J. (2012). Research review: Structural language in autistic spectrum disorder - Characteristics and causes. In *Journal of Child Psychology and Psychiatry and Allied*

Disciplines (Vol. 53, Issue 3, pp. 219–233). J Child Psychol Psychiatry. https://doi.org/10.1111/j.1469-7610.2011.02508.x

Boyd, B. A., Baranek, G. T., Sideris, J., Poe, M. D., Watson, L. R., Patten, E., & Miller, H. (2010). Sensory features and repetitive behaviors in children with autism and developmental delays. *Autism Research*, n/a-n/a. https://doi.org/10.1002/aur.124

Brown, A. C., Chouinard, P. A., & Crewther, S. G. (2017). Vision research literature may not represent the full intellectual range of autism spectrum disorder. In *Frontiers in Human Neuroscience* (Vol. 11, p. 57). Frontiers. https://doi.org/10.3389/fnhum.2017.00057

Brown, T., Morrison, I., & Stagnitti, K. (2010). The convergent validity of two sensory processing scales used with school-age children: comparing the Sensory Profile and the Sensory Processing Measure. *New Zealand Journal of Occupational Therapy*, *57*(2), 56–65. http://hdl.handle.net/10536/DRO/DU:30032049

Butera, C., Ring, P., Sideris, J., Jayashankar, A., Kilroy, E., Harrison, L., Cermak, S., & Aziz-Zadeh, L. (2020). Impact of Sensory Processing on School Performance Outcomes in High Functioning Individuals with Autism Spectrum Disorder. *Mind, Brain, and Education*, *14*(3), 243–254. https://doi.org/10.1111/mbe.12242

Camara, B., Padoin, C., & Bolea, B. (2022). Relationship between sex hormones, reproductive stages and ADHD: a systematic review. In *Archives of Women's Mental Health* (Vol. 25, Issue 1, pp. 1–8). Springer. https://doi.org/10.1007/s00737-021-01181-w

Cascio, C. J., Woynaroski, T., Baranek, G. T., & Wallace, M. T. (2016). Toward an interdisciplinary approach to understanding sensory function in autism spectrum disorder. In *Autism Research* (Vol. 9, Issue 9, pp. 920–925). John Wiley and Sons Inc. https://doi.org/10.1002/aur.1612

Cervantes, P. E., Matson, J. L., Adams, H. L., Williams, L. W., Goldin, R. L., & Jang, J. (2013). Comparing social skill profiles of children with autism spectrum disorders versus children with attention deficit hyperactivity disorder: Where the deficits lie. *Research in Autism Spectrum Disorders*, *7*(9), 1104–1110. https://doi.org/10.1016/j.rasd.2013.05.008

Chaney, R., & Wilkey, L. (2016). Examining Sensory Processing Tools for a School System. *Occupational Therapy Graduate Student Evidenced-Based Research Reviews*. https://scholarworks.wmich.edu/ot_posters/19

Chen, Y. H., Rodgers, J., & McConachie, H. (2009). Restricted and repetitive behaviours, sensory processing and cognitive style in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(4), 635–642. https://doi.org/10.1007/s10803-008-0663-6

Cheung, P. P. P., & Siu, A. M. H. (2009). A comparison of patterns of sensory processing in children with and without developmental disabilities. *Research in Developmental Disabilities*, *30*(6), 1468–1480. https://doi.org/10.1016/j.ridd.2009.07.009

Christensen, D. L., Baio, J., Van Naarden Braun, K., Bilder, D., Charles, J., Constantino, J. N., Daniels, J., Durkin, M. S., Fitzgerald, R. T., Kurzius-Spencer, M., Lee, L. C., Pettygrove, S., Robinson, C., Schulz, E., Wells, C., Wingate, M. S., Zahorodny, W., & Yeargin-Allsopp, M. (2016). Prevalence and characteristics of autism spectrum disorder among children aged 8 years - Autism and developmental disabilities monitoring network, 11 sites, United States, 2012. *MMWR Surveillance Summaries*, *65*(3), 1–23. https://doi.org/10.15585/mmwr.ss6503a1

Clark, T., Feehan, C., Tinline, C., & Vostanis, P. (1999). Autistic symptoms in children with attention deficit-hyperactivity disorder. *European Child and Adolescent Psychiatry*, *8*(1),

50–55. https://doi.org/10.1007/s007870050083

Colombi, C., & Ghaziuddin, M. (2017). Neuropsychological characteristics of children with mixed autism and ADHD. *Autism Research and Treatment*, *2017*, 1–5. https://doi.org/10.1155/2017/5781781

Constantino, J., Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., Metzger, L. M., Shoushtari, C. S., Splinter, R., & Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: Comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of Autism and Developmental Disorders*, *33*(4), 427–433. https://doi.org/10.1023/A:1025014929212

Corbett, B. A., & Constantine, L. J. (2006). Autism and attention deficit hyperactivity disorder: Assessing attention and response control with the integrated visual and auditory continuous performance test. *Child Neuropsychology*, *12*(4–5), 335–348. https://doi.org/10.1080/09297040500350938

Crespi, B. J. (2016). Autism as a disorder of high intelligence. *Frontiers in Neuroscience*, *10*(JUN). https://doi.org/10.3389/fnins.2016.00300

de Boo, G. M., & Prins, P. J. M. (2007). Social incompetence in children with ADHD: Possible moderators and mediators in social-skills training. *Clinical Psychology Review*, *27*(1), 78–97. https://doi.org/10.1016/j.cpr.2006.03.006

de Giambattista, C., Ventura, P., Trerotoli, P., Margari, F., & Margari, L. (2021). Sex Differences in Autism Spectrum Disorder: Focus on High Functioning Children and Adolescents. *Frontiers in Psychiatry*, *12*, 1063. https://doi.org/10.3389/fpsyt.2021.539835

Deckers, A., Muris, P., Roelofs, J., & Arntz, A. (2016). A Group-Administered social Skills Training for 8- to 12- Year-Old, high-Functioning Children With Autism Spectrum

Disorders: An Evaluation of its Effectiveness in a Naturalistic Outpatient Treatment Setting. *Journal of Autism and Developmental Disorders*, *46*(11), 3493. https://doi.org/10.1007/S10803-016-2887-1

Dellapiazza, F. (2018). Links between sensory processing, adaptive behaviours, and attention in children with autism spectrum disorder: A systematic review. In *Psychiatry Research* (Vol. 270, pp. 78–88). https://doi.org/10.1016/j.psychres.2018.09.023

Dellapiazza, F., Audras-Torrent, L., Michelon, C., Baghdadli, A., & Baghdadli, A. (2021). Clinical characteristics of children with ASD and comorbid ADHD: Association with social impairment and externalizing and internalizing behaviours. *Research in Developmental Disabilities*, *113*, 103930. https://doi.org/10.1016/j.ridd.2021.103930

Dellapiazza, F., Michelon, C., Vernhet, C., Muratori, F., Blanc, N., Picot, M. C., Baghdadli, A., Baghdadli, A., Chabaux, C., Chatel, C., Cohen, D., Damville, E., Geoffray, M. M., Gicquel, L., Jardri, R., Maffre, T., Novo, A., Odoyer, R., Oreve, M. J., … Vespirini, S. (2021). Sensory processing related to attention in children with ASD, ADHD, or typical development: results from the ELENA cohort. *European Child and Adolescent Psychiatry*, *30*(2), 283–291. https://doi.org/10.1007/s00787-020-01516-5

Demchick, B., Eskow, K., & Crabtree, L. A. (2014). Autism and Transitioning Youth: A Pilot Study of Sensory Processing and Family Quality of Life. *Journal of Occupational Therapy, Schools, and Early Intervention*, *7*(1), 54–69. https://doi.org/10.1080/19411243.2014.898492

Demopoulos, C., Hopkins, J., & Davis, A. (2013). A comparison of social cognitive profiles in children with autism spectrum disorders and attention-deficit/hyperactivity disorder: A matter of quantitative but not qualitative difference? *Journal of Autism and Developmental*

Disorders, *43*(5), 1157–1170. https://doi.org/10.1007/s10803-012-1657-y

DuBois, D., Lymer, E., Gibson, B. E., Desarkar, P., & Nalder, E. (2017). Assessing sensory processing dysfunction in adults and adolescents with autism spectrum disorder: A scoping review. In *Brain Sciences* (Vol. 7, Issue 8, p. 108). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/brainsci7080108

Dunn, W. (1999). *The sensory profile: User's manual*. Psychological Corporation.

Dunn, Winnie, & Bennett, D. (2002). Patterns of sensory processing in children with Attention Deficit Hyperactivity Disorder. *Occupational Therapy Journal of Research*, *22*(1), 4–15. https://doi.org/10.1177/153944920202200102

Elliot, C. (2007). *Differential abilities scale—2nd Edition (DAS-II) manual. 2nd ed.*

Engel-Yeger, B., & Ziv-On, D. (2011). The relationship between sensory processing difficulties and leisure activity preference of children with different types of ADHD. *Research in Developmental Disabilities*, *32*(3), 1154–1162. https://doi.org/10.1016/j.ridd.2011.01.008

Esler, A. N., Bal, V. H., Guthrie, W., Wetherby, A., Weismer, S. E., & Lord, C. (2015). The autism diagnostic observation schedule, toddler module: Standardized severity scores. *Journal of Autism and Developmental Disorders*, *45*(9), 2704–2720. https://doi.org/10.1007/s10803-015-2432-7

Factor, R. S., Ryan, S. M., Farley, J. P., Ollendick, T. H., & Scarpa, A. (2017). Does the presence of anxiety and ADHD symptoms add to social impairment in children with autism spectrum disorder? *Journal of Autism and Developmental Disorders*, *47*(4), 1122–1134. https://doi.org/10.1007/s10803-016-3025-9

Fernell, E., Hedvall, Å., Norrelgen, F., Eriksson, M., Höglund-Carlsson, L., Barnevik-Olsson, M., Svensson, L., Holm, A., Westerlund, J., & Gillberg, C. (2010). Developmental profiles

in preschool children with autism spectrum disorders referred for intervention. *Research in Developmental Disabilities*, *31*(3), 790–799. https://doi.org/10.1016/j.ridd.2010.02.003

Frazier, J. A., Biederman, J., Bellordre, C. A., Garfield, S. B., Geller, D. A., Coffey, B. J., & Faraone, S. V. (2001). Should the diagnosis of attention-deficit/ hyperactivity disorder be considered in children with pervasive developmental disorder? *Journal of Attention Disorders*, *4*(4), 203–211. https://doi.org/10.1177/108705470100400402

Frazier, T. W., Youngstrom, E. A., Speer, L., Embacher, R., Law, P., Constantino, J., Findling, R. L., Hardan, A. Y., & Eng, C. (2012). Validation of proposed DSM-5 criteria for autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(1), 28–40. https://doi.org/10.1016/j.jaac.2011.09.021

Freeman, L. M. M., Locke, J., Rotheram-Fuller, E., & Mandell, D. (2017). Brief report: Examining executive and social functioning in elementary-aged children with autism. *Journal of Autism and Developmental Disorders*, *47*(6), 1890–1895. https://doi.org/10.1007/s10803-017-3079-3

Gadow, K. D., DeVincent, C. J., & Pomeroy, J. (2006). ADHD symptom subtypes in children with pervasive developmental disorder. *Journal of Autism and Developmental Disorders*, *36*(2), 271–283. https://doi.org/10.1007/s10803-005-0060-3

Gal, E., Dyck, M. J., & Passmore, A. (2010). Relationships between Stereotyped Movements and sensory processing disorders in children with and without developmental or sensory disorders. *American Journal of Occupational Therapy*, *64*(3), 453–461. https://doi.org/10.5014/ajot.2010.09075

Gargaro, B. A., Rinehart, N. J., Bradshaw, J. L., Tonge, B. J., & Sheppard, D. M. (2011). Autism and ADHD: How far have we come in the comorbidity debate? *Neuroscience and*

Biobehavioral Reviews, *35*(5), 1081–1088. https://doi.org/10.1016/j.neubiorev.2010.11.002

Ghanizadeh, A. (2013). Parents reported oral sensory sensitivity processing and food preference in ADHD. *Journal of Psychiatric and Mental Health Nursing*, *20*(5), 426–432. https://doi.org/10.1111/j.1365-2850.2011.01830.x

Ghanizadeh, Ahmad. (2011). Sensory processing problems in children with ADHD, a systematic review. *Psychiatry Investigation*, *8*(2), 89–94. https://doi.org/10.4306/pi.2011.8.2.89

Ghirardi, L., Pettersson, E., Taylor, M. J., Freitag, C. M., Franke, B., Asherson, P., Larsson, H., & Kuja-Halkola, R. (2019). Genetic and environmental contribution to the overlap between ADHD and ASD trait dimensions in young adults: A twin study. *Psychological Medicine*, *49*(10), 1713–1721. https://doi.org/10.1017/S003329171800243X

Glod, M., Riby, D. M., Honey, E., & Rodgers, J. (2015). Psychological correlates of sensory processing patterns in individuals with autism spectrum disorder: A systematic review. *Review Journal of Autism and Developmental Disorders*, *2*(2), 199–221. https://doi.org/10.1007/s40489-015-0047-8

Goldin, R. L., Matson, J. L., Tureck, K., Cervantes, P. E., & Jang, J. (2013). A comparison of tantrum behavior profiles in children with ASD, ADHD and comorbid ASD and ADHD. *Research in Developmental Disabilities*, *34*(9), 2669–2675. https://doi.org/10.1016/j.ridd.2013.04.022

Goldstein, S., & Schwebach, A. J. (2004). The comorbidity of pervasive developmental disorder and attention deficit hyperactivity disorder: Results of a retrospective chart review. *Journal of Autism and Developmental Disorders*, *34*(3), 329–339. https://doi.org/10.1023/B:JADD.0000029554.46570.68

Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of

severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(5), 693–705. https://doi.org/10.1007/s10803-008-0674-3

Gotham, K., Risi, S., Pickles, A., & Lord, C. (2007). The autism diagnostic observation schedule: Revised algorithms for improved diagnostic validity. In *Journal of Autism and Developmental Disorders* (Vol. 37, Issue 4, pp. 613–627). J Autism Dev Disord. https://doi.org/10.1007/s10803-006-0280-1

Grandin, T. (2009a). Visual Abilities and Sensory Differences in a Person with Autism. *Biological Psychiatry*, *65*(1), 15–16. https://doi.org/10.1016/j.biopsych.2008.11.005

Grandin, T. (2009b). Visual Abilities and Sensory Differences in a Person with Autism. In *Biological Psychiatry* (Vol. 65, Issue 1, pp. 15–16). Biol Psychiatry. https://doi.org/10.1016/j.biopsych.2008.11.005

Gray, S., Kirby, A. V., & Holmes, L. G. (2021). Autistic Narratives of Sensory Features, Sexuality, and Relationships. *Https://Home.Liebertpub.Com/Aut*. https://doi.org/10.1089/AUT.2020.0049

Green, S. A., Ben-Sasson, A., Soto, T. W., & Carter, A. S. (2012). Anxiety and sensory over-responsivity in toddlers with autism spectrum disorders: Bidirectional effects across time. *Journal of Autism and Developmental Disorders*, *42*(6), 1112–1119. https://doi.org/10.1007/s10803-011-1361-3

Grzadzinski, R., Di Martino, A., Brady, E., Mairena, M. A., O'Neale, M., Petkova, E., Lord, C., & Castellanos, F. X. (2011a). Examining autistic traits in children with ADHD: Does the Autism Spectrum Extend to ADHD? *Journal of Autism and Developmental Disorders*, *41*(9), 1178–1191. https://doi.org/10.1007/s10803-010-1135-3

Grzadzinski, R., Di Martino, A., Brady, E., Mairena, M. A., O'Neale, M., Petkova, E., Lord, C.,

& Castellanos, F. X. (2011b). Examining autistic traits in children with ADHD: Does the autism spectrum extend to ADHD? *Journal of Autism and Developmental Disorders*, *41*(9), 1178–1191. https://doi.org/10.1007/s10803-010-1135-3

Grzadzinski, R., Dick, C., Lord, C., & Bishop, S. (2016a). Parent-reported and clinician-observed autism spectrum disorder (ASD) symptoms in children with attention deficit/hyperactivity disorder (ADHD): Implications for practice under DSM-5. *Molecular Autism*, *7*(1), 1–13. https://doi.org/10.1186/s13229-016-0072-1

Grzadzinski, R., Dick, C., Lord, C., & Bishop, S. (2016b). Parent-reported and clinician-observed autism spectrum disorder (ASD) symptoms in children with attention deficit/hyperactivity disorder (ADHD): Implications for practice under DSM-5. *Molecular Autism*, *7*(1). https://doi.org/10.1186/s13229-016-0072-1

Guevremont, D. C., & Dumas, M. C. (1994). Peer relationship problems and disruptive behavior disorders. *Journal of Emotional and Behavioral Disorders*, *2*(3), 164–172. https://doi.org/10.1177/106342669400200304

Guttmann-Steinmetz, S., Gadow, K. D., & DeVincent, C. J. (2009). Oppositional defiant and conduct disorder behaviors in boys with autism spectrum disorder with and without attention-deficit hyperactivity disorder versus several comparison samples. *Journal of Autism and Developmental Disorders*, *39*(7), 976–985. https://doi.org/10.1007/s10803-009-0706-7

Halvorsen, M., Aman, M. G., Mathiassen, B., Brøndbo, P. H., Steinsvik, O. O., & Martinussen, M. (2019). Psychometric Properties of the Norwegian Aberrant Behavior Checklist and Diagnostic Relationships in a Neuro-Pediatric Sample. *Journal of Mental Health Research in Intellectual Disabilities*, *12*(3–4), 234–255.

https://doi.org/10.1080/19315864.2019.1630872

Harkins, C. M., Handen, B. L., & Mazurek, M. O. (2021). The Impact of the Comorbidity of ASD and ADHD on Social Impairment. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-021-05150-1

Hartley, S. L., & Sikora, D. M. (2009). Which DSM-IV-TR criteria best differentiate high-functioning autism spectrum disorder from ADHD and anxiety disorders in older children? *Autism*, *13*(5), 485–509. https://doi.org/10.1177/1362361309335717

Hazen, E. P., Stornelli, J. L., O'Rourke, J. A., Koesterer, K., & McDougle, C. J. (2014). Sensory symptoms in autism spectrum disorders. In *Harvard Review of Psychiatry* (Vol. 22, Issue 2, pp. 112–124). Lippincott Williams and Wilkins. https://doi.org/10.1097/01.HRP.0000445143.08773.58

Herz, R. S., Van Reen, E., Gredvig-Ardito, C. A., & Carskadon, M. A. (2020). Insights into smell and taste sensitivity in normal weight and overweight-obese adolescents. *Physiology and Behavior*, *221*. https://doi.org/10.1016/j.physbeh.2020.112897

Hill, T. L., Gray, S. A. O., Baker, C. N., Boggs, K., Carey, E., Johnson, C., Kamps, J. L., & Enrique Varela, R. (2017). A Pilot Study Examining the Effectiveness of the PEERS Program on Social Skills and Anxiety in Adolescents with Autism Spectrum Disorder. *Journal of Developmental and Physical Disabilities*, *29*(5), 797–808. https://doi.org/10.1007/s10882-017-9557-x

Hilton, C., Graver, K., & LaVesser, P. (2007). Relationship between social competence and sensory processing in children with high functioning autism spectrum disorders. *Research in Autism Spectrum Disorders*, *1*(2), 164–173. https://doi.org/10.1016/j.rasd.2006.10.002

Hochhauser, M., & Engel-Yeger, B. (2010). Sensory processing abilities and their relation to

participation in leisure activities among children with high-functioning autism spectrum disorder (HFASD). *Research in Autism Spectrum Disorders*, *4*(4), 746–754. https://doi.org/10.1016/J.RASD.2010.01.015

Hollocks, M. J., Lerh, J. W., Magiati, I., Meiser-Stedman, R., & Brugha, T. S. (2019). Anxiety and depression in adults with autism spectrum disorder: A systematic review and meta-analysis. In *Psychological Medicine* (Vol. 49, Issue 4, pp. 559–572). https://doi.org/10.1017/S0033291718002283

Houghton, R., Monz, B., Law, K., Loss, G., Le Scouiller, S., de Vries, F., & Willgoss, T. (2019). Psychometric Validation of the Autism Impact Measure (AIM). *Journal of Autism and Developmental Disorders*, *49*(6), 2559–2570. https://doi.org/10.1007/s10803-019-04011-2

Hoza, B., Mrug, S., Gerdes, A. C., Bukowski, W. M., Kraemer, H. C., Wigal, T., Hinshaw, S. P., Gold, J. A., Pelham, W. E., & Arnold, L. E. (2005). What aspects of peer relationships are impaired in children with attention-deficit/hyperactivity disorder? *Journal of Consulting and Clinical Psychology*, *73*(3), 411–423. https://doi.org/10.1037/0022-006X.73.3.411

Hus, V., Bishop, S., Gotham, K., Huerta, M., & Lord, C. (2013). Factors influencing scores on the social responsiveness scale. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *54*(2), 216–224. https://doi.org/10.1111/j.1469-7610.2012.02589.x

Hus, V., & Lord, C. (2014). The autism diagnostic observation schedule, module 4: Revised algorithm and standardized severity scores. *Journal of Autism and Developmental Disorders*, *44*(8), 1996–2012. https://doi.org/10.1007/s10803-014-2080-3

Ismael, N., Lawson, L. M., & Hartwell, J. (2018). Relationship between sensory processing and participation in daily occupations for children with autism spectrum disorder: A systematic review of studies that used Dunn's sensory processing framework. *American Journal of*

Occupational Therapy, *72*(3). https://doi.org/10.5014/ajot.2018.024075

James, K., Miller, L. J., Schaaf, R., Nielsen, D. M., & Schoen, S. A. (2011). Phenotypes within sensory modulation dysfunction. *Comprehensive Psychiatry*, *52*(6), 715–724. https://doi.org/10.1016/j.comppsych.2010.11.010

Jang, J., Matson, J. L., Williams, L. W., Tureck, K., Goldin, R. L., & Cervantes, P. E. (2013). Rates of comorbid symptoms in children with ASD, ADHD, and comorbid ASD and ADHD. *Research in Developmental Disabilities*, *34*(8), 2369–2378. https://doi.org/10.1016/j.ridd.2013.04.021

Kanne, S. M., Mazurek, M. O., Sikora, D., Bellando, J., Branum-Martin, L., Handen, B., Katz, T., Freedman, B., Powell, M. P., & Warren, Z. (2014). The autism impact measure (AIM): Initial development of a new tool for treatment outcome measurement. *Journal of Autism and Developmental Disorders*, *44*(1), 168–179. https://doi.org/10.1007/s10803-013-1862-3

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Keating, J., Gaffney, R., Bramham, J., & Downes, M. (2021). Sensory modulation difficulties and assessment in children with attention deficit hyperactivity disorder: A systematic review. In *European Journal of Developmental Psychology*. Routledge. https://doi.org/10.1080/17405629.2021.1889502

Kern, J. K., Geier, D. A., Sykes, L. K., Geier, M. R., & Deth, R. C. (2015). Are ASD and ADHD a Continuum? A Comparison of Pathophysiological Similarities Between the Disorders.

