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REVIEW

Treatment for Co-Occurring Attention Deficit/Hyperactivity Disorder and Autism Spectrum Disorder

Naomi Ornstein Davis · Scott H. Kollins

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Abstract Interest in the co-occurrence of attention deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) has grown in the last decade. Research on clinical populations supports the frequent co-occurrence of ADHD traits (e.g., hyperactivity) in individuals with ASD and ASD traits (e.g., social communication deficits) in individuals with ADHD. Similar trends in co-occurring traits have been observed in population-based samples, as well as family and genetic studies of affected individuals. Despite increased interest in co-occurring ADHD and ASD, relatively little research has been devoted to treatment considerations. The vast majority of intervention research has examined pharmacological treatment using traditional ADHD medications. Relatively few psychosocial interventions have directly addressed co-occurring symptoms. Treatment development will benefit from enhanced understanding of the phenomenon of co-occurring ADHD and ASD. Key topics for future research include examining developmental trajectories of co-occurring disorders, comorbid psychiatric conditions, deficits in social skills, and the nature of executive functioning impairment in individuals with co-occurring ADHD and ASD. In the current review, research in these areas is reviewed along with recommendation for future study. Given that clinicians are routinely observing and treating individuals with co-occurring symptoms, further research will yield needed information to inform intervention development and maximize benefits for affected individuals.

N. O. Davis (✉) · S. H. Kollins
Department of Psychiatry and Behavioral Sciences,
Duke University Medical Center,
2608 Erwin Rd., Pavilion East, Suite 300,
Durham, NC 27705, USA
e-mail: naomi.davis@duke.edu

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Introduction

In the last decade, studies have reported increased prevalence of both attention deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) [1], as well as more cases of co-occurring ADHD and ASD symptoms [2]. Current nosology, however, precludes diagnosis of both disorders to the same individual and specifies that the presence of an ASD is an exclusion criterion for ADHD [3, 4]. As neurodevelopmental disorders, ADHD and ASD share some phenotypic similarities but they are characterized by distinct diagnostic criteria. ADHD is defined by impaired functioning in the areas of attention, hyperactivity, and impulsivity, whereas ASD is defined by social dysfunction, communicative impairment, and restricted/repetitive behaviors [3]. Despite these core differences, between 30 and 50 % of individuals diagnosed with ASD also exhibit elevated levels of ADHD symptoms [5–7]. Similarly, some estimates suggest that features of ASD are present in approximately two-thirds of individuals with ADHD [8]. Epidemiological research has also demonstrated notable associations between ADHD and ASD traits in nonclinical samples [2, 9, 10]. Taken together, these findings have significant implications for treatment research and service provision for individuals affected by co-occurring symptoms of these 2 common disorders.

Although clinicians have long recognized behavioral features, such as hyperactivity among children with ASD and impairing social deficits in children with ADHD, research on the co-occurrence of ASD and ADHD has burgeoned

only in recent years [11]. Multiple family studies have shown that family members of individuals with either ADHD or ASD frequently display symptoms of the other disorder [8, 12]. Genetic findings support the possibility of common genetic origins for both disorders [13–16]. In addition, evidence for common neurobiological substrates has been found through similarities in neuropsychological profiles among individuals with ADHD and ASD [11, 17]. Debate continues in the literature regarding the clinical implications of these findings, such that some researchers argue that co-occurring symptoms reflect the presence of 2 distinct disorders with a common etiology [18], and others suggest these disorders are better characterized as part of 1 broad spectrum, ranging from mild (ADHD) to more severe (ASD) impairment [11]. Given these findings, many researchers have advocated for revising diagnostic criteria to allow for dual diagnosis. By permitting the assignment of both ADHD and ASD, these researchers argue that individuals who experience co-occurring symptoms can be better characterized and studied to enhance research on effective treatments [2, 6, 18].

Diagnostic constraints have limited the scope of past research on co-occurring ADHD and ASD, because many studies have excluded individuals with any co-occurring symptoms to establish homogeneous samples. In addition, studies of ADHD and/or ASD have often excluded individuals with other psychiatric or developmental difficulties, thereby limiting the ability to generalize findings to the majority of patients who present with a combination of disorders. The co-occurrence of conditions has significant implications for level of functioning and treatment planning. Accumulating research comparing individuals with both ADHD and ASD to individuals with single a diagnosis (i.e., ADHD or ASD) suggests that co-occurring symptoms are associated with more impairment than single diagnoses. By both parent and teacher report, children with ADHD and ASD experience more difficulty in daily situations as compared to those with only 1 disorder [6]. Higher levels of additional psychopathology have been reported among individuals with co-occurring ADHD and ASD [19, 20]. Recent findings from the Autism Treatment Network database suggest that co-occurrence of ADHD and ASD is associated with a lower quality of life and poorer adaptive functioning as compared to children with ASD only [21]. Youth characterized as having both ADHD and ASD are more likely to be taking psychiatric medication (58 %) than youth with ADHD (49 %) or ASD (34 %) alone [22]. Furthermore, co-occurring ADHD and ASD may be less responsive to standard treatments for either disorder than individuals with "pure" forms of the disorders [23, 24].

In summary, research suggests the existence of a distinct phenotype characterized by both co-occurring symptoms and the unique needs for treatment that address multiple domains. Unfortunately, guidelines for optimal pharmacological and psychosocial interventions are limited. As such, the goals of the current review are: 1) to examine current research on pharmacological and nonpharmacological interventions for co-occurring ADHD and ASD symptoms, 2) to describe research on 4 key topics associated with co-occurring ADHD and ASD that have implications for treatment, and 3) to outline recommendations for future treatment studies to improve care for this high–need population.

Treatment for Co-Occurring ADHD and ASD

Pharmacological Interventions

Pharmacological treatment for ADHD is effective for reducing impairment associated with core ADHD symptoms (i.e., inattention, hyperactivity, impulsivity) and improving functioning in children and adults [25, 26]. For ASD, current pharmacological treatments primarily target comorbid symptoms (e.g., irritability, aggression, hyperactivity) rather than core social and communication impairments. Only 2 medications have been formally approved for use with individuals with ASD and both of these medicines target irritability: risperidone (Risperdal, Janssen Pharmaceutical Inc.; Titusville, NJ) and aripiprazole (Abilify, Otsuka America Pharmaceutical Inc.; Rockville, MD) [27–29]. Although some medications have demonstrated the potential to treat stereotyped or repetitive behaviors associated with ASD, efficacy data on these treatments has been less strong [30]. Similarly, exploratory research is being conducted on new agents, including intranasal oxytocin to target social impairments [31]. Despite limited research on medications, pharmacological treatment among individuals with ASD has significantly increased in recent years [32]. This trend is partly accounted for by an increase in use of ADHD medicines with individuals who are diagnosed with ASD to address ADHD-related impairments [33]. In the following section, we present an overview of current research on the efficacy of medication for co-occurring ADHD and ASD. More detailed descriptions on past psychopharmacological treatment studies can be found elsewhere [2, 34, 35].

Psychostimulant Medications

Psychostimulants are the most widely researched medications used to treat ADHD alone [26], but conflicting findings have been reported regarding the efficacy and safety of stimulants in cases of co-occurring ADHD and ASD. A series of early studies showed that children with ADHD and ASD experienced significant negative side effects (e.g., irritability, self–injury, stereotypy) and limited therapeutic benefit when treated with methylphenidate, in particular compared to expected outcomes based on methylphenidate

use for treating ADHD [34, 36, 37]. Given methodological limitations associated with these studies (i.e., open-label rather than blinded; preschool age subjects only; insufficient measurement of ADHD symptoms), recent research