Journal of Attention Disorders, *19*(9), 805–827. https://doi.org/10.1177/1087054712459886

Kjellmer, L., Hedvall, Å., Fernell, E., Gillberg, C., & Norrelgen, F. (2012). Language and communication skills in preschool children with autism spectrum disorders: Contribution of cognition, severity of autism symptoms, and adaptive functioning to the variability. *Research in Developmental Disabilities*, *33*(1), 172–180. https://doi.org/10.1016/J.RIDD.2011.09.003

Klassen, A. F. (2004). Health-related quality of life in children and adolescents who have a diagnosis of attention-deficit/hyperactivity disorder. *Pediatrics*, *114*(5), e541–e547. https://doi.org/10.1542/peds.2004-0844

Kotte, A., Joshi, G., Fried, R., Uchida, M., Spencer, A., Woodworth, K. Y., Kenworthy, T., Faraone, S. V., & Biederman, J. (2013). Autistic traits in children with and without ADHD. *Pediatrics*, *132*(3), e612–e622. https://doi.org/10.1542/peds.2012-3947

Landau, S., Milich, R., & Diener, M. (1998). Peer relations of children with attention-deficit hyperactivity disorder. *Reading and Writing Quarterly: Overcoming Learning Difficulties.*, *14*, 83–105.

Lane, A. E., Molloy, C. A., & Bishop, S. L. (2014). Classification of Children With Autism Spectrum Disorder by Sensory Subtype: A Case for Sensory-Based Phenotypes. *Autism Research*, *7*(3), 322–333. https://doi.org/10.1002/aur.1368

Laugeson, E. A., Frankel, F., Gantman, A., Dillon, A. R., & Mogil, C. (2012). Evidence-based social skills training for adolescents with autism spectrum disorders: The UCLA PEERS program. *Journal of Autism and Developmental Disorders*, *42*(6), 1025–1036. https://doi.org/10.1007/s10803-011-1339-1

Lecavalier, L., Mccracken, C. E., Aman, M. G., Mcdougle, C. J., Mccracken, J. T., Tierney, E.,

Smith, T., Johnson, C., King, B., Handen, B., Swiezy, N. B., Arnold, L. E., Bearss, K., Vitiello, B., & Scahill, L. (2018). *An exploration of concomitant psychiatric disorders in children with autism spectrum disorder*. https://doi.org/10.1016/j.comppsych.2018.10.012

Lecavalier, L., McCracken, C. E., Aman, M. G., McDougle, C. J., McCracken, J. T., Tierney, E., Smith, T., Johnson, C., King, B., Handen, B., Swiezy, N. B., Eugene Arnold, L., Bearss, K., Vitiello, B., & Scahill, L. (2019). An exploration of concomitant psychiatric disorders in children with autism spectrum disorder. *Comprehensive Psychiatry*, *88*, 57–64. https://doi.org/10.1016/j.comppsych.2018.10.012

Leitner, Y. (2014). The Co-occurrence of autism and attention deficit hyperactivity disorder in children: What do we know? *Frontiers in Human Neuroscience*, *8*(April), 1–8. https://doi.org/10.3389/fnhum.2014.00268

Leyfer, O. T., Folstein, S. E., Bacalman, S., Davis, N. O., Dinh, E., Morgan, J., Tager-Flusberg, H., & Lainhart, J. E. (2006). Comorbid psychiatric disorders in children with autism: Interview development and rates of disorders. *Journal of Autism and Developmental Disorders*, *36*(7), 849–861. https://doi.org/10.1007/s10803-006-0123-0

Lidstone, J., Uljarević, M., Sullivan, J., Rodgers, J., McConachie, H., Freeston, M., Le Couteur, A., Prior, M., & Leekam, S. (2014). Relations among restricted and repetitive behaviors, anxiety and sensory features in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *8*(2), 82–92. https://doi.org/10.1016/j.rasd.2013.10.001

Lin, L.-Y., & Huang, P.-C. (2017). Quality of life and its related factors for adults with autism spectrum disorder. *Https://Doi.Org/10.1080/09638288.2017.1414887*, *41*(8), 896–903. https://doi.org/10.1080/09638288.2017.1414887

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006a). Sensory and attention abnormalities

in autistic spectrum disorders. *Autism*, *10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006b). Sensory and attention abnormalities in autistic spectrum disorders. *Autism*, *10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Lord, C, Rutter, M., DiLvaore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism diagnostic observation schedule, second edition (ADOS-2) manual (Part 1): Modules 1–4.* Western Psychological Services.

Lord, Catherine, & Jones, R. M. (2012). Annual research review: Re-thinking the classification of autism spectrum disorders. In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 53, Issue 5, pp. 490–509). J Child Psychol Psychiatry. https://doi.org/10.1111/j.1469-7610.2012.02547.x

Lord, Catherine, Petkova, E., Hus, V., Gan, W., Lu, F., Martin, D. M., Ousley, O., Guy, L., Bernier, R., Gerdts, J., Algermissen, M., Whitaker, A., Sutcliffe, J. S., Warren, Z., Klin, A., Saulnier, C., Hanson, E., Hundley, R., Piggot, J., … Risi, S. (2012). A multisite study of the clinical diagnosis of different autism spectrum disorders. *Archives of General Psychiatry*, *69*(3), 306–313. https://doi.org/10.1001/archgenpsychiatry.2011.148

Lord, Catherine, Risi, S., Lambrecht, L., Cook, Jr., E. H., Leventhal, B. L., DiLavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism diagnostic observation schedule—generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, *30*(3), 205–223. https://doi.org/10.1023/A:1005592401947

Lord, Catherine, Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., Dilavore, P. C., Pickles,

A., & Rutter, M. (2000). The Autism Diagnostic Observation Schedule-Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, *30*(3), 205–223. https://doi.org/10.1023/A:1005592401947

Lugo-Marín, J., Magán-Maganto, M., Rivero-Santana, A., Cuellar-Pompa, L., Alviani, M., Jenaro-Rio, C., Díez, E., & Canal-Bedia, R. (2019). Prevalence of psychiatric disorders in adults with autism spectrum disorder: A systematic review and meta-analysis. In *Research in Autism Spectrum Disorders* (Vol. 59, pp. 22–33). Elsevier. https://doi.org/10.1016/j.rasd.2018.12.004

Luteijn, E. F., Serra, M., Jackson, S., Steenhuis, M. P., Althaus, M., Volkmar, F., & Minderaa, R. (2000). How unspecified are disorders of children with a pervasive developmental disorder not otherwise specified? A study of social problems in children with PDD-NOS and ADHD. *European Child and Adolescent Psychiatry*, *9*(3), 168–179. https://doi.org/10.1007/s007870070040

Machado, B. C., Dias, P., Lima, V. S., Campos, J., & Gonçalves, S. (2016). Prevalence and correlates of picky eating in preschool-aged children: A population-based study. *Eating Behaviors*, *22*, 16–21. https://doi.org/10.1016/j.eatbeh.2016.03.035

MacLennan, K., Roach, L., & Tavassoli, T. (2020). The Relationship Between Sensory Reactivity Differences and Anxiety Subtypes in Autistic Children. *Autism Research*, *13*(5), 785–795. https://doi.org/10.1002/aur.2259

Maenner, M. J., Shaw, K. A., Baio, J., Washington, A., Patrick, M., DiRienzo, M., Christensen, D. L., Wiggins, L. D., Pettygrove, S., Andrews, J. G., Lopez, M., Hudson, A., Baroud, T., Schwenk, Y., White, T., Rosenberg, C. R., Lee, L. C., Harrington, R. A., Huston, M., …

Dietz, P. M. (2020). Prevalence of autism spectrum disorder among children aged 8 Years-Autism and developmental disabilities monitoring network, 11 Sites, United States, 2016. *MMWR Surveillance Summaries*, *69*(4), 1–12. https://doi.org/10.15585/MMWR.SS6904A1

Mandy, W. P., Charman, T., & Skuse, D. H. (2012). Testing the construct validity of proposed criteria for DSM-5 autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(1), 41–50. https://doi.org/10.1016/j.jaac.2011.10.013

Mandy, W. P. L., & Skuse, D. H. (2008). Research Review: What is the association between the social-communication element of autism and repetitive interests, behaviours and activities? In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 49, Issue 8, pp. 795–808). https://doi.org/10.1111/j.1469-7610.2008.01911.x

Mangeot, S. D., Miller, L. J., McIntosh, D. N., McGrath-Clarke, J., Simon, J., Hagerman, R. J., & Goldson, E. (2001). Sensory modulation dysfunction in children with attention-deficit–hyperactivity disorder. *Developmental Medicine and Child Neurology*, *43*(06), 399. https://doi.org/10.1017/s0012162201000743

Martin, J., Hamshere, M. L., O'Donovan, M. C., Rutter, M., & Thapar, A. (2014). Factor structure of autistic traits in children with ADHD. *Journal of Autism and Developmental Disorders*, *44*(1), 204–215. https://doi.org/10.1007/s10803-013-1865-0

Matson, J. L., Mahan, S., Hess, J. A., Fodstad, J. C., & Neal, D. (2010). Progression of challenging behaviors in children and adolescents with Autism Spectrum Disorders as measured by the Autism Spectrum Disorders-Problem Behaviors for Children (ASD-PBC). *Research in Autism Spectrum Disorders*, *4*(3), 400–404. https://doi.org/10.1016/j.rasd.2009.10.010

Matson, J. L., & Wilkins, J. (2007). A critical review of assessment targets and methods for

social skills excesses and deficits for children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *1*(1), 28–37. https://doi.org/10.1016/j.rasd.2006.07.003

Matthews, N. L., Orr, B. C., Warriner, K., DeCarlo, M., Sorensen, M., Laflin, J., & Smith, C. J. (2018). Exploring the Effectiveness of a Peer-Mediated Model of the PEERS Curriculum: A Pilot Randomized Control Trial. *Journal of Autism and Developmental Disorders*, *48*(7), 2458–2475. https://doi.org/10.1007/s10803-018-3504-2

May-Benson, T. A., Lopes de Mello Gentil, J., & Teasdale, A. (2020). Characteristics and Prevalence of Gravitational Insecurity in Children with Sensory Processing Dysfunction. *Research in Developmental Disabilities*, *101*, 103640. https://doi.org/10.1016/j.ridd.2020.103640

Mazurek, M. O., Carlson, C., Baker-Ericzén, M., Butter, E., Norris, M., Barr, C., & Kanne, S. (2020). The Autism Impact Measure (AIM): Examination of Sensitivity to Change. *Autism Research*, *13*(11), 1867–1879. https://doi.org/10.1002/aur.2397

Mazurek, M. O., Carlson, C., Baker-Ericzén, M., Butter, E., Norris, M., & Kanne, S. (2020). Construct Validity of the Autism Impact Measure (AIM). *Journal of Autism and Developmental Disorders*, *50*(7), 2307–2319. https://doi.org/10.1007/s10803-018-3462-8

Mazurek, M. O., Lu, F., Symecko, H., Butter, E., Bing, N. M., Hundley, R. J., Poulsen, M., Kanne, S. M., Macklin, E. A., & Handen, B. L. (2017). A Prospective Study of the Concordance of DSM-IV and DSM-5 Diagnostic Criteria for Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *47*(9), 2783–2794. https://doi.org/10.1007/s10803-017-3200-7

Mazurek, M. O., Vasa, R. A., Kalb, L. G., Kanne, S. M., Rosenberg, D., Keefer, A., Murray, D. S., Freedman, B., & Lowery, L. A. (2013). Anxiety, sensory over-responsivity, and

gastrointestinal problems in children with autism spectrum disorders. *Journal of Abnormal Child Psychology*, *41*(1), 165–176. https://doi.org/10.1007/s10802-012-9668-x

McClain, M. B., Hasty Mills, A. M., & Murphy, L. E. (2017). Inattention and hyperactivity/impulsivity among children with attention-deficit/hyperactivity-disorder, autism spectrum disorder, and intellectual disability. *Research in Developmental Disabilities*, *70*(August), 175–184. https://doi.org/10.1016/j.ridd.2017.09.009

McIntosh, D. N., Miller, L. J., Shyu, V., & Dunn, W. (1999). Overview of the Short Sensory Profile (SSP). In *The sensory profile: Examiner's manual* (pp. 59–73). The Psychological Corporation.

McVey, A. J., Schiltz, H. K., Haendel, A. D., Dolan, B. K., Willar, K. S., Pleiss, S. S., Karst, J. S., Carlson, M., Krueger, W., Murphy, C. C., Casnar, C. L., Yund, B., & Van Hecke, A. V. (2018). Social difficulties in youth with autism with and without anxiety and ADHD symptoms. *Autism Research*, *11*(12), 1679–1689. https://doi.org/10.1002/aur.2039

Mikami, A. (2011). The importance of friendship fo youth with ADHD. *Clinical Child Family Psychology Review*, *13*(2), 181–198. https://doi.org/10.1007/s10567-010-0067-y.The

Miller, L. J., McIntosh, D. N., McGrath, J., Shyu, V., Lampe, M., Taylor, A. K., Tassone, F., Neitzel, K., Stackhouse, T., & Hagerman, R. J. (1999). Electrodermal responses to sensory stimuli in individuals with fragile X syndrome: A preliminary report. *American Journal of Medical Genetics*, *83*(4), 268–279. https://doi.org/10.1002/(sici)1096-8628(19990402)83:4<268::aid-ajmg7>3.3.co;2-b

Miller, L., Nielsen, D. M., & Schoen, S. A. (2012). Attention deficit hyperactivity disorder and sensory modulation disorder: A comparison of behavior and physiology. *Research in Developmental Disabilities*, *33*(3), 804–818. https://doi.org/10.1016/j.ridd.2011.12.005

Mimouni-Bloch, A., Offek, H., Rosenblum, S., Posener, I., Silman, Z., & Engel-Yeger, B. (2018). Association between sensory modulation and daily activity function of children with attention deficit/hyperactivity disorder and children with typical development. *Research in Developmental Disabilities*, *83*, 69–76. https://doi.org/10.1016/j.ridd.2018.08.002

Moul, C., Cauchi, A., Hawes, D. J., Brennan, J., & Dadds, M. R. (2015). Differentiating Autism Spectrum Disorder and Overlapping Psychopathology with a Brief Version of the Social Responsiveness Scale. *Child Psychiatry and Human Development*, *46*(1), 108–117. https://doi.org/10.1007/s10578-014-0456-4

Mullen, E. (1995). *Mullen scales of early learning.*

Mulligan, A., Anney, R. J. L., O'Regan, M., Chen, W., Butler, L., Fitzgerald, M., Buitelaar, J., Steinhausen, H. C., Rothenberger, A., Minderaa, R., Nijmeijer, J., Hoekstra, P. J., Oades, R. D., Roeyers, H., Buschgens, C., Christiansen, H., Franke, B., Gabriels, I., Hartman, C., … Gill, M. (2009). Autism symptoms in attention-deficit/hyperactivity disorder: A familial trait which correlates with conduct, oppositional defiant, language and motor disorders. *Journal of Autism and Developmental Disorders*, *39*(2), 197–209. https://doi.org/10.1007/s10803-008-0621-3

Murray, D. S., Fedele, A., Shui, A., & Coury, D. L. (2016). The Autism speaks Autism treatment network registry data: Opportunities for investigators. *Pediatrics*, *137*(S2), S72–S78. https://doi.org/10.1542/peds.2015-2851E

Murray, M. J. (2010). Attention-deficit/Hyperactivity Disorder in the Context of Autism Spectrum Disorders. *Current Psychiatry Reports 2010 12:5*, *12*(5), 382–388. https://doi.org/10.1007/S11920-010-0145-3

Nakamura, B. J., Ebesutani, C., Bernstein, A., & Chorpita, B. F. (2008). A Psychometric

Analysis of the Child Behavior Checklist DSM-Oriented Scales. *Journal of Psychopathology and Behavioral Assessment 2008 31:3*, *31*(3), 178–189. https://doi.org/10.1007/S10862-008-9119-8

Ng, R., Heinrich, K., & Hodges, E. (2021). Associations Between ADHD Subtype Symptomatology and Social Functioning in Children With ADHD, Autism Spectrum Disorder, and Comorbid Diagnosis: Utility of Diagnostic Tools in Treatment Considerations. *Journal of Attention Disorders*, *25*(6), 820–828. https://doi.org/10.1177/1087054719855680

Panagiotidi, M., Overton, P. G., & Stafford, T. (2018). The relationship between ADHD traits and sensory sensitivity in the general population. *Comprehensive Psychiatry*, *80*, 179–185. https://doi.org/10.1016/j.comppsych.2017.10.008

Pandolfi, V., Magyar, C. I., & Dill, C. A. (2012). An initial psychometric evaluation of the CBCL 6–18 in a sample of youth with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(1), 96–108. https://doi.org/10.1016/J.RASD.2011.03.009

Parush, S., Sohmer, H., Steinberg, A., & Kaitz, M. (2007). Somatosensory function in boys with ADHD and tactile defensiveness. *Physiology and Behavior*, *90*(4), 553–558. https://doi.org/10.1016/j.physbeh.2006.11.004

Pelham, W. (1989). Behavior therapy, behavioral assessment and psychostimulant medication in the treatment fo attention deficit disorders: An interactive approach. In *Current Concepts and Emerging Trends in Attentional and Behavioral Disorders of Childhood* (pp. 169–201). Pergamon. https://doi.org/10.1016/B978-0-08-036508-4.50016-3

Pelham, W., McBurnett, K., Harper, G. W., Milich, R., Murphy, D. A., Clinton, J., & Thiele, C. (1990). Methylphenidate and baseball playing in ADHD children: Who's on first? *Journal*

of Consulting and Clinical Psychology, *58*(1), 130–133. https://doi.org/10.1037/0022-006X.58.1.130

Perrin, J., Coury, D., Klatka, K., Winklosky, B., Wolfe, A., Murray, D., & Kuhlthau, K. (2016). The Autism Intervention Research Network on Physical Health and the Autism Speaks Autism Treatment Network. *Pediatrics*, *137 Suppl*, S67–S71. https://doi.org/10.1542/PEDS.2015-2851D

Pfeiffer, B., Daly, B. P., Nicholls, E. G., & Gullo, D. F. (2015). Assessing sensory processing problems in children with and without attention deficit hyperactivity disorder. *Physical and Occupational Therapy in Pediatrics*, *35*(1), 1–12. https://doi.org/10.3109/01942638.2014.904471

Pfeiffer, B., Kinnealey, M., Reed, C., & Herzberg, G. (2005). Sensory modulation and affective disorders in children and adolescents with Asperger's disorder. *American Journal of Occupational Therapy*, *59*(3), 335–345. https://doi.org/10.5014/ajot.59.3.335

Polderman, T. J. C., Hoekstra, R. A., Posthuma, D., & Larsson, H. (2014). The co-occurrence of autistic and ADHD dimensions in adults: An etiological study in 17 770 twins. *Translational Psychiatry*, *4*(9), e435. https://doi.org/10.1038/tp.2014.84

Polderman, T. J. C., Hoekstra, R. A., Vinkhuyzen, A. A. E., Sullivan, P. F., Van Der Sluis, S., & Posthuma, D. (2013). Attentional switching forms a genetic link between attention problems and autistic traits in adults. *Psychological Medicine*, *43*(9), 1985–1996. https://doi.org/10.1017/S0033291712002863

Rao, P. A., & Landa, R. J. (2014). Association between severity of behavioral phenotype and comorbid attention deficit hyperactivity disorder symptoms in children with autism spectrum disorders. *Autism*, *18*(3), 272–280. https://doi.org/10.1177/1362361312470494

Rich, E. C., Loo, S. K., Yang, M., Dang, J., & Smalley, S. L. (2009). Social functioning difficulties in ADHD: Association with PDD risk. *Clinical Child Psychology Psychiatry*, *14*(3), 329–344. https://doi.org/10.1177/1359104508100890

Roid, G. H. (2003). *Stanford Binet intelligence scales (5th ed.)*.

Ronald, A., Larsson, H., Anckarsäter, H., & Lichtenstein, P. (2014). Symptoms of autism and ADHD: A Swedish twin study examining their overlap. *Journal of Abnormal Psychology*, *123*(2), 440–451. https://doi.org/10.1037/a0036088

Rose, V., Trembath, D., Keen, D., & Paynter, J. (2016). The proportion of minimally verbal children with autism spectrum disorder in a community-based early intervention programme. *Journal of Intellectual Disability Research*, *60*(5), 464–477. https://doi.org/10.1111/jir.12284

Rosen, N. E., Lord, C., & Volkmar, F. R. (2021). The Diagnosis of Autism: From Kanner to DSM-III to DSM-5 and Beyond. In *Journal of Autism and Developmental Disorders* (pp. 1–18). Springer. https://doi.org/10.1007/s10803-021-04904-1

Salley, B., Gabrielli, J., Smith, C. M., & Braun, M. (2015). Do communication and social interaction skills differ across youth diagnosed with autism spectrum disorder, attention-deficit/hyperactivity disorder, or dual diagnosis? *Research in Autism Spectrum Disorders*, *20*, 58–66. https://doi.org/10.1016/j.rasd.2015.08.006

Sannar, E. M., Palka, T., Beresford, C., Peura, C., Kaplan, D., Verdi, M., Siegel, M., Kaplan, S., Grados, M., Erickson, C., Gabriels, R. L., Mazefsky, C., Morrow, E. M., Righi, G., Santangelo, S. L., Wink, L., Benevides, J., Best, C., Bowen, K., … Williams, D. (2018). Sleep Problems and Their Relationship to Maladaptive Behavior Severity in Psychiatrically Hospitalized Children with Autism Spectrum Disorder (ASD). *Journal of Autism and*

Developmental Disorders, *48*(11), 3720–3726. https://doi.org/10.1007/s10803-017-3362-3

Sanz-Cervera, P., Pastor-Cerezuela, G., Fernández-Andrés, M. I., & Tárraga-Mínguez, R. (2015). Sensory processing in children with Autism Spectrum Disorder: Relationship with non-verbal IQ, autism severity and Attention Deficit/Hyperactivity Disorder symptomatology. *Research in Developmental Disabilities*, *45–46*, 188–201. https://doi.org/10.1016/j.ridd.2015.07.031

Sanz-Cervera, P., Pastor-Cerezuela, G., González-Sala, F., Tárraga-Mínguez, R., & Fernández-Andrés, M. I. (2017). Sensory processing in children with autism spectrum disorder and/or attention deficit hyperactivity disorder in the home and classroom contexts. *Frontiers in Psychology*, *8*, 1772. https://doi.org/10.3389/fpsyg.2017.01772

Schauder, K. B., & Bennetto, L. (2016). Toward an interdisciplinary understanding of sensory dysfunction in autism spectrum disorder: An integration of the neural and symptom literatures. In *Frontiers in Neuroscience* (Vol. 10, Issue JUN, p. 268). Frontiers. https://doi.org/10.3389/fnins.2016.00268

Sedgewick, F., Hill, V., & Pellicano, E. (2019). 'It's different for girls': Gender differences in the friendships and conflict of autistic and neurotypical adolescents. *Autism*, *23*(5), 1119–1132. https://doi.org/10.1177/1362361318794930

Sikora, D. M., Vora, P., Coury, D. L., & Rosenberg, D. (2012). Attention-deficit/hyperactivity disorder symptoms, adaptive functioning, and quality of life in children with autism spectrum disorder. *Pediatrics*, *130*(Supplement 2), S91–S97. https://doi.org/10.1542/peds.2012-0900G

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008a). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity,

and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008b). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f

Sinzig, J., Morsch, D., & Lehmkuhl, G. (2008). Do hyperactivity, impulsivity and inattention have an impact on the ability of facial affect recognition in children with autism and ADHD? *European Child & Adolescent Psychiatry*, *17*(2), 63–72. https://doi.org/10.1007/s00787-007-0637-9

Snow, A. V., & Lecavalier, L. (2011). Comparing autism, PDD-NOS, and other developmental disabilities on parent-reported behavior problems: Little evidence for ASD subtype validity. *Journal of Autism and Developmental Disorders*, *41*(3), 302–310. https://doi.org/10.1007/s10803-010-1054-3

Sokolova, E., Oerlemans, A. M., Rommelse, N. N., Groot, P., Hartman, C. A., Glennon, J. C., Claassen, T., Heskes, T., & Buitelaar, J. K. (2017). A causal and mediation analysis of the comorbidity between attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD). *Journal of Autism and Developmental Disorders*, *47*(6), 1595–1604. https://doi.org/10.1007/s10803-017-3083-7

Spitzer, R., & Siegel, B. (1990). The DSM-III-R Field Trial of Pervasive Developmental Disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *29*(6),

855–862. https://doi.org/10.1097/00004583-199011000-00003

Sprenger, L., Bühler, E., Poustka, L., Bach, C., Heinzel-Gutenbrunner, M., Kamp-Becker, I., & Bachmann, C. (2013a). Impact of ADHD symptoms on autism spectrum disorder symptom severity. *Research in Developmental Disabilities*, *34*(10), 3545–3552. https://doi.org/10.1016/j.ridd.2013.07.028

Sprenger, L., Bühler, E., Poustka, L., Bach, C., Heinzel-Gutenbrunner, M., Kamp-Becker, I., & Bachmann, C. (2013b). Impact of ADHD symptoms on autism spectrum disorder symptom severity. *Research in Developmental Disabilities*, *34*(10), 3545–3552. https://doi.org/10.1016/j.ridd.2013.07.028

Staikova, E., Gomes, H., Tartter, V., McCabe, A., & Halperin, J. M. (2013). Pragmatic deficits and social impairment in children with ADHD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *54*(12), 1275–1283. https://doi.org/10.1111/jcpp.12082

Stevens, T., Peng, L., & Barnard-Brak, L. (2016). The comorbidity of ADHD in children diagnosed with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *31*, 11–18. https://doi.org/10.1016/j.rasd.2016.07.003

Stichter, J. P., Christ, S. E., Herzog, M. J., O'Donnell, R. M., & O'Connor, K. V. (2016). Exploring the role of executive functioning measures for social competence research. *Assessment for Effective Intervention*, *41*(4), 243–254. https://doi.org/10.1177/1534508416644179

Stichter, J. P., Herzog, M. J., Owens, S. A., & Malugen, E. (2016). Manualization, Feasibility, and Effectiveness of the School-Based Social Competence Intervention for Adolescents (Sci-a). *Psychology in the Schools*, *53*(6), 583–600. https://doi.org/10.1002/pits.21928

Stichter, J. P., Herzog, M. J., Visovsky, K., Schmidt, C., Randolph, J., Schultz, T., & Gage, N.

(2010). Social competence intervention for youth with asperger syndrome and high-functioning autism: An initial investigation. *Journal of Autism and Developmental Disorders*, *40*(9), 1067–1079. https://doi.org/10.1007/s10803-010-0959-1

Stichter, J. P., O'Connor, K. V., Herzog, M. J., Lierheimer, K., & McGhee, S. D. (2012). Social competence intervention for elementary students with Aspergers Syndrome and high functioning autism. *Journal of Autism and Developmental Disorders*, *42*(3), 354–366. https://doi.org/10.1007/s10803-011-1249-2

Stratis, E. A., & Lecavalier, L. (2013). Restricted and repetitive behaviors and psychiatric symptoms in youth with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *7*(6), 757–766. https://doi.org/10.1016/J.RASD.2013.02.017

Syu, Y. C., Huang, P. C., Wang, T. Y., Chang, Y. C., & Lin, L. Y. (2020). Relationship among sensory over-responsivity, problem behaviors, and anxiety in emerging adults with autism spectrum disorder. *Neuropsychiatric Disease and Treatment*, *16*, 2181–2190. https://doi.org/10.2147/NDT.S270308

Taylor, M. J., Charman, T., & Ronald, A. (2015). Where are the strongest associations between autistic traits and traits of ADHD? evidence from a community-based twin study. *European Child and Adolescent Psychiatry*, *24*(9), 1129–1138. https://doi.org/10.1007/s00787-014-0666-0

Thye, M. D., Bednarz, H. M., Herringshaw, A. J., Sartin, E. B., & Kana, R. K. (2018). The impact of atypical sensory processing on social impairments in autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*(September 2016), 151–167. https://doi.org/10.1016/j.dcn.2017.04.010

Tomchek, S. D., & Dunn, W. (2007). Sensory Processing in Children With and Without Autism:

A Comparative Study Using the Short Sensory Profile. *American Journal of Occupational Therapy*, *61*(2), 190–200. https://doi.org/10.5014/ajot.61.2.190

Van Der Meer, J. M. J., Oerlemans, A. M., Van Steijn, D. J., Lappenschaar, M. G. A., De Sonneville, L. M. J., Buitelaar, J. K., & Rommelse, N. N. J. (2012). NEW RESEARCH Are Autism Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder Different Manifestations of One Overarching Disorder? Cognitive and Symptom Evidence From a Clinical and Population-Based Sample. *JAAC*, *51*(11), 1160-1172.e3. https://doi.org/10.1016/j.jaac.2012.08.024

Van Der Oord, S., Van Der Meulen, E. M., Prins, P. J. M., Oosterlaan, J., Buitelaar, J. K., & Emmelkamp, P. M. G. (2005). A psychometric evaluation of the social skills rating system in children with attention deficit hyperactivity disorder. *Behaviour Research and Therapy*, *43*(6), 733–746. https://doi.org/10.1016/j.brat.2004.06.004

Varni, J. W., Seid, M., & Kurtin, P. S. (2001). PedsQL™ 4.0: Reliability and Validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in Healthy and Patient Populations. *Medical Care*, *39*(8), 800–812. https://doi.org/10.1097/00005650-200108000-00006

Vasa, R. A., Keefer, A., McDonald, R. G., Hunsche, M. C., & Kerns, C. M. (2020). A Scoping Review of Anxiety in Young Children with Autism Spectrum Disorder. *Autism Research*, *13*(12), 2038–2057. https://doi.org/10.1002/aur.2395

Visser, S. N., Danielson, M. L., Bitsko, R. H., Holbrook, J. R., Kogan, M. D., Ghandour, R. M., Perou, R., & Blumberg, S. J. (2014). NEW RESEARCH Trends in the Parent-Report of Health Care Provider-Diagnosed and Medicated Attention-Deficit/Hyperactivity Disorder: United States, 2003-2011. *J. Am. Acad. Child Adolesc. Psychiatry*, *53*(1), 34–46.

www.jaacap.org

Volkmar, F. R., Klin, A., Siegel, B., Szatmari, P., Lord, C., Campbell, M., Freeman, B. J., Cicchetti, D. V., Rutter, M., Kline, W., Buitelaar, J., Hattab, Y., Fombonne, E., Fuentes, J., Werry, J., Stone, W., Kerbeshian, J., Hoshino, Y., & Bregman, J. (1994). Field trial for autistic disorder in DSM-IV. *American Journal of Psychiatry*, *151*(9), 1361–1367. https://doi.org/10.1176/ajp.151.9.1361

Watson, L. R., Patten, E., Baranek, G. T., Poe, M., Boyd, B. A., Freuler, A., & Lorenzi, J. (2011). Differential associations between sensory response patterns and language, social, and communication measures in children with autism or other developmental disabilities. *Journal of Speech, Language, and Hearing Research*, *54*(6), 1562–1576. https://doi.org/10.1044/1092-4388(2011/10-0029)

Wechsler, D. (2002). *Wechsler preschool and primary scale of intelligence (3rd ed.)*.

Wechsler, D. (2003). *Wechsler intelligence scale for children (4th ed.)*.

Wechsler, D. (2008). *Wechsler adult intelligence scale. 4th ed.*

Wechsler, D. (2011). *WASI-II: Wechsler abbreviated scale of intelligence (2nd ed.)*.

Wechsler, D. (2014). *Wechsler intelligence scale for children (5th ed.)*.

Wehmeier, P. M., Schacht, A., & Barkley, R. A. (2010). Social and emotional impairment in children and adolescents with ADHD and the impact on quality of life. *Journal of Adolescent Health*, *46*(3), 209–217. https://doi.org/10.1016/j.jadohealth.2009.09.009

Weitlauf, A. S., Sathe, N., McPheeters, M. L., & Warren, Z. E. (2017). Interventions targeting sensory challenges in autism spectrum disorder: A systematic review. In *Pediatrics* (Vol. 139, Issue 6, p. 2021). American Academy of Pediatrics. https://doi.org/10.1542/peds.2017-0347

Whalen, C. K., & Henker, B. (1985). The social worlds of hyperactive (ADDH) children. *Clinical Psychology Review*, *5*(5), 447–478. https://doi.org/10.1016/0272-7358(85)90004-2

Wiggins, L. D., Robins, D. L., Bakeman, R., & Adamson, L. B. (2009). Breif report: Sensory abnormalities as distinguishing symptoms of autism spectrum disorders in young children. *Journal of Autism and Developmental Disorders*, *39*(7), 1087–1091. https://doi.org/10.1007/s10803-009-0711-x

Wodka, E. L., Parish-Morris, J., Annett, R. D., Carpenter, L., Dillon, E., Michaelson, J., Kim, S. H., Landa, R., & Kanne, S. (2021). Co-occurring attention-deficit/hyperactivity disorder and anxiety disorders differentially affect males and females with autism. *The Clinical Neuropsychologist*, 1–25. https://doi.org/10.1080/13854046.2021.1942554

Wolstencroft, J., Robinson, L., Srinivasan, R., Kerry, E., Mandy, W., & Skuse, D. (2018). A Systematic Review of Group Social Skills Interventions, and Meta-analysis of Outcomes, for Children with High Functioning ASD. *Journal of Autism and Developmental Disorders*, *48*(7), 2293–2307. https://doi.org/10.1007/s10803-018-3485-1

Wood-Downie, H., Wong, B., Kovshoff, H., Cortese, S., & Hadwin, J. A. (2021). Research Review: A systematic review and meta-analysis of sex/gender differences in social interaction and communication in autistic and nonautistic children and adolescents. In *Journal of Child Psychology and Psychiatry and Allied Disciplines* (Vol. 62, Issue 8, pp. 922–936). J Child Psychol Psychiatry. https://doi.org/10.1111/jcpp.13337

Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2009). Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders. *Autism Research*, *2*(6), 322–333. https://doi.org/10.1002/aur.103

Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2010). *Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders*. *2*(6), 322–333. https://doi.org/10.1002/aur.103

Yochman, A., Parush, S., & Ornoy, A. (2004). Responses of preschool children with and without ADHD to sensory events in daily life. *American Journal of Occupational Therapy*, *58*(3), 294–302. https://doi.org/10.5014/ajot.58.3.294

Zachor, D. A., & Ben-Itzchak, E. (2013). The Relationship Between Clinical Presentation and Unusual Sensory Interests in Autism Spectrum Disorders: A Preliminary Investigation. *Journal of Autism and Developmental Disorders*, *44*(1), 229–235. https://doi.org/10.1007/s10803-013-1867-y

Zheng, S., Kim, H., Salzman, E., Ankenman, K., & Bent, S. (2021). Improving Social Knowledge and Skills among Adolescents with Autism: Systematic Review and Meta-Analysis of UCLA PEERS® for Adolescents. *Journal of Autism and Developmental Disorders*, 1–16. https://doi.org/10.1007/s10803-021-04885-1

Zucker, N., Copeland, W., Franz, L., Carpenter, K., Keeling, L., Angold, A., & Egger, H. (2015). Psychological and psychosocial impairment in preschoolers with selective eating. *Pediatrics*, *136*(3), e582–e590. https://doi.org/10.1542/peds.2014-2386

Table 1 *Sample characteristics by group.*

	Total (N/%)	ASD *(n/%)*	ADHD *(n/%)*	ASD + ADHD *(n/%)*
	282	151	82	49
Age (months) *M (SD)*	93.12 (50.46)	67.26 (47.39)	122.07 (38.45)	124.37 (29.36)
Sex				
Male	232 (82.27%)	123 (81.46%)	67 (81.71%)	42 (85.71%)
Female	50 (17.73%)	28 (18.54%)	15 (18.29%)	7 (14.29%)
Race				
White	228 (80.85%)	113 (74.83%)	69 (84.15%)	46 (93.88%)
Non-White	48 (17.02%)	34 (22.52%)	12 (14.63%)	2 (4.08%)
NR	6 (2.13%)	4 (2.65%)	1 (1.22%)	1 (2.04%)
Ethnicity				
Hisp.	21 (7.45%)	16 (10.60%)	4 (4.88%)	1 (2.04%)
Non-Hisp.	241 (85.46%)	121 (80.13%)	73 (89.02%)	47 (95.92%)
NR	20 (7.09%)	14 (9.27%)	5 (6.10%)	1 (2.04%)
Income				
Under 25,000	73 (25.89%)	43 (28.48%)	16 (19.51%)	14 (28.57%)
25-49,999	61 (21.63%)	32 (21.19%)	20 (24.39%)	9 (18.37%)
50-74,999	39 (13.83%)	26 (17.22%)	10 (12.20%)	3 (6.12%)
75-99,999	34 (12.06%)	16 (10.60%)	7 (8.54%)	11 (22.45%)
100,000	45 (15.96%)	20 (13.25%)	19 (23.17%)	6 (12.24%)
NR	30 (10.64%)	14 (9.27%)	10 (12.20%)	6 (12.24%)

Note: NR= Not Reported or Missing; Hisp.= Hispanic or Latino; Non-Hisp.= Not Hispanic or Latino.

Table 2 *Bivariate correlations among study variables*

N =282	Age	IQ	ADOS-2 SA-CSS	ABC Lethargy/ Social Withdrawal
Age	-			
IQ	.479**	-		
ADOS-2 SA-CSS	-.396**	-.302**	-	
ABC Lethargy/ Social Withdrawal	.011	-.079	.052	-

Note: ADOS-2 SA-CSS = Autism Diagnostic Observation Schedule 2nd Edition Social Affect Calibrated Severity Score; ABC = Aberrant Behavior Checklist.
**p < .01

Table 3 *Group differences on age and measures of cognition and social functioning.*

	ASD n = 151	ADHD n = 82	ASD + ADHD n = 49	*F*	*p*
	M (SD)				
Age	67.26 (47.39)	122.07 (38.45)	124.37 (29.36)	55.091	<.001
IQ	73.13 (21.68)	88.43 (17.97)	86.99 (21.38)	23.502	<.001
ADOS-2 SA-CSS	7.43 (2.03)	4.06 (1.89)	6.54 (1.69)	80.555	<.001
ABC Lethargy/ Social Withdrawal	13.14 (8.53)	11.80 (8.59)	10.68 (7.66)	1.81	.17

Note: Results from univariate ANOVAs. Age is reported in months. The ADOS-2 SA-CSS is a calibrated severity score, where higher scores indicate greater social impairment. The ABC Lethargy/Social Withdrawal is an empirically derived subscale score, where higher scores indicate the presence of more symptoms of social impairment.

Manuscript Two

The Association Between ADHD Symptoms and Atypical Sensory Processing in Individuals with Autism Spectrum Disorder

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Abstract

Atypical sensory processing (SP) is common among individuals with autism spectrum disorder (ASD) and is a core feature of the disorder. Differences in SP are also observed in individuals with attention deficit/hyperactivity disorder (ADHD) and up to 70% of children with ASD show symptoms of ADHD. Prior research has suggested that ADHD symptoms may be associated with increased problems related to SP. This study investigated the relationship between ADHD symptoms and types of atypical SP in 2,108 youth with ASD, controlling for demographic and clinical characteristics. Results indicate that ADHD symptoms significantly predicted several types of atypical SP, but not movement sensitivity or low energy/weakness. Findings suggest that ADHD symptoms differentially impact types of atypical SP among youth with autism.

Keywords: autism, ASD, ADHD, sensory processing, comorbidity, atypical SP

Sensory differences have been recognized since the earliest clinical descriptions of children with autism (Kanner, 1943) and are now included in the diagnostic criteria for autism spectrum disorder (ASD; American Psychiatric Association, 2013). Sensory experiences and associated distress remain highly salient to many individuals on the autism spectrum (Ben-Sasson et al., 2019; Grandin, 2009; Gray et al., 2021) and increasing empirical and clinical attention has been devoted to understanding how these differences impact individuals with ASD. Research over the last decade has demonstrated that atypical sensory processing (SP) is associated with cognitive, emotional, and behavioral functioning (for review, see Glod et al., 2015). It has been suggested that atypical SP may have cascading effects on the development of attentional skills (Baranek et al., 2018; Cascio et al., 2016; Dellapiazza, Michelon, et al., 2021), social skills (Baranek et al., 2013; Thye et al., 2018), and adaptive functioning (Dellapiazza, 2018) in individuals with ASD. Sensory problems hinder participation in family routines (Hochhauser & Engel-Yeger, 2010) and community/ leisure activities (Bagby et al., 2012), and are associated with poorer individual and family quality of life (Demchick et al., 2014; Lin & Huang, 2017) and worse school performance (Butera et al., 2020).

While atypical SP is common in ASD, it is not unique to ASD, and is also commonly observed in individuals with attention deficit/hyperactivity disorder (ADHD). ASD and ADHD are two of the most common neurodevelopmental disorders, and it is estimated that 30-70% of individuals with ASD also experience symptoms of ADHD (Ames & White, 2011; Amr et al., 2012; Antshel et al., 2016; Frazier et al., 2001; Stevens et al., 2016). Given the significant comorbidity of ASD and ADHD, and high prevalence of sensory problems in both disorders, it is surprising that little research to date has explored the associations between ADHD symptoms and atypical SP in individuals with ASD. It is possible that ADHD symptoms may be associated

with greater atypical SP in individuals with ASD. Further, it is unclear if ADHD symptoms may be universally or differentially associated with type of atypical SP. As sensory dysfunction has been associated with a host of co-occurring problems and altered developmental trajectories, further investigation of the association between ADHD symptoms and atypical SP is warranted.

Atypical SP in ASD

SP is defined as the way visual, auditory, gustatory, tactile, olfactory, vestibular, and proprioceptive information is perceived and organized in the central nervous system for optimal functioning (Dunn, 2001). According to Dunn's model, reactivity to sensory stimulation can vary based on the individual and neurological threshold, and when this is disturbed, two categories of atypical SP result. A high neurological threshold is involved in under-responsivity to sensory stimulation, whereas over-responsivity involves a low neurological threshold, with all sensory modalities potentially affected. As SP fundamentally impacts how individuals interact with their environment and learn throughout development, atypical SP has widespread effects on various developmental systems and domains of functioning.

It is estimated that 82-97% of children with ASD present with atypical SP (Dellapiazza, 2018). The increased attention devoted to understanding sensory problems in people with autism has resulted in several systematic reviews over the last decade. Some reviews have focused on the neurobiological correlates of atypical SP and synthesized findings on the neurobiology of sensory symptoms (Hazen et al., 2014), assessment methodologies for adolescents and adults with autism (DuBois et al., 2017), and the relationship between neurobiology and sensory symptoms (Schauder & Bennetto, 2016). Others have focused on behavioral correlates of sensory systems, including attention and adaptive behavior (Dellapiazza, 2018), daily functioning (Ismael et al., 2018), and emotional, behavioral, and affective symptoms (Glod et al.,

2015). Glod and colleagues' 2015 review of 21 studies synthesized several important findings on the psychological correlates of atypical SP relevant to the present study. Greater atypical SP was associated with more overall symptoms of autism (Ashburner et al., 2008; Hilton et al., 2007; Liss et al., 2006), poorer social communication skills (Baranek et al., 2013; Watson et al., 2011), and higher levels of certain repetitive and restricted behaviors (Boyd et al., 2010; Chen et al., 2009; Gal et al., 2010; Lidstone et al., 2014). Additionally, several studies employing a variety of measures have demonstrated a significant association between sensory over-responsivity and anxiety (Green et al., 2012; Lane et al., 2014; Lidstone et al., 2014; Mazurek et al., 2013; Pfeiffer et al., 2005). Several more recent studies have similarly found a significant relationship between anxiety symptoms and sensory over-responsivity in individuals with ASD (MacLennan et al., 2020; Syu et al., 2020; Vasa et al., 2020). Less research, however, has focused on the relationship between atypical SP and symptoms associated with ADHD among youth with autism.

Atypical SP and ADHD Symptoms

Atypical SP is more frequently reported among individuals with ADHD than among those with TD (Ghanizadeh, 2011) and differences in SP have been reported to affect approximately half of individuals with ADHD (Miller et al., 2012; Mimouni-Bloch et al., 2018). Over-responsivity and under-responsivity to sensory stimuli have been demonstrated in individuals with ADHD using both behavioral measures (Cheung & Siu, 2009; Engel-Yeger & Ziv-On, 2011; Pfeiffer et al., 2015) and physiological measures (Mangeot et al., 2001; Parush et al., 2007). The Sensory Profile (Dunn, 1999; Dunn, 2014) and its short form, the Short Sensory Profile (SSP; McIntosh et al., 1999) are two of the most commonly used behavioral measures (i.e., proxy-report measures of observable sensory behaviors) to assess atypical SP. Studies

comparing children with TD and ADHD have found that children with ADHD demonstrated atypical SP on as many as 11 to all 14 of the subscales of the Sensory Profile (Cheung & Siu, 2009; Dunn & Bennett, 2002; Yochman et al., 2004) and across five or more of the eight subscales of the SSP (Engel-Yeger & Ziv-On, 2011; Mangeot et al., 2001; McIntosh et al., 1999; Mimouni-Bloch et al., 2018). ADHD has been associated with atypical SP in the areas of visual, auditory, tactile, olfactory, and vestibular/proprioceptive processing (see Ghanizadeh, 2011 and Keating et al., 2021 for reviews). Studies that have explored atypical SP among children with ADHD have not found significant differences between those with the primarily hyperactive/impulsive type and those with the primarily inattentive type across several sensory measures (Engel-Yeger & Ziv-On, 2011; Ghanizadeh, 2011; Miller et al., 2012; Pfeiffer et al., 2015). This suggests that the atypical SP observed in ADHD is not subtype-dependent or attributable to a specific set of core symptoms, but rather is associated with the broader developmental differences attributed to ADHD. While the relationship between ADHD symptoms and atypical SP has been robustly demonstrated, the nature of this relationship in the presence of ASD is less clear.

Atypical SP and ADHD Symptoms in ASD

Despite the high co-occurrence of ADHD and ASD, and global impact of atypical SP on functioning, only a handful of studies have examined the associations between SP and ADHD symptoms in autism using behavioral measures. Some of these studies, as well as studies employing other measurement approaches (e.g., experimental paradigms, physiological measures) are discussed in Dellapiazza and colleagues' 2018 systematic review of the links between SP, adaptive behavior, and attention in ASD. As the present study focuses on the relationship between ADHD symptoms and atypical SP in autism using a behavioral measure

(i.e., the SSP), the review of the literature on atypical SP and ADHD symptoms below includes only studies that have used behavioral measures to quantify atypical SP.

A 2006 study that investigated the relationship between attention and patterns of atypical SP found that a subset of the sample (10%) of 114 children (*M* age=8.53 years) with ASD displayed a behavioral pattern characterized by sensory over-responsivity and over-selective/over-focused attention (Liss et al., 2006). While the authors employed rigorous statistical methods, an experimental measure was employed to assess atypical SP that has not been validated in ASD and lacks published psychometric data. Additionally, only a brief checklist designed to measure over-focusing was used. Another study exploring associations between attention and atypical SP found a significant negative association between attention difficulties and the auditory filtering, tactile sensitivity, and under-responsiveness/sensation seeking subscales, and total score of the SSP among children age 6-10 with ASD (Ashburner et al., 2008). While this was one of the first investigations to look at the relationship between attention problems and specific types of atypical SP in youth with autism, findings are limited due to the reliance on bivariate correlations. This approach does not consider the role of other potentially important factors that could influence the strength of the relationship between attention and types of atypical SP. Additionally, children with an IQ less than 80 were excluded from the study, which limits generalizability of findings.

Two studies have been published by Sanz-Cervera and colleagues on atypical SP in ASD using the Sensory Processing Measure (SPM; Parham et al., 2007). Results from the first study showed that greater atypical SP significantly predicted the number of ADHD symptoms observed at home and school after controlling for gender, age, and non-verbal IQ in a sample of 41 children age 5-8 (Sanz-Cervera et al., 2015). Additionally, the subscales on the SPM

explained a significant amount of the variance in inattention and hyperactive/impulsive symptoms on a parent-report measure adapted from DSM-IV-TR. The second study compared atypical SP across 90 children ages 5-8 with ASD, ADHD, ASD + ADHD, or TD (Sanz-Cervera et al., 2017). The ASD + ADHD and ADHD groups demonstrated greater atypical SP on the body awareness subscale of the SPM Home Form than the ASD group, which suggests that ADHD symptoms may be associated with increased difficulties with proprioception and coordinated movements. Additionally, the ASD + ADHD group showed more dysfunction on the hearing subscale of the SPM classroom form than the ADHD group, which may indicate that ADHD exacerbates auditory processing problems in ASD. Notably, the measure used in both of these studies, the SPM, measures constructs such as social participation and praxis (i.e., planning, organizing, and executing actions in sequence), in addition to SP. Caution may be warranted in comparing results of studies using the SPM to measures like the Sensory Profile or SSP, as they assess distinct constructs and were developed based on different theoretical models (Brown et al., 2010; Chaney & Wilkey, 2016; Dugas et al., 2017). Research suggests that the convergent validity among these measures is only moderate and the SPM may yield scores indicative of greater dysfunction than the Sensory Profile (Brown et al., 2010; Dugas et al., 2017).

A recent study compared atypical SP and attention symptoms in 120 children age 6-12 with ASD, ADHD, ASD + ADHD, and TD (Dellapiazza, Michelon, et al., 2021). Children with ASD + ADHD presented with the greatest atypical SP and showed more atypical SP in the areas of multisensory and auditory processing than the ASD group on the Sensory Profile. Additionally, atypical sensory seeking was related to attention problems for all ASD and ADHD groups. While the study suggests that ADHD symptoms may impact auditory and multisensory processing in

children with ASD, findings must be interpreted in the context of methodological limitations. The sample was limited to children with an IQ over 80 and only 18 children were in the ASD + ADHD group. This precluded the use of statistical analysis that could have controlled for the role of age, gender, IQ, and other clinical characteristics.

While findings from all of these studies support an association between atypical SP and ADHD symptoms in youth with ASD, it is difficult to draw conclusions about the relationship between ADHD symptoms and types of atypical SP. Factors contributing to these difficulties include variability in measurement approach for atypical SP and ADHD symptoms, significant methodological differences and limitations, and exclusion criteria based on age and IQ. Furthermore, the aforementioned studies did not consistently account for demographic and clinical characteristics known to be related to ADHD symptoms and atypical SP, including gender, age, IQ, autism symptom severity, and co-occurring anxiety. Thus, the present study evaluates the association between ADHD symptoms and types of atypical SP controlling for the role of gender, age, IQ, ASD symptoms, and anxiety symptoms in a large, well-characterized sample of youth with ASD. Consistent with the literature illustrating the pervasive impact of ADHD symptoms on atypical SP, it was hypothesized that ADHD symptoms would be significantly associated with all types of atypical SP assessed by the SSP.

Methods

Participants and Procedures

The current study conducted secondary analysis of data collected through the Autism Speaks Autism Treatment Network (ATN) registry. The ATN registry is a multisite database including developmental, behavioral, and health data on a sample of children with ASD who received clinical care at an ATN site in the United States or Canada. The ATN and ATN registry

have both been previously described in greater detail (Murray et al., 2016; Perrin et al., 2016). The ATN registry study was approved by the Institutional Review Board at each site. Informed written consent was obtained from all parents and assent was obtained from children when appropriate.

Participants in the current study included 2,108 children and adolescents enrolled in the ATN registry who had complete data on measures required for the analyses. See Table 1 for sample characteristics. All participants were assessed by ATN clinicians using a standard diagnostic battery, including a clinical interview, the Autism Diagnostic Observation Schedule (Lord et al., 2012), cognitive assessment, and assessment of adaptive functioning. Eligibility for ATN registry enrollment required participants to have a confirmed diagnosis of ASD (including autistic disorder, Asperger's disorder, and pervasive developmental disorder, not otherwise specified). Participants in the current study ranged from 23 months to 17.5 years of age at enrollment, with a mean age of 6.37 years (standard deviation (SD) = 3.34 years). The majority of the sample was male (83.59%) and Caucasian (80.36%).

[INSERT TABLE 1]

Measures

Demographics

Primary caregivers completed a demographic questionnaire, which included information about the participant's age, sex, ethnicity, and race.

Sensory Processing

The Short Sensory Profile (SSP) is a 38-item questionnaire that measures atypical SP (McIntosh et al., 1999). The SSP is an abbreviated version of the Sensory Profile (Dunn, 1999) that has good psychometric properties and is commonly used to assess sensory problems in

children with ASD (Miller et al., 1999; Tomchek & Dunn, 2007). The SSP contains items related to seven sensory domains as follows: (1) Tactile Sensitivity, (2) Taste/Smell Sensitivity, (3) Movement Sensitivity, (4) Under-Responsive/Seeks Sensation, (5) Auditory Filtering, (6) Low Energy/Weak and (7) Visual/Auditory Sensitivity. Items are scored for frequency on a scale of 0–4 points, with lower scores indicating greater atypical SP, or more severe sensory dysfunction.

Autism Symptom Severity

The ADOS-2 total calibrated severity score (CSS; Esler et al., 2015; Gotham, Pickles, & Lord, 2009; Hus & Lord, 2014) served as a measure of ASD symptom severity. The ADOS-2 is a standardized, semi-structured assessment of communication and social interaction, and repetitive behaviors and restricted interests. The CSS is based on a 10-point scale: scores from 1 to 3 are in the ‘‘Nonspectrum’’ range; 4–5 are in the ‘‘ASD’’ range; and 6–10 in the ‘‘Autism’’ range. The CSS is less influenced by child characteristics such as verbal IQ, nonverbal IQ, age, and race (Gotham et al. 2009; Hus & Lord, 2014). The CSS has been employed in studies assessing participants across broad age ranges (Gotham et al., 2009; Shumway et al. 2012) and allows for comparison of symptom severity across modules (Gotham et al., 2007; Gotham et al., 2009).

Intellectual Ability

Full Scale IQ was assessed using one of a range of measures depending on an individual’s age, verbal ability, and ability to participate in testing. IQ measures included the Stanford Binet Scales of Intelligence–5th Edition (Roid, 2003), the Wechsler Intelligence Scale for Children–Fourth Edition (Wechsler, 2003), the Wechsler Intelligence Scale for Children–Fifth Edition (Wechsler, 2014), the Wechsler Preschool and Primary Scale of Intelligence–Third Edition (Wechsler, 2002), the Wechsler Abbreviated Scale of Intelligence–Second Edition

(Wechsler, 2011), Wechsler Adult Intelligence Scale—Fourth Edition (Wechsler, 2008), the Differential Ability Scales–Second Edition (Elliot, 2007). Additionally, the Bayley Scales of Infant and Toddler Development–Third Edition (Bayley, 2006) and the Mullen Scales of Early Learning (MSEL; Mullen, 1995) were used to assess emerging cognitive skills as a proxy for Full Scale IQ (FSIQ). For participants receiving the MSEL, the Early Learning Composite Standard Score was used.

Co-occurring Symptoms

ADHD symptoms and anxiety symptoms were assessed using the associated DSM-Oriented Scales from the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001). The CBCL is a broadband parent-report questionnaire that assesses for emotional and behavioral symptoms. Items are rated on a three-point Likert scale. The CBCL is widely used in ASD research and has excellent psychometric properties (Nakamura et al., 2008; Pandolfi et al., 2012). The DSM-Oriented scales for ADHD Problems and Anxiety Problems were used in the present study.

Data Analysis

Sample characteristics and means and standard deviations for study measures were generated (see Table 1). Eight multiple linear regressions were conducted with the CBCL ADHD Problems T-score as the independent variable and the following SSP scores as the dependent variables: Total score, Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Unresponsive/Seeks Sensation, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity. Covariates included age, gender, IQ, ADOS CSS, and the CBCL Anxiety Problems T-score. Correlations among study variables are presented in Table 2. Visual analysis indicated model residuals were normally distributed for the SSP Total score and many of the SSP subscale

scores. The Taste/Smell Sensitivity, Movement Sensitivity, and Low Energy/Weak outcome variables were transformed using a two-step transformation, as more traditional transformation methods were unable to produce normal distributions to meet the assumptions of normality. Step 1 involved transforming the variable into a percentile rank, which resulted in uniformly distributed probabilities. Step 2 applied the inverse-normal transformation to the results of the first step to form a variable consisting of normally distributed z-scores (Templeton, 2011).

[INSERT TABLE 2]

Results

Eight multiple linear regressions were performed to determine the association between atypical SP and ADHD symptoms using the SSP total and subscale scores. Other predictors included age, gender, IQ, autism symptom severity, and anxiety symptoms. In order to determine if the effect of ADHD symptoms on SSP scores varied by age or IQ, interactions between age and ADHD symptoms, and IQ and ADHD symptoms were evaluated. Interaction terms were initially tested in all models and were dropped from subsequent models when not significant. Table 3 shows results from the multiple regression analyses.

[INSERT TABLE 3]

SSP Total Score

Results from a multiple regression analysis revealed that ADHD symptoms ($\beta = -0.31$, $p < .001$) significantly predicted the SSP Total score. The overall model, $F(6, 2101) = 146.39$, $p < .001$, explained 29% of the variance on this global measure of atypical SP.

Tactile Sensitivity

ADHD symptoms ($\beta = -0.16$, $p < .001$) significantly predicted Tactile Sensitivity. There was a significant interaction between age and ADHD symptoms ($\beta = 0.06$, $p = .001$), which

indicated that ADHD symptoms were more strongly associated with tactile sensitivity at younger age. The overall model, $F(6, 2101) = 73.64$, $p < .001$, explained 20% of the variance in scores within this subscale.

Taste/Smell Sensitivity

ADHD symptoms ($\beta = -0.06$, $p = 0.01$) significantly predicted Taste/Smell Sensitivity. There was a significant interaction between age and ADHD symptoms within this subscale ($\beta = 0.08$, $p < 0.001$). The association between ADHD symptoms and taste/smell sensitivity was strongest at younger and older age. The overall model, $F(6, 2101) = 27.01$, $p < .001$, explained 8% of the variance in scores.

Movement Sensitivity

ADHD symptoms ($\beta = -0.03$, $p = 0.25$) were not a significant predictor of Movement Sensitivity. The overall model, $F(6, 2101) = 44.32$, $p < .001$ explained 11 % of the variance in scores on this subscale.

Under-Responsivity and Sensation Seeking

ADHD symptoms ($\beta = -0.55$, $p < .001$) significantly predicted scores on the Under-Responsive/Seeks Sensation subscale. Initially, a significant interaction was found between age and ADHD symptoms ($\beta = -0.05$, $p = 0.01$). However, further examination of the predictive margins indicated the presence of a statistically significant relationship between ADHD symptoms and the Under-Responsive/Seeks Sensation subscale score for all age values. Thus, no substantively significant interaction effect was found within this subscale. The overall model, $F(6, 2101) = 149.90$, $p < .001$, explained 33% of the variance in scores.

Auditory Filtering

ADHD symptoms (β= -0.40, p < .001) significantly predicted scores on the Auditory Filtering subscale. The overall model, $F(6, 2101) = 122.08$, p < .001, explained 26% of the variance within this scale.

Low Energy/Weak

ADHD symptoms (β= -0.01, p = .54) did not significantly predict scores on the Low Energy/Weak subscale. The overall model, $F(6, 2101) = 55.95$, p < .001, explained 14% of the variance in scores.

Visual/Auditory Sensitivity

ADHD symptoms (β= -0.12, p < .001) significantly predicted Visual and Auditory Sensitivity. The overall model, $F(6, 2101) = 78.93$, p < .001, explained 18% of the variance in scores on this subscale.

Discussion and Implications

The current study sought to examine relationships between ADHD symptoms and different types of atypical SP in a large sample of children and adolescents with ASD. Results indicated that ADHD symptoms significantly predicted several types of atypical SP on the SSP. Contrary to our hypothesis, ADHD symptoms were not universally associated with types of atypical SP in this sample of youth with autism. After controlling for relevant demographic and clinical characteristics, ADHD symptoms significantly predicted Tactile Sensitivity, Taste/Smell Sensitivity, Under-Responsivity and Sensation Seeking, Auditory Filtering, Visual/Auditory Sensitivity, and overall atypical SP as measured by the SSP. ADHD symptoms were not significantly associated with the Movement Sensitivity or Low Energy/Weakness subscales of the SSP. The present study also examined the potential moderating effect of age and IQ on the relationship between ADHD symptoms and types of atypical SP. Age significantly moderated

the relationship between ADHD symptoms and tactile sensitivity and taste/smell sensitivity, which highlights potentially meaningful age-related differences between symptoms associated with ADHD and sensory problems among youth with autism.

Our findings are consistent with prior research that has demonstrated a significant relationship between ADHD symptoms and tactile sensitivity (Ashburner et al., 2008), auditory filtering (Ashburner et al., 2008), and sensory under-responsivity and sensation seeking (Ashburner et al., 2008; Dellapiazza, Michelon, et al., 2021; Sanz-Cervera et al., 2017) in individuals with ASD. The moderating role of age in the relationship between ADHD symptoms and tactile sensitivity in novel and suggests that these symptoms may be more strongly linked among younger children. Results also showed that ADHD symptoms were a significant predictor of visual and auditory sensitivity. This finding is in line with previous research on ADHD symptoms and visual and auditory processing in youth with ASD (Dellapiazza, Michelon, et al., 2021; Sanz-Cervera et al., 2017), and provides additional information about the specific relation to over-responsivity within these modalities. The Visual/Auditory Sensitivity subscale on the SSP solely measures over-responsivity, which differs from the measures employed in the aforementioned studies. Dellapiazza and colleagues (2021) assessed atypical SP with the Sensory Profile, which measures over-and under-responsivity within each modality, and Sanz-Cervera and colleagues (2017) used the SPM, which measures over-and under-responsivity, sensory seeking, and perceptual problems for each modality. Our findings support a specific and significant relationship between ADHD symptoms and visual/auditory over-responsivity among youth with ASD.

Results also showed that ADHD symptoms were significantly associated with taste/smell sensitivity and that age moderated this relationship. To our knowledge, no prior study has

revealed a significant relationship between ADHD symptoms and this types of atypical SP among youth with autism. The taste/smell sensitivity subscale of the SSP measures both avoidance of, and strong preferences for, common tastes/smells, temperatures, and textures. Two studies have found that children with ADHD showed greater atypical SP on this subscale than did children with TD (Cheung & Siu, 2009; Mimouni-Bloch et al., 2018) and selective eating has been documented in youth diagnosed with ADHD (Ghanizadeh, 2013) and with ADHD symptoms (Machado et al., 2016; Zucker et al., 2015). Thus, it is possible that ADHD symptoms have an additive effect on the taste/smell sensitivity commonly observed in ASD, and this relationship may change with age. The association between ADHD symptoms and taste/smell sensitivity was strongest at the youngest and oldest ages among the current sample. The relationship between symptoms of ADHD and sensitivity to taste and smell may be particularly strong during early childhood and during puberty, when emotional and behavioral regulation challenges may be particularly salient and associated with sensory reactivity. The hormonal changes that occur during puberty have also been associated with increased symptoms of ADHD (Camara et al., 2022) and changes in sensitivity to taste and smell (Herz et al., 2020).

Movement sensitivity and low energy/weakness were the two domains of atypical SP that were not significantly associated with ADHD symptoms among this sample of youth with autism. The Movement Sensitivity subscale of the SSP consists of only three questions about distress associated with feet leaving the ground, the head being upside down, and falling or heights, or being upside down (e.g., somersaults, roughhousing). Ashburner and colleagues (2008) similarly did not find a significant relationship between ADHD symptoms and the Movement Sensitivity subscale among children with autism. As Miller and colleagues (2012) found no significant differences on this subscale between children with ADHD and with TD, it is

possible that ADHD symptoms are not associated with disruptions in this sensory system among individuals with TD or ASD. Another study that employed the SPM to measure atypical SP also found no significant differences among individuals with ASD, ADHD, and ASD + ADHD on the Balance and Motion subscale (Sanz-Cervera et al., 2017). While it is not a direct comparison to the Movement Sensitivity subscale on the SSP, there is content overlap between the scales as the subscale measures vestibular SP and one's ability to maintain upright posture and sense orientation with respect to gravity. Similarly, children with ADHD and a co-occurring sensory modulation disorder did not differ from children with ADHD on a measure of gravitational insecurity (May-Benson et al., 2020). Taken together, the current literature base and the results of this study do not support an association between ADHD symptoms and movement sensitivity among youth with autism.

The SSP's Low Energy/Weak subscale taps into muscular weakness (e.g., weak grasp, tires easily, difficulty lifting). ADHD symptoms were not significantly associated with this subscale score among the current sample. While two prior studies have found that children with ADHD demonstrated greater atypical SP on this subscale compared to those with TD (Engel-Yeger & Ziv-On, 2011; Mangeot et al., 2001), no significant association between ADHD symptoms and greater atypical SP on the this subscale has been found among youth with autism (Ashburner et al., 2008). It has been proposed that two distinct clusters of atypical SP exist; one cluster is explained by hyperactivity and is characterized by sensory seeking, externalizing behaviors, and poor social communication skills, and the other cluster is explained by movement sensitivity and characterized by withdrawal and low energy/weak behaviors (James et al., 2011). It is possible that ADHD symptoms are more strongly associated with the types of atypical SP captured by the first cluster, as the explanatory variable of hyperactivity is core to ADHD

symptomatology. This hypothesis is strengthened by the fact that the present study did not find a significant relationship between ADHD symptoms and the explanatory variable of movement sensitivity or clinical characteristic of low energy/weakness. However, further research that specifically investigates the relationship between ADHD symptoms and these potential sensory subtypes in ASD is warranted.

The present study has several noteworthy strengths. The large, well-characterized and representative sample of children and adolescents received expert clinical evaluation and diagnosis of ASD. The comprehensiveness of the data allowed us to control for important demographic (i.e., age, gender) and clinical characteristics (i.e., IQ, ASD symptom severity, anxiety) known to be associated with atypical SP. Prior studies have either inconsistently controlled for such differences or relied on statistical methods that could not account for differences attributed to these factors. Nevertheless, there are several limitations of the current study. First, data on atypical SP were collected from a questionnaire that relies on parent/caregiver report and not direct examination, as is common in published studies on SP. However, high agreement among the SSP, clinical diagnosis, and physiological measures have been reported (Mangeot et al., 2001; Miller et al., 2012). Second, we did not account for the potential role that medication could play in atypical SP. Individuals receiving medication for attention problems or other psychiatric/physical conditions were not excluded from the present study due to concern that this exclusion would result in a sample with less severe symptoms. Additionally, there is not sufficient data on the relationship between medication and atypical SP to discern which medications may impact SP. Third, the present study did not investigate the relationship between specific symptoms of ADHD (i.e., hyperactivity, impulsivity, inattention, over attention) and atypical SP. While prior studies have failed to demonstrate a significant

relationship between types of ADHD symptoms and types of atypical SP, addition of such analyses may have yielded potentially useful information. The present study did not include an appropriate measure capable of parsing out such symptoms.

In considering these limitations, there are several opportunities for future research to address these and add to the growing body of literature on ADHD and atypical SP in autism. Given the significant theoretical and measurement differences that characterize the study of atypical SP in autism, it will be important for studies to include more than one behavioral measure of SP and collect responses from more than reporter (i.e., teacher and parent, parent and self-report). As physiological measures capable of quantifying different types of atypical SP are limited, reliance on behavioral measures is necessary at present. Thus, a multi-measure, multi-informant approach may further inform research on atypical SP and its relation to ADHD, or other symptoms. Future research on the relations between ADHD symptoms and atypical SP in ASD would benefit from quantifying different ADHD symptoms, further exploring the role of age, and explicitly investigating which symptoms predict types of atypical SP controlling for medication effects. Physiological studies of SP within a pre- and post-medication framework will likely be necessary to determine what effect, if any, psychiatric medications, and particularly medications targeting ADHD symptoms, have on sensory dysfunction. Findings from such studies may be capable of informing medication decisions for youth with ASD and ADHD and significant sensory problems.

In summary, this study found that ADHD symptoms significantly predict several types of atypical SP measured by the SSP among a large sample of children and adolescents with autism. ADHD symptoms predicted the scores for the following SSP subscales controlling for age, gender, IQ, ASD symptom severity, and anxiety symptoms: Tactile Sensitivity, Taste/Smell

Sensitivity, Under-Responsivity and Sensation Seeking, Auditory Filtering, Visual/Auditory Sensitivity, and the SSP Total Score. ADHD symptoms were not significantly associated with the Movement Sensitivity or Low Energy/Weakness subscales of the SSP. ADHD symptoms appear to differentially impact sensory systems and types of atypical SP in youth with autism.

References

Achenbach, T & Rescorla, L. Manual for the ASEBA school-age forms & profiles: an integrated system of multi-informant assessment. Burlington, VT: University of Vermont, Research Center for Children, Youth & Families; 2001.

American Psychiatric Association (2000). Diagnostic and statistical manual of mental disorders (4th ed., text rev.). Washington DC: Author.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Ames, C. S., & White, S. J. (2011). Brief report: Are ADHD traits dissociable from the autistic profile? Links between cognition and behaviour. *Journal of Autism and Developmental Disorders*, *41*(3), 357–363. https://doi.org/10.1007/s10803-010-1049-0

Amr, M., Raddad, D., El-Mehesh, F., Bakr, A., Sallam, K., & Amin, T. (2012). Comorbid psychiatric disorders in Arab children with Autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(1), 240–248. https://doi.org/10.1016/j.rasd.2011.05.005

Antshel, K. M., Zhang-James, Y., Wagner, K. E., Ledesma, A., & Faraone, S. V. (2016). An update on the comorbidity of ADHD and ASD: a focus on clinical management. *Expert Review of Neurotherapeutics*, *16*(3), 279–293. https://doi.org/10.1586/14737175.2016.1146591

Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy*, *62*(5), 564–573. https://doi.org/10.5014/ajot.62.5.564

Bagby, M. S., Dickie, V. A., & Baranek, G. T. (2012). How sensory experiences of children with and without autism affect family occupations. *American Journal of Occupational Therapy*,

66(1), 78–86. https://doi.org/10.5014/ajot.2012.000604

Baranek, G. T., Watson, L. R., Boyd, B. A., Poe, M. D., David, F. J., & McGuire, L. (2013a). Hyporesponsiveness to social and nonsocial sensory stimuli in children with autism, children with developmental delays, and typically developing children. *Development and Psychopathology*, *25*(02), 307–320. https://doi.org/10.1017/s0954579412001071

Baranek, G. T., Watson, L. R., Boyd, B. A., Poe, M. D., David, F. J., & McGuire, L. (2013b). Hyporesponsiveness to social and nonsocial sensory stimuli in children with autism, children with developmental delays, and typically developing children. *Development and Psychopathology*, *25*(2), 307–320. https://doi.org/10.1017/S0954579412001071

Baranek, G. T., Woynaroski, T. G., Nowell, S., Turner-Brown, L., DuBay, M., Crais, E. R., & Watson, L. R. (2018). Cascading effects of attention disengagement and sensory seeking on social symptoms in a community sample of infants at-risk for a future diagnosis of autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*, 30–40. https://doi.org/10.1016/j.dcn.2017.08.006

Bayley, N. (2006). *Bayley scales of infant and toddler development.3rd ed.*

Ben-Sasson, A., Gal, E., Fluss, R., Katz-Zetler, N., & Cermak, S. A. (2019). Update of a meta-analysis of sensory symptoms in ASD: A new decade of research. *Journal of Autism and Developmental Disorders*, *49*(12), 4974–4996. https://doi.org/10.1007/s10803-019-04180-0

Boyd, B. A., Baranek, G. T., Sideris, J., Poe, M. D., Watson, L. R., Patten, E., & Miller, H. (2010). Sensory features and repetitive behaviors in children with autism and developmental delays. *Autism Research*, n/a-n/a. https://doi.org/10.1002/aur.124

Brown, T., Morrison, I., & Stagnitti, K. (2010). The convergent validity of two sensory processing scales used with school-age children: comparing the Sensory Profile and the

Sensory Processing Measure. *New Zealand Journal of Occupational Therapy*, *57*(2), 56–65. http://hdl.handle.net/10536/DRO/DU:30032049

Butera, C., Ring, P., Sideris, J., Jayashankar, A., Kilroy, E., Harrison, L., Cermak, S., & Aziz-Zadeh, L. (2020). Impact of Sensory Processing on School Performance Outcomes in High Functioning Individuals with Autism Spectrum Disorder. *Mind, Brain, and Education*, *14*(3), 243–254. https://doi.org/10.1111/mbe.12242

Camara, B., Padoin, C., & Bolea, B. (2022). Relationship between sex hormones, reproductive stages and ADHD: a systematic review. In *Archives of Women's Mental Health* (Vol. 25, Issue 1, pp. 1–8). Springer. https://doi.org/10.1007/s00737-021-01181-w

Cascio, C. J., Woynaroski, T., Baranek, G. T., & Wallace, M. T. (2016). Toward an interdisciplinary approach to understanding sensory function in autism spectrum disorder. In *Autism Research* (Vol. 9, Issue 9, pp. 920–925). John Wiley and Sons Inc. https://doi.org/10.1002/aur.1612

Chaney, R., & Wilkey, L. (2016). Examining Sensory Processing Tools for a School System. *Occupational Therapy Graduate Student Evidenced-Based Research Reviews*. https://scholarworks.wmich.edu/ot_posters/19

Chen, Y. H., Rodgers, J., & McConachie, H. (2009). Restricted and repetitive behaviours, sensory processing and cognitive style in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(4), 635–642. https://doi.org/10.1007/s10803-008-0663-6

Cheung, P. P. P., & Siu, A. M. H. (2009). A comparison of patterns of sensory processing in children with and without developmental disabilities. *Research in Developmental Disabilities*, *30*(6), 1468–1480. https://doi.org/10.1016/j.ridd.2009.07.009

Dellapiazza, F. (2018). Links between sensory processing, adaptive behaviours, and attention in children with autism spectrum disorder: A systematic review. In *Psychiatry Research* (Vol. 270, pp. 78–88). https://doi.org/10.1016/j.psychres.2018.09.023

Dellapiazza, F., Michelon, C., Vernhet, C., Muratori, F., Blanc, N., Picot, M. C., Baghdadli, A., Baghdadli, A., Chabaux, C., Chatel, C., Cohen, D., Damville, E., Geoffray, M. M., Gicquel, L., Jardri, R., Maffre, T., Novo, A., Odoyer, R., Oreve, M. J., … Vespirini, S. (2021). Sensory processing related to attention in children with ASD, ADHD, or typical development: results from the ELENA cohort. *European Child and Adolescent Psychiatry*, *30*(2), 283–291. https://doi.org/10.1007/s00787-020-01516-5

Demchick, B., Eskow, K., & Crabtree, L. A. (2014). Autism and Transitioning Youth: A Pilot Study of Sensory Processing and Family Quality of Life. *Journal of Occupational Therapy, Schools, and Early Intervention*, *7*(1), 54–69. https://doi.org/10.1080/19411243.2014.898492

DuBois, D., Lymer, E., Gibson, B. E., Desarkar, P., & Nalder, E. (2017). Assessing sensory processing dysfunction in adults and adolescents with autism spectrum disorder: A scoping review. In *Brain Sciences* (Vol. 7, Issue 8, p. 108). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/brainsci7080108

Dunn, W. (1999). *The sensory profile: User's manual*. Psychological Corporation.

Dunn, Winnie, & Bennett, D. (2002). Patterns of sensory processing in children with Attention Deficit Hyperactivity Disorder. *Occupational Therapy Journal of Research*, *22*(1), 4–15. https://doi.org/10.1177/153944920202200102

Elliot, C. (2007). *Differential abilities scale—2nd Edition (DAS-II) manual. 2nd ed.*

Engel-Yeger, B., & Ziv-On, D. (2011). The relationship between sensory processing difficulties

and leisure activity preference of children with different types of ADHD. *Research in Developmental Disabilities*, *32*(3), 1154–1162. https://doi.org/10.1016/j.ridd.2011.01.008

Esler, A. N., Bal, V. H., Guthrie, W., Wetherby, A., Weismer, S. E., & Lord, C. (2015). The autism diagnostic observation schedule, toddler module: Standardized severity scores. *Journal of Autism and Developmental Disorders*, *45*(9), 2704–2720. https://doi.org/10.1007/s10803-015-2432-7

Frazier, J. A., Biederman, J., Bellordre, C. A., Garfield, S. B., Geller, D. A., Coffey, B. J., & Faraone, S. V. (2001). Should the diagnosis of attention-deficit/ hyperactivity disorder be considered in children with pervasive developmental disorder? *Journal of Attention Disorders*, *4*(4), 203–211. https://doi.org/10.1177/108705470100400402

Gal, E., Dyck, M. J., & Passmore, A. (2010). Relationships between Stereotyped Movements and sensory processing disorders in children with and without developmental or sensory disorders. *American Journal of Occupational Therapy*, *64*(3), 453–461. https://doi.org/10.5014/ajot.2010.09075

Ghanizadeh, A. (2013). Parents reported oral sensory sensitivity processing and food preference in ADHD. *Journal of Psychiatric and Mental Health Nursing*, *20*(5), 426–432. https://doi.org/10.1111/j.1365-2850.2011.01830.x

Ghanizadeh, Ahmad. (2011). Sensory processing problems in children with ADHD, a systematic review. *Psychiatry Investigation*, *8*(2), 89–94. https://doi.org/10.4306/pi.2011.8.2.89

Glod, M., Riby, D. M., Honey, E., & Rodgers, J. (2015). Psychological correlates of sensory processing patterns in individuals with autism spectrum disorder: A systematic review. *Review Journal of Autism and Developmental Disorders*, *2*(2), 199–221. https://doi.org/10.1007/s40489-015-0047-8

Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(5), 693–705. https://doi.org/10.1007/s10803-008-0674-3

Grandin, T. (2009). Visual Abilities and Sensory Differences in a Person with Autism. In *Biological Psychiatry* (Vol. 65, Issue 1, pp. 15–16). Biol Psychiatry. https://doi.org/10.1016/j.biopsych.2008.11.005

Gray, S., Kirby, A. V., & Holmes, L. G. (2021). Autistic Narratives of Sensory Features, Sexuality, and Relationships. *Https://Home.Liebertpub.Com/Aut*. https://doi.org/10.1089/AUT.2020.0049

Green, S. A., Ben-Sasson, A., Soto, T. W., & Carter, A. S. (2012). Anxiety and sensory over-responsivity in toddlers with autism spectrum disorders: Bidirectional effects across time. *Journal of Autism and Developmental Disorders*, *42*(6), 1112–1119. https://doi.org/10.1007/s10803-011-1361-3

Hazen, E. P., Stornelli, J. L., O'Rourke, J. A., Koesterer, K., & McDougle, C. J. (2014). Sensory symptoms in autism spectrum disorders. In *Harvard Review of Psychiatry* (Vol. 22, Issue 2, pp. 112–124). Lippincott Williams and Wilkins. https://doi.org/10.1097/01.HRP.0000445143.08773.58

Herz, R. S., Van Reen, E., Gredvig-Ardito, C. A., & Carskadon, M. A. (2020). Insights into smell and taste sensitivity in normal weight and overweight-obese adolescents. *Physiology and Behavior*, *221*. https://doi.org/10.1016/j.physbeh.2020.112897

Hilton, C., Graver, K., & LaVesser, P. (2007). Relationship between social competence and sensory processing in children with high functioning autism spectrum disorders. *Research in Autism Spectrum Disorders*, *1*(2), 164–173. https://doi.org/10.1016/j.rasd.2006.10.002

Hochhauser, M., & Engel-Yeger, B. (2010). Sensory processing abilities and their relation to participation in leisure activities among children with high-functioning autism spectrum disorder (HFASD). *Research in Autism Spectrum Disorders*, *4*(4), 746–754. https://doi.org/10.1016/J.RASD.2010.01.015

Hus, V., & Lord, C. (2014). The autism diagnostic observation schedule, module 4: Revised algorithm and standardized severity scores. *Journal of Autism and Developmental Disorders*, *44*(8), 1996–2012. https://doi.org/10.1007/s10803-014-2080-3

Ismael, N., Lawson, L. M., & Hartwell, J. (2018). Relationship between sensory processing and participation in daily occupations for children with autism spectrum disorder: A systematic review of studies that used Dunn's sensory processing framework. *American Journal of Occupational Therapy*, *72*(3). https://doi.org/10.5014/ajot.2018.024075

James, K., Miller, L. J., Schaaf, R., Nielsen, D. M., & Schoen, S. A. (2011). Phenotypes within sensory modulation dysfunction. *Comprehensive Psychiatry*, *52*(6), 715–724. https://doi.org/10.1016/j.comppsych.2010.11.010

Keating, J., Gaffney, R., Bramham, J., & Downes, M. (2021). Sensory modulation difficulties and assessment in children with attention deficit hyperactivity disorder: A systematic review. In *European Journal of Developmental Psychology*. Routledge. https://doi.org/10.1080/17405629.2021.1889502

Lane, A. E., Molloy, C. A., & Bishop, S. L. (2014). Classification of Children With Autism Spectrum Disorder by Sensory Subtype: A Case for Sensory-Based Phenotypes. *Autism Research*, *7*(3), 322–333. https://doi.org/10.1002/aur.1368

Lidstone, J., Uljarević, M., Sullivan, J., Rodgers, J., McConachie, H., Freeston, M., Le Couteur, A., Prior, M., & Leekam, S. (2014). Relations among restricted and repetitive behaviors,

anxiety and sensory features in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *8*(2), 82–92. https://doi.org/10.1016/j.rasd.2013.10.001

Lin, L.-Y., & Huang, P.-C. (2017). Quality of life and its related factors for adults with autism spectrum disorder. *Https://Doi.Org/10.1080/09638288.2017.1414887*, *41*(8), 896–903. https://doi.org/10.1080/09638288.2017.1414887

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006a). Sensory and attention abnormalities in autistic spectrum disorders. *Autism*, *10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006b). Sensory and attention abnormalities in autistic spectrum disorders. *Autism*, *10*(2), 155–172. https://doi.org/10.1177/1362361306062021

Lord, C., Rutter, M., DiLvaore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism diagnostic observation schedule, second edition (ADOS-2) manual (Part 1): Modules 1–4.* Western Psychological Services.

Machado, B. C., Dias, P., Lima, V. S., Campos, J., & Gonçalves, S. (2016). Prevalence and correlates of picky eating in preschool-aged children: A population-based study. *Eating Behaviors*, *22*, 16–21. https://doi.org/10.1016/j.eatbeh.2016.03.035

MacLennan, K., Roach, L., & Tavassoli, T. (2020). The Relationship Between Sensory Reactivity Differences and Anxiety Subtypes in Autistic Children. *Autism Research*, *13*(5), 785–795. https://doi.org/10.1002/aur.2259

Mangeot, S. D., Miller, L. J., McIntosh, D. N., McGrath-Clarke, J., Simon, J., Hagerman, R. J., & Goldson, E. (2001). Sensory modulation dysfunction in children with attention-deficit–hyperactivity disorder. *Developmental Medicine and Child Neurology*, *43*(06), 399.

https://doi.org/10.1017/s0012162201000743

May-Benson, T. A., Lopes de Mello Gentil, J., & Teasdale, A. (2020). Characteristics and Prevalence of Gravitational Insecurity in Children with Sensory Processing Dysfunction. *Research in Developmental Disabilities*, *101*, 103640. https://doi.org/10.1016/j.ridd.2020.103640

Mazurek, M. O., Vasa, R. A., Kalb, L. G., Kanne, S. M., Rosenberg, D., Keefer, A., Murray, D. S., Freedman, B., & Lowery, L. A. (2013). Anxiety, sensory over-responsivity, and gastrointestinal problems in children with autism spectrum disorders. *Journal of Abnormal Child Psychology*, *41*(1), 165–176. https://doi.org/10.1007/s10802-012-9668-x

McIntosh, D. N., Miller, L. J., Shyu, V., & Dunn, W. (1999). Overview of the Short Sensory Profile (SSP). In *The sensory profile: Examiner's manual* (pp. 59–73). The Psychological Corporation.

Miller, L. J., McIntosh, D. N., McGrath, J., Shyu, V., Lampe, M., Taylor, A. K., Tassone, F., Neitzel, K., Stackhouse, T., & Hagerman, R. J. (1999). Electrodermal responses to sensory stimuli in individuals with fragile X syndrome: A preliminary report. *American Journal of Medical Genetics*, *83*(4), 268–279. https://doi.org/10.1002/(sici)1096-8628(19990402)83:4<268::aid-ajmg7>3.3.co;2-b

Miller, L., Nielsen, D. M., & Schoen, S. A. (2012). Attention deficit hyperactivity disorder and sensory modulation disorder: A comparison of behavior and physiology. *Research in Developmental Disabilities*, *33*(3), 804–818. https://doi.org/10.1016/j.ridd.2011.12.005

Mimouni-Bloch, A., Offek, H., Rosenblum, S., Posener, I., Silman, Z., & Engel-Yeger, B. (2018). Association between sensory modulation and daily activity function of children with attention deficit/hyperactivity disorder and children with typical development. *Research in*

Developmental Disabilities, *83*, 69–76. https://doi.org/10.1016/j.ridd.2018.08.002

Mullen, E. (1995). *Mullen scales of early learning.*

Murray, D. S., Fedele, A., Shui, A., & Coury, D. L. (2016). The Autism speaks Autism treatment network registry data: Opportunities for investigators. *Pediatrics*, *137*(S2), S72–S78. https://doi.org/10.1542/peds.2015-2851E

Nakamura, B. J., Ebesutani, C., Bernstein, A., & Chorpita, B. F. (2008). A Psychometric Analysis of the Child Behavior Checklist DSM-Oriented Scales. *Journal of Psychopathology and Behavioral Assessment 2008 31:3*, *31*(3), 178–189. https://doi.org/10.1007/S10862-008-9119-8

Pandolfi, V., Magyar, C. I., & Dill, C. A. (2012). An initial psychometric evaluation of the CBCL 6–18 in a sample of youth with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(1), 96–108. https://doi.org/10.1016/J.RASD.2011.03.009

Parush, S., Sohmer, H., Steinberg, A., & Kaitz, M. (2007). Somatosensory function in boys with ADHD and tactile defensiveness. *Physiology and Behavior*, *90*(4), 553–558. https://doi.org/10.1016/j.physbeh.2006.11.004

Perrin, J., Coury, D., Klatka, K., Winklosky, B., Wolfe, A., Murray, D., & Kuhlthau, K. (2016). The Autism Intervention Research Network on Physical Health and the Autism Speaks Autism Treatment Network. *Pediatrics*, *137 Suppl*, S67–S71. https://doi.org/10.1542/PEDS.2015-2851D

Pfeiffer, B., Daly, B. P., Nicholls, E. G., & Gullo, D. F. (2015). Assessing sensory processing problems in children with and without attention deficit hyperactivity disorder. *Physical and Occupational Therapy in Pediatrics*, *35*(1), 1–12. https://doi.org/10.3109/01942638.2014.904471

Pfeiffer, B., Kinnealey, M., Reed, C., & Herzberg, G. (2005). Sensory modulation and affective disorders in children and adolescents with Asperger's disorder. *American Journal of Occupational Therapy*, *59*(3), 335–345. https://doi.org/10.5014/ajot.59.3.335

Roid, G. H. (2003). *Stanford Binet intelligence scales (5th ed.)*.

Sanz-Cervera, P., Pastor-Cerezuela, G., Fernández-Andrés, M. I., & Tárraga-Mínguez, R. (2015). Sensory processing in children with Autism Spectrum Disorder: Relationship with non-verbal IQ, autism severity and Attention Deficit/Hyperactivity Disorder symptomatology. *Research in Developmental Disabilities*, *45–46*, 188–201. https://doi.org/10.1016/j.ridd.2015.07.031

Sanz-Cervera, P., Pastor-Cerezuela, G., González-Sala, F., Tárraga-Mínguez, R., & Fernández-Andrés, M. I. (2017). Sensory processing in children with autism spectrum disorder and/or attention deficit hyperactivity disorder in the home and classroom contexts. *Frontiers in Psychology*, *8*, 1772. https://doi.org/10.3389/fpsyg.2017.01772

Schauder, K. B., & Bennetto, L. (2016). Toward an interdisciplinary understanding of sensory dysfunction in autism spectrum disorder: An integration of the neural and symptom literatures. In *Frontiers in Neuroscience* (Vol. 10, Issue JUN, p. 268). Frontiers. https://doi.org/10.3389/fnins.2016.00268

Stevens, T., Peng, L., & Barnard-Brak, L. (2016). The comorbidity of ADHD in children diagnosed with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *31*, 11–18. https://doi.org/10.1016/j.rasd.2016.07.003

Syu, Y. C., Huang, P. C., Wang, T. Y., Chang, Y. C., & Lin, L. Y. (2020). Relationship among sensory over-responsivity, problem behaviors, and anxiety in emerging adults with autism spectrum disorder. *Neuropsychiatric Disease and Treatment*, *16*, 2181–2190.

https://doi.org/10.2147/NDT.S270308

Thye, M. D., Bednarz, H. M., Herringshaw, A. J., Sartin, E. B., & Kana, R. K. (2018). The impact of atypical sensory processing on social impairments in autism spectrum disorder. *Developmental Cognitive Neuroscience*, *29*(September 2016), 151–167. https://doi.org/10.1016/j.dcn.2017.04.010

Tomchek, S. D., & Dunn, W. (2007). Sensory Processing in Children With and Without Autism: A Comparative Study Using the Short Sensory Profile. *American Journal of Occupational Therapy*, *61*(2), 190–200. https://doi.org/10.5014/ajot.61.2.190

Vasa, R. A., Keefer, A., McDonald, R. G., Hunsche, M. C., & Kerns, C. M. (2020). A Scoping Review of Anxiety in Young Children with Autism Spectrum Disorder. *Autism Research*, *13*(12), 2038–2057. https://doi.org/10.1002/aur.2395

Watson, L. R., Patten, E., Baranek, G. T., Poe, M., Boyd, B. A., Freuler, A., & Lorenzi, J. (2011). Differential associations between sensory response patterns and language, social, and communication measures in children with autism or other developmental disabilities. *Journal of Speech, Language, and Hearing Research*, *54*(6), 1562–1576. https://doi.org/10.1044/1092-4388(2011/10-0029)

Wechsler, D. (2002). *Wechsler preschool and primary scale of intelligence (3rd ed.)*.

Wechsler, D. (2003). *Wechsler intelligence scale for children (4th ed.)*.

Wechsler, D. (2008). *Wechsler adult intelligence scale. 4th ed.*

Wechsler, D. (2011). *WASI-II: Wechsler abbreviated scale of intelligence (2nd ed.)*.

Wechsler, D. (2014). *Wechsler intelligence scale for children (5th ed.)*.

Yochman, A., Parush, S., & Ornoy, A. (2004). Responses of preschool children with and without ADHD to sensory events in daily life. *American Journal of Occupational Therapy*, *58*(3),

294–302. https://doi.org/10.5014/ajot.58.3.294

Zucker, N., Copeland, W., Franz, L., Carpenter, K., Keeling, L., Angold, A., & Egger, H. (2015). Psychological and psychosocial impairment in preschoolers with selective eating. *Pediatrics*, *136*(3), e582–e590. https://doi.org/10.1542/peds.2014-2386

Table 1 *Demographic and clinical characteristics.*

	M (SD)/Frequency
Age	6. 37 (3.34)
Gender	
Male	83.59%
Female	16.41%
Race	
White	80.36%
Black	5.41%
Asian	3.56%
American Indian/ Alaskan Native	0.62%
Native Hawaiian/Other Pacific Islander	0.24%
Two or More Races	5.93%
Not reported	3.89%
Ethnicity	
Hispanic	7.92%
IQ	77.69 (23.16)
ADOS CSS	7.05 (1.94)
CBCL Anxiety Problems	61.31 (10.24)
At or Above Clinical Cutoff	26.94%
CBCL ADHD Problems	62.66 (8.70)
At or Above Clinical Cutoff	24.48%
SSP Total Score	130.08 (23.81)

[a]ADOS CSS: Autism Diagnostic Observation Schedule Calibrated Severity Score, CBCL: Child Behavioral Checklist, SSP: Short Sensory Profile.

Table 2 *Bivariate correlations among study variables.*

N=2108	Age	Gender	IQ	ADOS CSS	CBCL Anxiety Problems T-score	CBCL ADHD Problems T-score
Age	-					
Gender	-.14	-				
IQ	.19**	-.02	-			
ADOS CSS	-.08**	-.05	.19**	-		
CBCL Anxiety Problems T-score	.19**	.02	.10**	-.04	-	
CBCL ADHD Problems T-score	.17**	.02	-.01	-.04	.40**	-

[a]ADOS CSS: Autism Diagnostic Observation Schedule Calibrated Severity Score, CBCL: Child Behavioral Checklist. **p <.01

Table 3 *Multiple linear regression results.*

	B (SE)	β	R^2	*p*
SSP Total Score				
Age	-0.00 (0.01)	-0.00		0.93
Gender	4.10 (1.18)	0.06		< 0.001
IQ	-0.01 (0.10)	-0.01		0.68
ADOS CSS	0.06 (0.23)	0.01		0.79
CBCL Anxiety Problems T-score	-0.80 (0.05)	-0.34		< 0.001
CBCL ADHD Problems T-Score	-0.86 (0.06)	-0.31	0.29	< 0.001
SSP Tactile Sensitivity				
Age	0.01 (0.00)	0.08		< 0.001
Gender	0.26 (0.29)	0.02		0.37
IQ	-0.01 (0.00)	-0.02		0.24
ADOS CSS	0.05 (0.06)	0.02		0.34
CBCL Anxiety Problems T-Score	-0.19 (0.01)	-0.36		< 0.001
CBCL ADHD Problems T-Score	-0.10 (0.01)	-0.16		< 0.001
Age X CBCL ADHD Problems T-Score	0.00 (0.00)	0.06	0.20	0.001
SSP Taste/Smell[b]				
Age	0.00 (0.00)	0.12		< 0.001
Gender	0.23 (0.05)	0.09		< 0.001
IQ	0.00 (0.00)	0.06		0.01
ADOS CSS	-0.01 (0.01)	-0.03		0.21
CBCL Anxiety Problems T-Score	-0.02 (0.00)	-0.20		< 0.001
CBCL ADHD Problems T-Score	-0.01 (0.00)	-0.06		0.01
Age X CBCL ADHD Problems T-Score	0.00 (0.00)	0.08	0.08	< 0.001
SSP Movement Sensitivity[b]				
Age	-0.00 (0.00)	-0.07		0.001
Gender	0.07 (0.05)	0.03		0.17
IQ	0.00 (0.00)	0.06		0.01
ADOS CSS	0.03 (0.01)	0.06		0.003
CBCL Anxiety Problems T-Score	-0.03 (0.00)	-0.30		< 0.001
CBCL ADHD Problems T-Score	-0.00 (0.00)	-0.03	0.11	0.25
SSP Under-Responsive and Seeks Sensation				
Age	0.02 (0.00)	0.13		< 0.001
Gender	1.19 (0.31)	0.07		< 0.001
IQ	0.02 (0.01)	0.08		< 0.001
ADOS CSS	-0.07 (0.06)	-0.02		0.27
CBCL Anxiety Problems T-score	-0.03 (0.01)	-0.05		0.01
CBCL ADHD Problems T-Score	-0.41 (0.01)	-0.55		< 0.001
Age X CBCL ADHD Problems T-Score	-0.00 (0.00)	-0.05	0.33	0.01
SSP Auditory Filtering				
Age	-0.01 (0.00)	-0.06		0.003
Gender	0.53 (0.25)	0.04		0.03
IQ	-0.01 (0.00)	-0.03		0.11
ADOS CSS	-0.08 (0.05)	-0.03		0.09
CBCL Anxiety Problems T-score	-0.08 (0.01)	-0.18		< 0.001
CBCL ADHD Problems T-Score	-0.23 (0.01)	-0.40	0.26	< 0.001
SSP Low Energy/Weak[b]				
Age	-0.01 (0.00)	-0.24		< 0.001
Gender	0.04 (0.05)	0.02		0.45
IQ	-0.00 (0.00)	-0.12		< 0.001
ADOS CSS	0.00 (0.01)	0.01		0.78
CBCL Anxiety Problems T-score	-0.01 (0.00)	-0.17		< 0.001
CBCL ADHD Problems T-Score	-0.00 (0.00)	-0.01	0.14	0.54
SSP Visual and Auditory Sensitivity				
Age	0.00 (0.00)	0.02		0.38
Gender	0.24 (0.26)	0.02		0.35
IQ	-0.00 (0.00)	-0.01		0.50
ADOS CSS	0.10 (0.05)	0.04		0.05

CBCL Anxiety Problems T-score	-0.18 (0.01)	-0.37		< 0.001
CBCL ADHD Problems T-Score	-0.07 (0.01)	-0.12	0.18	< 0.001

[a]ADOS CSS: Autism Diagnostic Observation Schedule Calibrated Severity Score, CBCL: Child Behavioral Checklist, SSP: Short Sensory Profile. B (SE): unstandardized beta (standard error for the unstandardized beta), β: standardized beta, R^2 : coefficient of determination, p: probability value.

[b] Outcome variable transformed so model residuals would follow the normal distribution

Manuscript Three

The Impact of Co-occurring ADHD on Social Competence Intervention Outcomes in Youth with Autism Spectrum Disorder

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Abstract

The co-occurrence of autism spectrum disorder (ASD) and attention deficit/hyperactivity disorder (ADHD) is significant and has been associated with a host of negative outcomes. Studies investigating social functioning in the presence of the ASD/ADHD co-occurrence have produced mixed findings. The present study further evaluated the impact of co-occurring ADHD on social functioning among youth with ASD and compared treatment response to a social competence intervention between youth with ASD and ASD + ADHD. Youth with co-occurring ADHD displayed more impairments related to social awareness, but not in other social areas. Participants in both the ASD and ASD + ADHD groups demonstrated significant improvement following a social competence intervention. Co-occurring ADHD did not negatively affect treatment response.

Keywords: autism, ASD, ADHD, social intervention, social competence

Autism spectrum disorder (ASD) is defined by core impairments in social communication and social interaction, and the presence of restricted, repetitive behaviors, interests, or activities (American Psychiatric Association, 2013). ASD is considered a social disability and the social and communication problems observed in ASD are often the primary target of intervention efforts. The social deficits in ASD include difficulties producing and integrating verbal and nonverbal (e.g., eye contact, gestures, facial expressions) communication, decreased engagement in turn-taking and sharing of emotion or interests, and problems understanding and participating in social relationships (American Psychiatric Association, 2013). Social problems are also relatively common in attention deficit/hyperactivity disorder (ADHD; Kern et al., 2015), and it is estimated that 37 to 85 % of youth with ASD meet criteria for ADHD (Lecavalier et al., 2018; Murray, 2010; Simonoff et al., 2008; Van Der Meer et al., 2012). It has been suggested that that youth with ASD + ADHD may be less responsive to standard treatments approaches (Leitner, 2014), as the co-occurrence has been associated with more significant cognitive delays (Rao & Landa, 2014; Sinzig et al., 2008), increased oppositional behavior (Guttmann-Steinmetz et al., 2009), worse executive functioning (Yerys et al., 2009), and greater social challenges (Factor et al., 2017; McVey et al., 2018) than ASD in the absence of ADHD. However, studies of psychosocial interventions amidst the ASD/ADHD co-occurrence are sorely lacking, and there may be important treatment implications for those with potentially compounded social behavioral difficulties.

Social Impact of the ASD/ADHD Co-occurrence

Studies comparing individuals with ASD + ADHD to those with only one of these diagnoses have suggested that they display greater social problems, though findings have been mixed and marked by inconsistencies in participants characteristics and measurement approaches

(Harkins et al., 2021). Several studies employing the parent-report Social Responsiveness Scale (SRS; Constantino et al., 2003; Constantino & Gruber, 2012) as a measure of social impairment have found significant differences between youth with ASD + ADHD and those with either ASD or ADHD alone. One study of young children with the ASD/ADHD co-occurrence indicated greater global social impairment on the SRS (Rao & Landa, 2014), while another study of children and adolescents (*M* age= 7.9 years) revealed that co-occurring ADHD was associated with greater impairments on the Social Awareness and Social Communication subscales (Factor et al., 2017). Studies relying on the clinician-reported ADOS social domain score as a measure of social impairment have similarly yielded mixed findings. While one study found that the ASD group had significantly greater social impairment than the ASD + ADHD group (Salley et al., 2015), another yielded no significant difference (Harkins et al., 2021). These contrasting findings may be attributed to measurement differences. Studies have shown that the SRS is sensitive (Moul et al., 2015), but not specific, and may be susceptible to symptoms of ADHD (Hus et al., 2013; Sprenger et al., 2013b). Additionally, it is possible that the ADOS is sensitive to core symptoms of ASD, but not the qualitive social differences that may be attributed to the co-occurrence of ASD and ADHD (Harkins et al., 2021).

Notably, the ASD + ADHD group in all of the aforementioned studies was determined based on the presence of clinically significant ADHD symptoms on a parent-report measure, rather than a clinical diagnosis of ADHD. Two studies that evaluated social impairment associated with the ASD/ADHD co-occurrence based on a DSM-5 diagnosis did not find significant differences between the ASD and ASD + ADHD groups on the SRS (Dellapiazza, Audras-Torrent, et al., 2021; Ng et al., 2021) or the ADOS social affect raw score (Ng et al., 2021). The differences in findings between studies that relied on a symptom threshold versus a

clinical diagnosis based on DSM-5 criteria are interesting and warrant further investigation. To address this, the present study will compare social impairment in youth with ASD with and without co-occurring ADHD using multiple measures of social impairment, with diagnostic group status based on clinical diagnosis.

Social Skills Interventions for Youth with ASD + ADHD

Despite the high co-occurrence of ASD and ADHD and potential for more severe symptoms in many domains, no known manualized psychosocial interventions have been developed specifically for individuals with ASD and ADHD. Social skills interventions for youth with ASD are often group-based and are variable in content, teaching approach, delivery methods, and intensity. Many manualized group-based social skills interventions include treatment components such as didactics, role-play exercises, structured activities, and a parent component (Wolstencroft et al., 2018). While many group social skills interventions designed for ASD are advertised as appropriate for ADHD, few have been evaluated in ADHD (see Willis et al., 2019 for review of social skills interventions for ADHD), and even fewer have been evaluated for youth with ASD + ADHD (Batson et al., 2017). Thus, it is difficult to discern which social skills interventions may be most effective for youth affected by the ASD + ADHD, and how co-occurring ADHD impacts treatment outcomes.

One factor that contributes to this difficulty is the lack of reporting of co-occurring psychiatric diagnoses in studies on social interventions for youth with ASD. A recent systematic review and meta-analysis of group-based social skills interventions included eight studies (Wolstencroft et al., 2018). Each article was reviewed for participant characteristics and assessment or report of co-occurring disorders, and not one of the included studies reported on co-occurring disorders among the samples of youth with ASD. A subsequent review of

participant characteristics and report of co-occurring disorders for articles included in another systematic review and meta-analysis of the UCLA PEERS Program (Zheng et al., 2021) revealed that only three (Hill et al., 2017; Laugeson et al., 2012; Matthews et al., 2018) of the 12 included articles reported on co-occurring conditions, including ADHD. This is surprising and concerning given that 63–78% of individuals with ASD have at least one co-occurring psychiatric condition (Simonoff et al., 2008). Exclusions of this nature hold the potential to limit understanding of how co-occurring mental health conditions are related to treatment outcomes.

Impact of ADHD on Social Skills Interventions for ASD

There is little research on the impact of co-occurring ADHD symptoms on treatment outcomes among youth with autism. It is possible that inattention interferes with learning of social skills, hyperactivity disrupts participation in group intervention, and impulsivity hinders application of the acquired abilities in context (Barkley, 1997; Deckers et al., 2016). Only two studies have investigated social treatment gains in the context of the ASD/ADHD co-occurrence.

Antshel and colleagues (2011) investigated the impact of psychiatric comorbidity (i.e., anxiety and ADHD) on social skills treatment outcomes for clinically-referred children age 8-12 with ASD. The manualized 10-session 60-minute group social intervention was based on a social adjustment enhancement intervention (described in Solomon et al., 2004) and included children with ASD (n = 21), ASD + Anxiety (n = 37), and ASD + ADHD (n = 25) with average cognitive abilities. There was also a weekly parent group that was unstructured and educational and supportive in nature. Co-occurring disorders were assessed using the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) and the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version.23 (Kaufman et al., 1997). The Social Skills Rating System (SSRS; Gresham & Elliott, 1990) results showed that the ASD

and ASD + Anxiety groups both showed significant improvement on the SSRS total score and on the Cooperation and Responsibility subscales. The ASD + ADHD group did not show improvement and were rated as somewhat worse as a function of time on the SSRS. The finding that the ASD + ADHD group did not improve like the other treatment groups is interesting, particularly considering that 72% of children with co-occurring ADHD were on medication throughout the intervention and that many were receiving concurrent school-based social skills training (32%) or individual therapy (32%). It is possible that the children with ASD + ADHD may not have been able to generalize skills or employ what they learned in context due to worse executive functioning skills or interfering symptoms of ADHD.

Another study by Deckers and colleagues (2016) evaluated the effectiveness of group social skills training delivered in a naturalistic setting for 26 children age 8-12 with ASD without intellectual disability (ID). The manualized social skills training (described in Deckers et al., 2013) consisted of 12 weekly 60-minute treatment sessions and three 1-hour parent sessions over the course of the intervention. Each group consisted of four children and treatment involved child and parent workbooks, personalized goals, and weekly homework activities. The primary outcome measure was the social skills observation (SSO; Barry et al., 2003), which was completed by both parents and teachers. ADHD symptoms were a hypothesized moderator, among other variables, and were assessed via the ADHD questionnaire (ADHD-Q; Scholte & Van der Ploeg, 1998). Results indicate that children's social skills significantly improved as a function of treatment per parent-and teacher-report as compared to the waitlist control group. Interestingly, ADHD symptoms did not have an effect on the change in teacher- or parent-reported social skills. It is possible that the participants who were recruited from a community mental health center presented with less severe social impairments and/or less significant

symptoms of ADHD. The majority of children in the treatment condition (19 of 26) were in the general education setting and 11 of the 26 children were on medication throughout the intervention. Additionally, the highly structured nature of the program, personalized treatment plan, and parent component may have bolstered treatment effects.

Findings regarding the impact of co-occurring ADHD on treatment outcomes for youth with ASD are mixed and limited. Both of the aforementioned studies only used one measure of social functioning, which relied exclusively on parent and/or teacher report. Additionally, neither of the studies reported on comparisons of baseline social impairment for the ASD and ASD + ADHD groups. The present study seeks to address these shortcomings and evaluate the impact of the ASD/ADHD co-occurrence on social functioning and social treatment outcomes using a multi-measure, multi-informant approach. It is hypothesized that the ASD and ASD + ADHD groups will be comparable in level of social impairment on parent- and clinician-reported measures of social impairment at baseline, and that the ASD + ADHD group will demonstrate less improvement in social functioning compared to the ASD group following a social competence intervention.

Methods

Participants and Procedures

Data were utilized from a previously completed study focused on validation of the Autism Impact Measure (AIM), as detailed in Mazurek et al., 2020. Participants who completed a manualized social competence intervention as part of the larger study were included in the present study. All participants had a previous professional diagnosis of ASD confirmed for eligibility in the study by a score at or above the clinical cut-off on the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012), a full scale IQ or 75 or

higher on the Differential Ability Scales, Second Edition (Elliot, 2007), and completed the social competence intervention. This resulted in a sample of 81 children and adolescents (age 6-14).

All participants completed baseline assessments within four weeks of the first treatment session. Post-treatment assessments were collected within two weeks of the last treatment session.

Treatment

The Social Competence Intervention (SCI) is a group-based manualized intervention program that combines both cognitive-behavioral and applied behavior analysis principles within a group-based structure (Stichter et al., 2010). The intervention was specifically designed to target social competence deficits associated with autism and was designed for children and youth with autism without intellectual disability. The SCI aims to address deficits in social perspective taking, emotion recognition, and executive functioning by teaching strategies to shift thinking patterns and by providing appropriate replacement skills to meet desired social functions (Stichter et al., 2010, 2012; Stichter, Herzog, et al., 2016). There are three versions of SCI designed to provide structure, consistency, and scaffolding for three specific age ranges (Elementary: 6-10; Adolescent: 11-14; High School: 14-18) to assist in skill acquisition and maintenance. The Elementary (SCI-E) and Adolescent (SCI-A) curricula include five units, which are taught in two-week increments. The curricular units include: (a) recognizing facial expressions, (b) sharing ideas, (c) turn taking in conversations, (d) recognizing feelings and emotions of self and others, and (e) problem solving, each in successive 2-week increments. Each unit follows a consistent structure of (a) reviewing a previously learned skill and introducing a new skill in an instructional and group discussion format, (b) skill modeling, (c)

opportunities to practice the skill in structured and naturalistic activities, and (d) a closing activity or review (Stichter et al., 2010, 2012; Stichter, Herzog, et al., 2016).

Previous research has shown that the SCI is effective in improving social behavior, interactions, and cognitive processes among youth with ASD (Stichter et al., 2010, 2012; Stichter, Herzog, et al., 2016). Additionally, a prior study found that youth who participated in the SCI showed improvements on informant-based measures of executive functioning and performance-based measures of specific executive functioning processes (Stichter, Christ, et al., 2016). In the present study, the SCI spanned an average of 15 weeks and the SCI-E and SCI-A were delivered to youth based on age.

Measures

Demographics and History

Parents of participants provided demographic information, including the child's age, gender, race and ethnicity, educational placement, and parental education and household income. They also provided clinical information, including diagnostic history and current medications.

Clinical Characterization

Cognitive ability was assessed using the Differential Ability Scales, Second Edition (Elliot, 2007) and a Full Scale IQ score was obtained for all participants. The Hyperactivity/Noncompliance subscale from the Aberrant Behavior Checklist (ABC; Aman & Singh, 1986) was used to compare the diagnostic groups on ADHD symptoms at baseline. The ABC is a 58-item caregiver-report questionnaire that measures current behavioral functioning. It has shown strong psychometric properties (Aman et al., 1995) and is widely used in individuals with ASD (Bagaiolo et al., 2019; Sannar et al., 2018). The Hyperactivity/Noncompliance subscale has strong convergent validity with the Behavioral Regulation Index and Global

Executive Composite of the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000), and has been shown to predict ADHD diagnostic status (Halvorsen et al., 2019).

Social Functioning

Social functioning was assessed using a variety of measures and informants. The ADOS-2 Social Affect Total algorithm score (ADOS-SA) served as a clinical observational method of measuring social impairment, as all participants received ADOS-2 Module 3. The ADOS-2 is a standardized, semi-structured assessment of communication and social interaction, and repetitive behaviors and restricted interests. (Lord et al., 2012). The ADOS-SA score consists of 10 clinician-scored items, with a possible range of 0–20 (with higher scores indicating greater symptom severity).

The Social Responsiveness Scale (SRS-2; Constantino & Gruber, 2012) was used as a parent-report measure of social functioning. The SRS-2 is a 65-item questionnaire that measure ASD symptom severity. The SRS-2 generates an overall Total T-Score indicating overall severity of autism symptoms, and subscales for Social Awareness, Social Cognition, Social Communication, and Social Motivation. The SRS-2 has shown good construct validity (Constantino et al. 2003) and strong reliability (Constantino and Gruber 2005), with an overall internal consistency (coefficient alpha) of 0.95.

The Pediatric Quality of Life Inventory (PedsQL) Version 4.0 (Varni et al., 2001) was administered as an additional measure of social functioning. The PedsQL was designed to assess core dimensions of quality of life across four domains (including physical, emotional, social, and school functioning), and includes 21 items rated on a 5-point scale ranging from 0 (“never a problem”) to 4 (“almost always a problem”). The PedsQL,is a parent-report measure that has been widely used across samples of children with various health and developmental problems,

including ASD, and has demonstrated good reliability and validity (Varni et al., 2001). The 5-item Social Functioning Domain Score was examined to measure of peer and social functioning.

The Autism Impact Measure (AIM) was also used to measure the impact of social symptoms on functioning. The AIM is a parent- report questionnaire consisting of 41 items assessing core ASD symptoms (including both maladaptive behaviors and skill deficits). Each item is rated on corresponding 5-point scales for frequency and impact. Frequency ratings reflect how often the behavior has occurred over the past 2 weeks (ranging from "never" to "always"). Frequency scale ratings for items focusing on the absence of expected skills (AIM items 28–41) are reverse-scored, such that higher scores indicate greater difficulties. Impact ratings reflect the degree to which the behaviors or skill deficits have interfered with the child's everyday functioning (ranging from "not at all" to "severely"). Five empirically derived subdomain scores are generated using a subset of 29 items: Repetitive Behavior, Atypical Behavior, Communication, Social Reciprocity, and Peer Interaction (Mazurek, Carlson, Baker-Ericzén, Butter, Norris, & Kanne, 2020). The AIM has demonstrated strong reliability, validity, and sensitivity to change (Houghton et al., 2019; Kanne et al., 2014; Mazurek, Carlson, Baker-Ericzén, Butter, Norris, & Kanne, 2020; Mazurek, Carlson, Baker-Ericzén, Butter, Norris, Barr, et al., 2020).The Communication, Social Reciprocity, and Peer Interaction subscales were used as measures of social functioning in the present study.

Analytic Plan

All data were cleaned and examined for outliers, missing data, and distributional assumptions using SPSS Statistics Software, Version 28. Multiple imputation was performed to replace missing data at post-testing (16% missing for all study measures). As the probability of missing data was related to other observed variables, they were assumed to be missing at random

and five imputation data sets were used. Descriptive statistics were generated to characterize the ASD and ASD + ADHD groups (See Table 1) and bivariate analyses were performed to compare the diagnostic groups at baseline. Co-occurring psychiatric disorders for participants in each group are presented in Table 2 and correlations among study variables are presented in Table 3. Two-way repeated measures analyses of variance (ANOVAs) were computed with diagnostic group and time as the independent variables and measures of social functioning as dependent variables. Analysis of covariance (ANCOVA) was employed if significant group differences were observed on variables of interest at baseline, with diagnostic group status as the independent variable, baseline score as the covariate, and the post-intervention score as the dependent variable. Measures of social functioning included the ADOS-SA score, SRS-2 Total T-score, SRS-2 Social Awareness T-score, SRS-2 Social Cognition T-score, SRS-2 Social Motivation T-score, PedsQL Social Functioning Domain score, and the AIM Communication, AIM Social Reciprocity, and AIM Peer Interaction subscale scores. Group and Time effects and Group by Time interactions were examined.

[INSERT TABLE 1]

[INSERT TABLE 2]

[INSERT TABLE 3]

Results

Baseline Group Comparisons

Diagnostic groups were compared on participant age, gender, race, and IQ. Independent samples t-tests were performed for age and IQ comparisons. Due to small cell sizes, Fisher's exact test was employed to compare groups by gender, and a likelihood ratio test was conducted to compare groups by race. Results indicated that the diagnostic groups did not significantly

differ on any demographic variables, and thus these variables were not included as covariates in subsequent analyses. The ASD and ASD + ADHD groups were compared on baseline ADHD symptoms using the ABC Hyperactivity/Noncompliance subscale score. As expected, the ASD + ADHD group displayed greater symptoms associated with ADHD on average, t(79)=0.4, p = 0.01, compared to the ASD group. Three participants (8.11%) in the ASD group and 32 participants (72.73%) in the ASD + ADHD group were on medication for ADHD symptoms throughout the study. Three participants in the ASD + ADHD group experienced a medication change for ADHD symptoms (i.e., from one ADHD medication to another), but medication use was stable for all other participants.

Independent samples t-tests were performed to compare the ASD and ASD + ADHD groups on all measures of social functioning at baseline. Results indicated significant group differences on the ADOS-SA, t(79) = 2.44, p = 0.02, with the ASD group demonstrating more social impairment on average than the ASD + ADHD group. Significant differences were also observed on the SRS-2 Social Awareness T-score, t(79) = -2.29, p = 0.03, with the ASD + ADHD group having higher scores, indicating more difficulties on average than the ASD group. No significant differences were observed for any other SRS-2 subscale or the SRS-2 Total T-score, any of the AIM subscales, or the PedsQL Social Domain score (See Table 4).

[INSERT TABLE 4]

Time and Group Effects

Analyses were performed to compare the effects of time and diagnostic group status and on all measures of social functioning. Two-way repeated measures ANOVAs were conducted for most study measures (i.e., AIM subscales, PedsQL Social Domain, SRS-2 Total and Social Communication, Cognition, and Motivation subscales). Two-way ANCOVAs were performed

for the two study measures that diagnostic groups significantly differed on at baseline assessment (i.e., ADOS-SA, SRS-2 Social Awareness).

Significant main effects of time and diagnostic group status were observed, but no significant interactions between time and diagnostic group. There was a significant main effect of time observed on all AIM subscales, including Communication, $F(1,79) = 22.84$, $p < .001$, Social Reciprocity, $F(1,79) = 7.31$, $p = .008$, and Peer Interaction, $F(1,79) = 23.87$, $p < .001$; scores were significantly lower, indicating symptom improvement following participation in SCI. The main effect of time was also significant for the SRS-2 Total T-Score, $F(1,79) = 25.00$, $p < .001$, and all social subscales, including Social Awareness, $F(1,79) = 10.80$, $p < .001$, Social Cognition, $F(1,79) = 12.99$, $p < .001$, Social Communication, $F(1,79) = 20.71$, $p < .001$, and Social Motivation, $F(1,79) = 23.87$, $p < .001$. Scores were significantly lower, indicating symptom improvement following participation in SCI. There was also a significant main effect of time on the PedsQL Social Domain score, $F(1,79) = 4.72$, $p = .03$, as scores significantly increased, indicating improved social functioning. No significant main effect of time was observed on the ADOS-SA ($F = 0.88$, $p = .35$).

The main effect of diagnostic group status was significant on the SRS-2 Total T-score, $F(1,79) = 4.58$, $p = .04$, as the mean scores significantly differed between diagnostic groups following participation in SCI, with the ASD group showing less severe symptoms than the ASD + ADHD group. The main effect of diagnostic group status approached significance on the SRS-2 Social Communication subscale, $F(1,79) = 3.89$, $p = .05$, with the ASD group showing fewer symptoms on average following participation in SCI than the ASD + ADHD group. No main effects of diagnostic group were observed for the ADOS-SA ($F = 0.01$, $p = .92$), AIM Communication subscale ($F = 0.004$, $p = 0.95$), AIM Social Reciprocity subscale ($F = 0.15$, $p =$

.70), AIM Peer Interaction subscale ($F = 2.39$, $p = .13$), SRS-2 Social Awareness subscale ($F = 0.85$, $p = .36$.), SRS-2 Social Cognition subscale ($F = 1.41$, $p = .24$), SRS-2 Social Motivation subscale ($F = 1.36$, $p = .25$), or PedsQL Social Domain score ($F = 0.17$, $p = .68$).

Discussion

This study sought to further explore the impact of the co-occurrence of ASD and ADHD on social functioning and determine if youth with ASD and ASD + ADHD demonstrate similar treatment gains following a social competence intervention. Contrary to our hypothesis, significant differences were observed between the ASD and ASD + ADHD groups at baseline on two measures, the ADOS-SA and SRS-2 Social Awareness subscale. The ASD group displayed greater social impairment than the ASD + ADHD group on the ADOS-SA, consistent with results found by Salley and colleagues (2015), but inconsistent with results found by Harkins and colleagues (2021) that revealed no differences between these diagnostic groups. Such discrepancies likely reflect differences in sample characteristics. Notably, the sample in the current study was restricted by age (6-14; *M* age = 10.8 years) and IQ (≥ 75) and all participants received ADOS Module 3. This may represent an older group of youth with ASD and solid language and cognitive abilities, which differs from the sample included by Harkins and colleagues. Their clinically-referred sample may have presented with lower cognitive abilities (*M* IQ for ASD group = 73.13 and ASD + ADHD group = 86.99), younger age (*M* = 7.76), and more social and behavioral difficulties, which could explain the lack of significant group differences between the ASD and ASD + ADHD groups.

The finding that the ASD + ADHD group demonstrated significantly more impairment on the SRS-2 Social Awareness subscale than the ASD group is consistent with results by Factor and colleagues (2017). Items within the Social Awareness subscale assess an individual's ability

to focus attention to where others are looking/listening and notice when they are making too much noise or interfering with others' conversation. It is perhaps unsurprising that youth with co-occurring ADHD display more impairment within this subscale, as social awareness requires that one attend to the environment, other people, and to how one's behavior affects other people in that environment.

As expected, the ASD and ASD + ADHD groups presented similarly on other social measures at baseline, including measures of global social functioning (i.e., SRS-2 Total, PedsQL Social Domain) and specific social symptoms of ASD (i.e., SRS and AIM subscales). The lack of significant group differences on the SRS-2 Total and most subscales is consistent with two prior studies using similarly-aged samples (Dellapiazza, Audras-Torrent, et al., 2021; Factor et al., 2017; McVey et al., 2018). Additionally, the ASD and ASD + ADHD groups scored similarly on the AIM Communication, Social Reciprocity, and Peer Interaction subscales, which might suggest that ADHD symptoms did not exacerbate the core symptoms assessed.

In the present study, youth with ASD and ASD + ADHD participated in a 15-week intervention focused on social competence (Stichter et al., 2010). Following the SCI, participants in both diagnostic groups demonstrated significant improvement on most measures of social functioning. Improvements were observed on the AIM Communication, Peer Interaction, and Social Reciprocity subscales, the SRS-2 Total Score and all social subscales (e.g., Awareness, Cognition, Communication, and Motivation), and the PedsQL Social Domain. The social gains align with the curricular constructs of the SCI (e.g., recognition of emotions in self and others, sharing of ideas/interests, conversational skills, problem solving) and prior research illustrating global and specific social improvements (Stichter et al., 2010, 2012; Stichter, Christ, et al., 2016; Stichter, Herzog, et al., 2016). Significant improvements were not observed on the ADOS-SA,

which is perhaps unsurprising as this diagnostic tool was designed to determine categorical presence or absence of autism, but not to be sensitive to short-term change across relatively brief intervals.

The finding that participants in both diagnostic groups showed significant improvement on several measures of social functioning is promising and lends support to the effectiveness of the SCI for youth with ASD and co-occurring ADHD. Our results are in line with those of Deckers and colleagues (2016), who found that that ADHD symptoms did not moderate the change in parent- or teacher- reported social skills following a similar social skills intervention. Notably, their intervention included a heavy parent component, therapist support (e.g., emails, phone calls between sessions), and individualized feedback to participants and parents. This additional support with skill acquisition, maintenance, and generalization may have aided participants with ADHD symptoms. Deckers and colleagues did not compare social treatment gains between youth with ASD and ASD and clinically-diagnosed ADHD, perhaps due to small sample sizes for diagnostic groups.

This is one of only two studies to date to compare social skills treatment gains among youth with ASD as compared to those with ASD + ADHD. The first, by Antshel and colleagues (2011), found that youth with ASD showed improvement on the SSRS Total and the Assertion, Cooperation, and Responsibility subscales, while those with co-occurring ADHD did not. While the present study is remarkably similar to that of Antshel and colleagues (2011) in regard to social skills intervention components and sample characteristics, there are noteworthy differences that may clarify differences in findings. The skill areas targeted by each group social intervention are similar (e.g., emotion recognition in self/others, conversation skills, social problem solving), but the scaffolded teaching design and ongoing practice of recurring concepts

is unique to the SCI. This additional structure and repetition may have aided participants with ADHD, as the SCI has been shown to improve certain executive functions, including the ability to attend, recall important information, monitor and inhibit responses, and apply rules to problems in the classroom and on standardized assessments (Stichter, Christ, et al., 2016). The SCI is also five weeks longer than the social skills intervention used by Antshel and colleagues, so it is possible the additional time on concepts and opportunities for practice and feedback was helpful for youth with the co-occurrence of ASD and ADHD.

Consideration of the outcome measures used in these treatment studies is important given the different results. The SSRS, used by Antshel and colleagues, contains 55 questions that fall into two domains, Social Skills and Problem Behaviors. The Social Skills domain includes 38 items and comprises the Cooperation, Assertion, Responsibility, and Self-Control subscales that assess social skills in the home and community setting. The remaining 17 items assess behavioral difficulties, and scores in both the Social Skills and Problem Behaviors domains are combined to generate the total score. In considering that a third of the items that compose the SRSS total score assess behaviors that map onto core symptoms of ADHD, it may be unsurprising that individuals with ASD and co-occurring ADHD demonstrate more impairment, and perhaps less improvement following intervention on this measure. Additionally, symptoms of inattention and hyperactivity/impulsivity have been associated with worse performance on the Cooperation, Assertion, Responsibility, and Self-Control subscales in a study of youth with ADHD (Van Der Oord et al., 2005).

Similar concerns have been raised regarding the associations between ADHD symptoms and items on the SRS-2 (Grzadzinski et al., 2011a; Hus et al., 2013), a measure employed in the present study. While both the ASD and ASD + ADHD groups demonstrated significant

improvement on all SRS-2 subscales and the total score following the SCI, the effect of diagnostic group status was significant on the SRS-2 Total score (p = .04) and approached significance on the SRS-2 Social Communication subscale score (p = .05). Though the difference in scores is marginal and not believed to be clinically meaningful, the emergence of diagnostic group differences on the SRS-2 may suggest that co-occurring ADHD symptoms contribute to specific social difficulties in older children and adolescents with ASD without ID. It is possible that ADHD symptoms impact social behaviors assessed by the SRS-2. For example, the Social Communication subscale includes several items that may be influenced by symptoms of inattention (e.g., wanders aimlessly from one activity to another, knows when they are invading someone's space, difficulty answering questions directly and talking around the subject) and hyperactivity/impulsivity (e.g., frustrated when trying to get ideas across in conversation, plays appropriately with other kids, is too silly or laughs inappropriately). It may be unsurprising that youth with co-occurring ADHD may show greater difficulties on items like these, compared to youth with ASD without ADHD. The finding that the ASD + ADHD group showed significantly higher scores on the SRS-2 Total score following the intervention is in line with this, as the Total score represents symptoms across social subscales and includes items related to repetitive and restricted behaviors, which have been associated with ADHD symptoms in youth with ASD (Avni et al., 2018; Stratis & Lecavalier, 2013; Zachor & Ben-Itzchak, 2013).

This study contributes to the growing body of research on the co-occurrence of ASD and ADHD. A primary aim of this study was to compare social functioning between youth with ASD and ASD + ADHD in efforts to reconcile the mixed findings that characterize the literature. The finding by Factor and colleagues (2017) that youth with ASD + ADHD display compounded difficulties with social awareness was replicated in the present study. Our results contribute to

mixed findings regarding the ADOS-SA amid the co-occurrence of ASD and ADHD comorbidity, and suggest that differences in sample characteristics may contribute to mixed findings. Another aim of this study was to compare treatment response to a social skills intervention in youth with ASD with and without co-occurring ADHD. Findings suggest the SCI is associated with significant social gains and is effective for youth with ASD even in the presence of co-occurring ADHD.

Limitations and Future Directions

There are a number of limitations to note in the present study related to measurement, the study design, and sample characteristics that impact generalizability of findings. This study assessed social functioning using several global and specific measures that have been designed or validated for individuals ASD. While both parent- and clinician- report tools were employed, the present study lacked teacher- report or multi-rater measures that may have provided more information about social functioning across contexts. Multi-rater data may also have allowed for evaluation of concordance among reporters. Inclusion of a direct or objective measure of social skills (e.g., observation, experimental paradigm) would have also strengthened this study and provided more information about social skill application in naturalistic environments or specific social situations. Additionally, it may have been informative to ask youth with ASD and ASD + ADHD about their perceived social abilities, social relationships, and barriers to social performance or the application of learned social skills. Analysis of self-report data may have strengthened this investigation and provided qualitative information about the role of ADHD symptoms in self-reported social experiences.

Given the focus on co-occurring ASD and ADHD, the present study would have been strengthened by inclusion of a more comprehensive, specific measure of ADHD symptoms. The

ABC Hyperactivity/Noncompliance subscale was used as a measure of ADHD symptoms, and to confirm that the clinically-diagnosed group with ASD + ADHD displayed more severe ADHD symptoms. However, more information on type of ADHD symptoms (e.g., inattention, hyperactivity, impulsivity) may have allowed for further characterization of the sample and additional analyses. Assessment of executive functioning may also have strengthened the current study, as the SCI has been shown to improve certain executive functions (Stichter, Christ, et al., 2016). Replication of these results and examination of executive functioning performance before and after the SCI may contribute to research on how the intervention structure and curricular constructs are related to executive functioning improvements among youth with ASD and ASD + ADHD. Further, additional measures of co-occurring symptoms known to impact social functioning, namely anxiety and depression, would have enabled analysis of the associations between internalizing symptoms and social functioning between youth with ASD and ASD + ADHD in the context of a psychosocial intervention.

In addition to measurement limitations, there are limitations associated with the study design. Data from the current study were collected within a pre-post framework, and short- and long-term follow up data are not available. The lack of data related to maintenance of treatment gains and generalization of skills across contexts is a major limitation and should be addressed in future studies of the SCI. Maintenance and generalization data may be particularly important when considering the appropriateness of the SCI for youth with co-occurring ADHD. It may be more challenging for individuals with ADHD to apply skills in different contexts in the absence of structure. Thus, the treatment setting (e.g., clinic, school, community setting) should be considered, as generalization and maintenance may be superior in naturalistic environments. Randomized controlled trials will be necessary to consider these factors and to determine the

effectiveness of the SCI. It will be useful to compare the SCI to social interventions with similar content that are less structured and lack the scaffolded teaching design and recurring practice activities of the SCI. Such research may contribute to knowledge regarding what interventions are most appropriate for youth with ASD and ASD + ADHD. It will be important for future studies to include larger samples that allow for separate examination of treatment response across the different age-based SCI groups (i.e., SCI-E, SCI-A, SCI-High School). These studies should measure treatment response from the perspective of many observers (e.g., parents, teachers, clinicians) and include direct social skills observations and/or more objective social measures.

Lastly, there are noteworthy limitations of the present study with regard to the study sample. The sample is relatively large compared to the two previous social intervention studies in ASD investigating the role of comorbid ADHD, and is well-characterized in regard to demographic, IQ, comorbid psychopathology, and medication use data. Nevertheless, the sample was fairly homogenous, which impacts generalizability of findings. First, the sample was almost entirely male, and it cannot be assumed that findings would look similar among females. A growing body of research points to differences in the social presentations and social experiences of males and females with autism without ID (de Giambattista et al., 2021; Sedgewick et al., 2019; Wood-Downie et al., 2021). While examination of gender differences is beyond the scope of this study, future social treatment studies should consider gender in the context of treatment response and composition of social intervention groups. In the current study only a handful of females participated in almost all-male groups; it is unclear how the unbalanced gender composition impacted the treatment experience of participants, particularly females. It is also important to note that groups comprised roughly equal numbers of participants with ASD and

ASD + ADHD. As it is unclear if there is a benefit to having more homogenous groups (e.g., all ASD or all ASD + ADHD), future treatment studies involving youth with co-occurring conditions should explore this.

Next, the sample is composed of predominately non-Hispanic, Caucasian males with autism without ID. The lack of diversity in the sample with regard to race and ethnicity is a noteworthy limitation. As normative social behaviors are often dependent on an individual's culture, future studies should carefully consider if a social skill intervention is an appropriate match for culturally- and linguistically- diverse youth with ASD. As participants in this study had IQ scores at or above 75, findings cannot be generalized to youth with ASD and ID. Individuals with ID and/or significant language concerns may not achieve the same level of gains from the SCI as youth with ASD without those difficulties. Further, the impact of co-occurring ADHD symptoms on social functioning and treatment response is likely very different among youth with ASD versus ASD + ID. Future studies may explore this, as there is a growing need for interventions that are appropriate and accessible for youth with ASD and co-occurring ID and other co-occurring mental health conditions.

In conclusion, additional research is surely needed to determine which social interventions may be most appropriate for youth with ASD and comorbid ADHD. Findings from this study suggest that youth with ASD and comorbid ADHD may benefit from interventions that are highly structured that utilize a scaffolded teaching design. It will be important for future psychosocial treatment studies in youth with ASD to report on co-occurring conditions for participants and evaluate the role these co-occurring symptoms have on treatment outcomes.

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Achenbach TM, Rescorla L. Manual for the ASEBA school-age forms & profiles: an integrated system of multi-informant assessment. Burlington, VT: University of Vermont, Research Center for Children, Youth & Families; 2001.

Aman, M., & Singh, N. (1986). *Aberrant behavior checklist: Manual.*

Avni, E., Ben-itzchak, E., & Zachor, D. A. (2018). *The Presence of comorbid ADHD and anxiety symptoms in autism spectrum disorder : Clinical presentation and predictors*. *9*(December), 1–12. https://doi.org/10.3389/fpsyt.2018.00717

Bagaiolo, L. F., Bordini, D., Cunha, G. R. da, Sasaki, T. N. D., Nogueira, M. L. M., Pacífico, C. R., & Braido, M. (2019). Implementing a community-based parent training behavioral intervention for Autism Spectrum Disorder. *Psicologia - Teoria e Prática*, *21*(3). https://doi.org/10.5935/1980-6906/psicologia.v21n3p456-472

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Barry, T. D., Klinger, L. G., Lee, J. M., Palardy, N., Gilmore, T., & Bodin, S. D. (2003). Examining the Effectiveness of an Outpatient Clinic-Based Social Skills Group for High-Functioning Children with Autism. *Journal of Autism and Developmental Disorders*, *33*(6), 685–701. https://doi.org/10.1023/B:JADD.0000006004.86556.e0

Batson, M., Elliott, S., Lam, G., Seimears, N., Batson, M., & Lam, G. (2017). *Social Skills Interventions for Adolescents with ASD , ADHD , and Other Comorbidities*.

http://soundideas.pugetsound.edu/ot_capstone/24

Constantino, J., Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., Metzger, L. M., Shoushtari, C. S., Splinter, R., & Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: Comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of Autism and Developmental Disorders*, *33*(4), 427–433. https://doi.org/10.1023/A:1025014929212

Cook, J. L., Rapp, J. T., Mann, K. R., McHugh, C., Burji, C., & Nuta, R. (2017). A Practitioner Model for Increasing Eye Contact in Children With Autism. *Behavior Modification*, *41*(3), 382–404. https://doi.org/10.1177/0145445516689323

Deckers, A., Muris, P., Roelofs, J., & Arntz, A. (2016). A Group-Administered social Skills Training for 8- to 12- Year-Old, high-Functioning Children With Autism Spectrum Disorders: An Evaluation of its Effectiveness in a Naturalistic Outpatient Treatment Setting. *Journal of Autism and Developmental Disorders*, *46*(11), 3493. https://doi.org/10.1007/S10803-016-2887-1

Dellapiazza, F., Audras-Torrent, L., Michelon, C., Baghdadli, A., & Baghdadli, A. (2021). Clinical characteristics of children with ASD and comorbid ADHD: Association with social impairment and externalizing and internalizing behaviours. *Research in Developmental Disabilities*, *113*, 103930. https://doi.org/10.1016/j.ridd.2021.103930

Elliot, C. (2007). *Differential abilities scale—2nd Edition (DAS-II) manual. 2nd ed.*

Factor, R. S., Ryan, S. M., Farley, J. P., Ollendick, T. H., & Scarpa, A. (2017). Does the presence of anxiety and ADHD symptoms add to social impairment in children with autism spectrum disorder? *Journal of Autism and Developmental Disorders*, *47*(4), 1122–1134. https://doi.org/10.1007/s10803-016-3025-9

Grzadzinski, R., Di Martino, A., Brady, E., Mairena, M. A., O'Neale, M., Petkova, E., Lord, C., & Castellanos, F. X. (2011). Examining autistic traits in children with ADHD: Does the Autism Spectrum Extend to ADHD? *Journal of Autism and Developmental Disorders*, *41*(9), 1178–1191. https://doi.org/10.1007/s10803-010-1135-3

Guttmann-Steinmetz, S., Gadow, K. D., & DeVincent, C. J. (2009). Oppositional defiant and conduct disorder behaviors in boys with autism spectrum disorder with and without attention-deficit hyperactivity disorder versus several comparison samples. *Journal of Autism and Developmental Disorders*, *39*(7), 976–985. https://doi.org/10.1007/s10803-009-0706-7

Halvorsen, M., Aman, M. G., Mathiassen, B., Brøndbo, P. H., Steinsvik, O. O., & Martinussen, M. (2019). Psychometric Properties of the Norwegian Aberrant Behavior Checklist and Diagnostic Relationships in a Neuro-Pediatric Sample. *Journal of Mental Health Research in Intellectual Disabilities*, *12*(3–4), 234–255. https://doi.org/10.1080/19315864.2019.1630872

Hamdan, M. A. (2018). Developing a proposed training program based on discrete trial training (DTT) to improve the non-verbal communication skills in children with autism spectrum disorder (ASD). *International Journal of Special Education*, *33*(3), 579–591.

Han, G. T., Tomarken, A. J., & Gotham, K. O. (2019). Social and nonsocial reward moderate the relation between autism symptoms and loneliness in adults with ASD, depression, and controls. *Autism Research*, *12*(6), 884–896. https://doi.org/10.1002/aur.2088

Harkins, C. M., Handen, B. L., & Mazurek, M. O. (2021). The Impact of the Comorbidity of ASD and ADHD on Social Impairment. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-021-05150-1

Hill, T. L., Gray, S. A. O., Baker, C. N., Boggs, K., Carey, E., Johnson, C., Kamps, J. L., & Enrique Varela, R. (2017). A Pilot Study Examining the Effectiveness of the PEERS Program on Social Skills and Anxiety in Adolescents with Autism Spectrum Disorder. *Journal of Developmental and Physical Disabilities*, *29*(5), 797–808. https://doi.org/10.1007/s10882-017-9557-x

Houghton, R., Monz, B., Law, K., Loss, G., Le Scouiller, S., de Vries, F., & Willgoss, T. (2019). Psychometric Validation of the Autism Impact Measure (AIM). *Journal of Autism and Developmental Disorders*, *49*(6), 2559–2570. https://doi.org/10.1007/s10803-019-04011-2

Hus, V., Bishop, S., Gotham, K., Huerta, M., & Lord, C. (2013). Factors influencing scores on the social responsiveness scale. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *54*(2), 216–224. https://doi.org/10.1111/j.1469-7610.2012.02589.x

Kanne, S. M., Mazurek, M. O., Sikora, D., Bellando, J., Branum-Martin, L., Handen, B., Katz, T., Freedman, B., Powell, M. P., & Warren, Z. (2014). The autism impact measure (AIM): Initial development of a new tool for treatment outcome measurement. *Journal of Autism and Developmental Disorders*, *44*(1), 168–179. https://doi.org/10.1007/s10803-013-1862-3

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Kern, J. K., Geier, D. A., Sykes, L. K., Geier, M. R., & Deth, R. C. (2015). Are ASD and ADHD a Continuum? A Comparison of Pathophysiological Similarities Between the Disorders. *Journal of Attention Disorders*, *19*(9), 805–827. https://doi.org/10.1177/1087054712459886

Laugeson, E. A., Frankel, F., Gantman, A., Dillon, A. R., & Mogil, C. (2012). Evidence-based social skills training for adolescents with autism spectrum disorders: The UCLA PEERS program. *Journal of Autism and Developmental Disorders*, *42*(6), 1025–1036. https://doi.org/10.1007/s10803-011-1339-1

Lecavalier, L., Mccracken, C. E., Aman, M. G., Mcdougle, C. J., Mccracken, J. T., Tierney, E., Smith, T., Johnson, C., King, B., Handen, B., Swiezy, N. B., Arnold, L. E., Bearss, K., Vitiello, B., & Scahill, L. (2018). *An exploration of concomitant psychiatric disorders in children with autism spectrum disorder*. https://doi.org/10.1016/j.comppsych.2018.10.012

Leitner, Y. (2014). The Co-occurrence of autism and attention deficit hyperactivity disorder in children: What do we know? *Frontiers in Human Neuroscience*, *8*(April), 1–8. https://doi.org/10.3389/fnhum.2014.00268

Lord, C., Rutter, M., DiLvaore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism diagnostic observation schedule, second edition (ADOS-2) manual (Part 1): Modules 1–4.* Western Psychological Services.

Matthews, N. L., Orr, B. C., Warriner, K., DeCarlo, M., Sorensen, M., Laflin, J., & Smith, C. J. (2018). Exploring the Effectiveness of a Peer-Mediated Model of the PEERS Curriculum: A Pilot Randomized Control Trial. *Journal of Autism and Developmental Disorders*, *48*(7), 2458–2475. https://doi.org/10.1007/s10803-018-3504-2

Mazurek, M. O., Carlson, C., Baker-Ericzén, M., Butter, E., Norris, M., Barr, C., & Kanne, S. (2020). The Autism Impact Measure (AIM): Examination of Sensitivity to Change. *Autism Research*, *13*(11), 1867–1879. https://doi.org/10.1002/aur.2397

Mazurek, M. O., Carlson, C., Baker-Ericzén, M., Butter, E., Norris, M., & Kanne, S. (2020). Construct Validity of the Autism Impact Measure (AIM). *Journal of Autism and*

Developmental Disorders, *50*(7), 2307–2319. https://doi.org/10.1007/s10803-018-3462-8

McVey, A. J., Schiltz, H. K., Haendel, A. D., Dolan, B. K., Willar, K. S., Pleiss, S. S., Karst, J. S., Carlson, M., Krueger, W., Murphy, C. C., Casnar, C. L., Yund, B., & Van Hecke, A. V. (2018). Social difficulties in youth with autism with and without anxiety and ADHD symptoms. *Autism Research*, *11*(12), 1679–1689. https://doi.org/10.1002/aur.2039

Moul, C., Cauchi, A., Hawes, D. J., Brennan, J., & Dadds, M. R. (2015). Differentiating Autism Spectrum Disorder and Overlapping Psychopathology with a Brief Version of the Social Responsiveness Scale. *Child Psychiatry and Human Development*, *46*(1), 108–117. https://doi.org/10.1007/s10578-014-0456-4

Murray, M. J. (2010). Attention-deficit/Hyperactivity Disorder in the Context of Autism Spectrum Disorders. *Current Psychiatry Reports 2010 12:5*, *12*(5), 382–388. https://doi.org/10.1007/S11920-010-0145-3

Ng, R., Heinrich, K., & Hodges, E. (2021). Associations Between ADHD Subtype Symptomatology and Social Functioning in Children With ADHD, Autism Spectrum Disorder, and Comorbid Diagnosis: Utility of Diagnostic Tools in Treatment Considerations. *Journal of Attention Disorders*, *25*(6), 820–828. https://doi.org/10.1177/1087054719855680

Rao, P. A., & Landa, R. J. (2014). Association between severity of behavioral phenotype and comorbid attention deficit hyperactivity disorder symptoms in children with autism spectrum disorders. *Autism*, *18*(3), 272–280. https://doi.org/10.1177/1362361312470494

Salley, B., Gabrielli, J., Smith, C. M., & Braun, M. (2015). Do communication and social interaction skills differ across youth diagnosed with autism spectrum disorder, attention-deficit/hyperactivity disorder, or dual diagnosis? *Research in Autism Spectrum Disorders*,

20, 58–66. https://doi.org/10.1016/j.rasd.2015.08.006

Sannar, E. M., Palka, T., Beresford, C., Peura, C., Kaplan, D., Verdi, M., Siegel, M., Kaplan, S., Grados, M., Erickson, C., Gabriels, R. L., Mazefsky, C., Morrow, E. M., Righi, G., Santangelo, S. L., Wink, L., Benevides, J., Best, C., Bowen, K., … Williams, D. (2018). Sleep Problems and Their Relationship to Maladaptive Behavior Severity in Psychiatrically Hospitalized Children with Autism Spectrum Disorder (ASD). *Journal of Autism and Developmental Disorders*, *48*(11), 3720–3726. https://doi.org/10.1007/s10803-017-3362-3

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f

Sinzig, J., Morsch, D., & Lehmkuhl, G. (2008). Do hyperactivity, impulsivity and inattention have an impact on the ability of facial affect recognition in children with autism and ADHD? *European Child & Adolescent Psychiatry*, *17*(2), 63–72. https://doi.org/10.1007/s00787-007-0637-9

So, W. C., Wong, M. K. Y., Lam, C. K. Y., Lam, W. Y., Chui, A. T. F., Lee, T. L., Ng, H. M., Chan, C. H., & Fok, D. C. W. (2018). Using a social robot to teach gestural recognition and production in children with autism spectrum disorders. *Disability and Rehabilitation: Assistive Technology*, *13*(6), 527–539. https://doi.org/10.1080/17483107.2017.1344886

Sprenger, L., Bühler, E., Poustka, L., Bach, C., Heinzel-Gutenbrunner, M., Kamp-Becker, I., & Bachmann, C. (2013). Impact of ADHD symptoms on autism spectrum disorder symptom severity. *Research in Developmental Disabilities*, *34*(10), 3545–3552.

https://doi.org/10.1016/j.ridd.2013.07.028

Stichter, J. P., Christ, S. E., Herzog, M. J., O'Donnell, R. M., & O'Connor, K. V. (2016). Exploring the role of executive functioning measures for social competence research. *Assessment for Effective Intervention*, *41*(4), 243–254. https://doi.org/10.1177/1534508416644179

Stichter, J. P., Herzog, M. J., Owens, S. A., & Malugen, E. (2016). Manualization, Feasibility, and Effectiveness of the School-Based Social Competence Intervention for Adolescents (Sci-a). *Psychology in the Schools*, *53*(6), 583–600. https://doi.org/10.1002/pits.21928

Stichter, J. P., Herzog, M. J., Visovsky, K., Schmidt, C., Randolph, J., Schultz, T., & Gage, N. (2010). Social competence intervention for youth with asperger syndrome and high-functioning autism: An initial investigation. *Journal of Autism and Developmental Disorders*, *40*(9), 1067–1079. https://doi.org/10.1007/s10803-010-0959-1

Stichter, J. P., O'Connor, K. V., Herzog, M. J., Lierheimer, K., & McGhee, S. D. (2012). Social competence intervention for elementary students with Aspergers Syndrome and high functioning autism. *Journal of Autism and Developmental Disorders*, *42*(3), 354–366. https://doi.org/10.1007/s10803-011-1249-2

Stratis, E. A., & Lecavalier, L. (2013). Restricted and repetitive behaviors and psychiatric symptoms in youth with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *7*(6), 757–766. https://doi.org/10.1016/J.RASD.2013.02.017

Van Der Meer, J. M. J., Oerlemans, A. M., Van Steijn, D. J., Lappenschaar, M. G. A., De Sonneville, L. M. J., Buitelaar, J. K., & Rommelse, N. N. J. (2012). NEW RESEARCH Are Autism Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder Different Manifestations of One Overarching Disorder? Cognitive and Symptom Evidence From a

Clinical and Population-Based Sample. *JAAC*, *51*(11), 1160-1172.e3. https://doi.org/10.1016/j.jaac.2012.08.024

Van Der Oord, S., Van Der Meulen, E. M., Prins, P. J. M., Oosterlaan, J., Buitelaar, J. K., & Emmelkamp, P. M. G. (2005). A psychometric evaluation of the social skills rating system in children with attention deficit hyperactivity disorder. *Behaviour Research and Therapy*, *43*(6), 733–746. https://doi.org/10.1016/j.brat.2004.06.004

Varni, J. W., Seid, M., & Kurtin, P. S. (2001). PedsQL™ 4.0: Reliability and Validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in Healthy and Patient Populations. *Medical Care*, *39*(8), 800–812. https://doi.org/10.1097/00005650-200108000-00006

White, S. W., & Roberson-Nay, R. (2009). Anxiety, social deficits, and loneliness in youth with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(7), 1006–1013. https://doi.org/10.1007/S10803-009-0713-8/TABLES/3

Wolstencroft, J., Robinson, L., Srinivasan, R., Kerry, E., Mandy, W., & Skuse, D. (2018). A Systematic Review of Group Social Skills Interventions, and Meta-analysis of Outcomes, for Children with High Functioning ASD. *Journal of Autism and Developmental Disorders*, *48*(7), 2293–2307. https://doi.org/10.1007/s10803-018-3485-1

Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2009). Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders. *Autism Research*, *2*(6), 322–333. https://doi.org/10.1002/aur.103

Zachor, D. A., & Ben-Itzchak, E. (2013). The Relationship Between Clinical Presentation and Unusual Sensory Interests in Autism Spectrum Disorders: A Preliminary Investigation.

Journal of Autism and Developmental Disorders, *44*(1), 229–235. https://doi.org/10.1007/s10803-013-1867-y

Zheng, S., Kim, H., Salzman, E., Ankenman, K., & Bent, S. (2021). Improving Social Knowledge and Skills among Adolescents with Autism: Systematic Review and Meta-Analysis of UCLA PEERS® for Adolescents. *Journal of Autism and Developmental Disorders*, 1–16. https://doi.org/10.1007/s10803-021-04885-1

Table 1 *Sample characteristics by group.*

	Total N (%)	ASD *n* (%)	ASD + ADHD *n* (%)
	81	37	44
Age (years) *M (SD)*	10.78 (2.35)	10.11 (2.46)	11.34 (2.21)
Gender			
Male	73 (90.13%)	34 (91.9%)	39 (88.6%)
Female	8 (9.87%)	3 (8.1%)	5 (11.4%)
Race			
White	73 (90.12%)	31 (83.78%)	42 (95.45%)
Black	2 (2.47%)	1 (2.7%)	1 (2.27%)
Asian	2 (2.47%)	2 (5.41%)	0 (0.0%)
Two or More Races	4 (4.94%)	3 (8.11%)	1 (2.27%)
Ethnicity			
Hispanic	2 (2.5%)	1 (2.7%)	1 (2.3%)
Non-Hispanic	79 (97.5%)	36 (97.3%)	44 (97.7%)
Income			
Under 15,000	2 (2.5%)	2 (5.4%)	0 (0.0%)
15-25,000	6 (7.4%)	3 (8.1%)	3 (6.8%)
25-35,000	5 (6.2%)	0 (0.0%)	5 (11.4%)
35-50,000	16 (19.8%)	9 (24.3%)	7 (15.9%)
50-75,000	11 (13.6%)	4 (10.8%)	7 (15.9%)
75-100,000	17 (20.0%)	7 (18.9%)	10 (22.7%)
100,000+	24 (29.6%)	12 (32.4%)	12 (27.3%)

Table 2 *Comorbid psychiatric diagnoses of participants by diagnostic group.*

	Total N (%)	ASD *n* (%)	ASD + ADHD *n* (%)
Anxiety Disorder	17 (20.99%)	6 (16.22%)	11 (25.0%)
Bipolar Disorder	2 (2.47%)	0 (0.0%)	2 (4.55%)
Depressive Disorder	7 (8.64%)	1 (2.70%)	6 (13.64%)
Obsessive Compulsive Disorder	7 (8.64%)	2 (5.41%)	5 (11.36%)
Oppositional Defiant Disorder	3 (3.70%)	1 (2.70%)	2 (4.55%)
Tourette Syndrome or Tic Disorder	2 (2.47%)	0 (0.0%)	2 (4.55%)

Table 3 *Bivariate correlations among study variables.*

	1	2	3	4	5	6	7	8	9
ADOS-SA	-								
AIM Communication	.004	-							
AIM Social Reciprocity	-.126	.606**	-						
AIM Peer Interaction	.048	.543**	.422**	-					
PedsQL Social Domain	-.080	-.243*	-.251*	-.450**	-				
SRS-2 Total T-Score	.055	.548**	.572**	.548**	-.568**	-			
SRS-2 Social Awareness	-.012	.327**	.394**	.217	-.192	.695**	-		
SRS-2 Social Cognition	.118	.463**	.549**	.439**	-.459**	.808**	.409**	-	
SRS-2 Social Communication	.022	.536**	.540**	.472**	-.549**	.961**	.706**	.732**	-
SRS-2 Social Motivation	.109	.393**	.407**	.639**	-.506**	.729**	.295**	.560**	.633**

[a] ADOS-SA= ADOS-2 Social Affect Score; AIM= Autism Impact Measure; PedsQL= Pediatric Quality of Life Inventory; SRS= Social Responsiveness Scale, Second Edition

[b] * $p < .05$

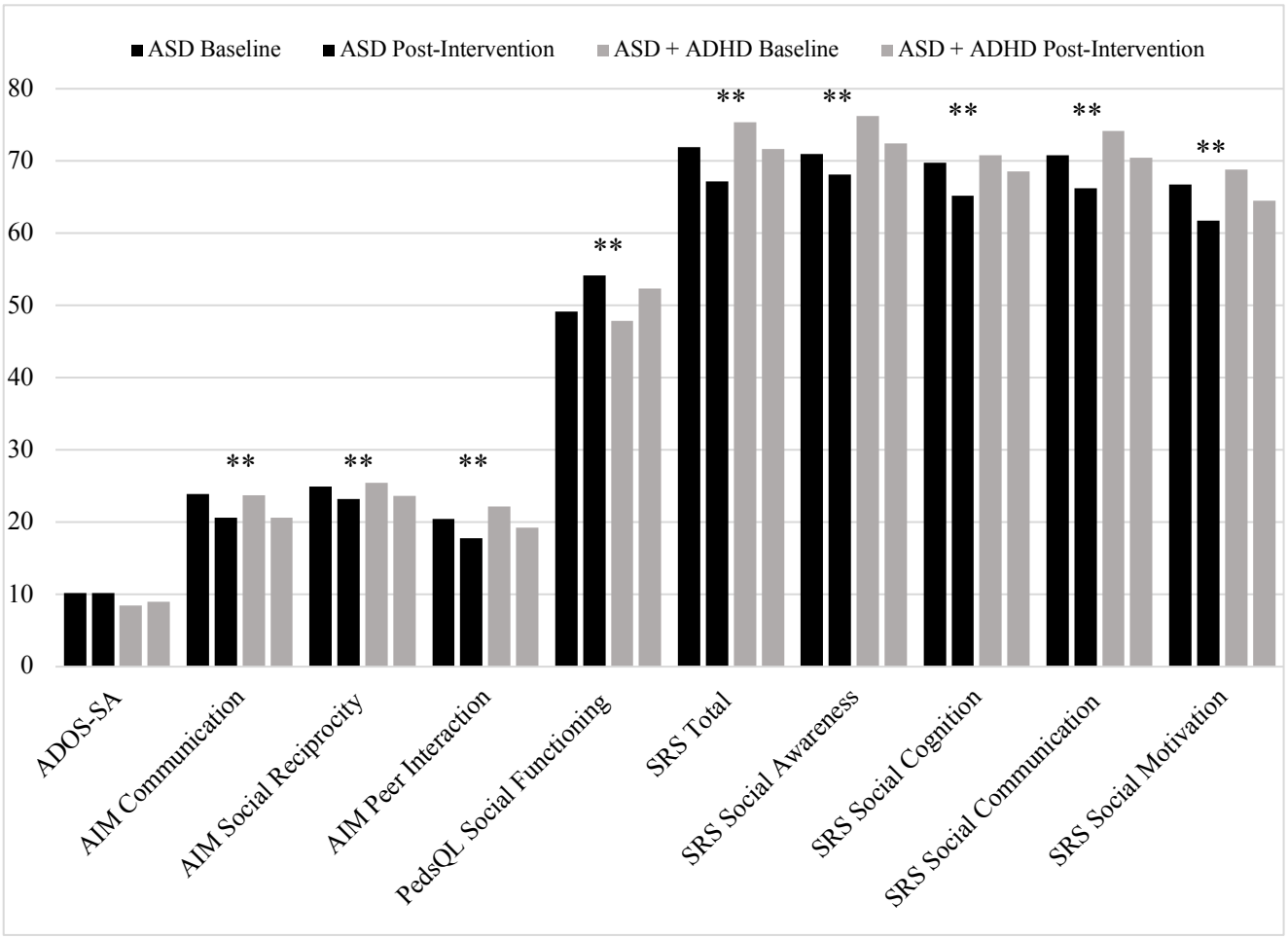
** $p < .01$

Table 4 *Comparison of diagnostic groups on demographic and baseline clinical characteristics.*

	M (SD)/n(%)		Significant Difference
	ASD	ASD + ADHD	
Age (years)	10.11 (2.46)	11.34 (2.21)	t(79) = -2.42, p = 0.07
Race (% White)	83.78%	95.45%	p = 0.18
Gender (% male)	88.6%	91.9%	p = 0.72
IQ	101.41 (14.82)	100.00 (15.81)	t(79) = 0.41, p = 0.54
ADOS-SA	10.19 (3.14)	8.48 (3.16)	t(79) = 2.44, p = 0.02
AIM			
Communication	23.89 (8.58)	23.73 (6.56)	t(79) = 0.09, p = 0.92
Social Reciprocity	24.97 (6.58)	25.45 (6.54)	t(79) = -0.33, p = 0.74
Peer Interaction	20.49 (6.04)	22.16 (5.21)	t(79) = -1.34, p = 0.18
PedsQL Social Domain	49.19 (18.62)	47.84 (23.06)	t(79) = 0.29, p = 0.78
SRS-2			
Total	71.92 (9.58)	75.35 (9.27)	t(79) = -1.63, p = 0.11
Social Awareness	70.97 (10.59)	76.22 (9.96)	t(79) = -2.29, p = 0.03
Social Cognition	69.78 (9.80)	70.82 (10.29)	t(79) = -0.46, p = 0.65
Social Communication	70.76 (9.79)	74.19 (9.95)	t(79) = -1.56, p = 0.12
Social Motivation	66.76 (10.89)	68.82 (11.74)	t(79) = -0.81, p = 0.42

[a]The ADOS- SA is a domain score with a possible range from 0-20, with higher scores indicating greater impairment. The AIM Communication, Social Reciprocity, and Peer Interaction subdomain raw scores are empirically derived and higher scores indicate greater impairment. The PedsQL Social Domain score range is 0-100, with higher scores indicating better social functioning. The SRS-2 Total and Social Awareness, Cognition, Communication, and Motivation subscale scores are T-scores, with higher scores indicating greater impairment.

Figure 1 *Scores on social measures as a function of time.*



[a] ADOS-SA= ADOS-2 Social Affect Score; AIM= Autism Impact Measure; PedsQL= Pediatric Quality of Life Inventory; SRS= Social Responsiveness Scale, Second Edition
[b] * $p < .05$
** $p < .01$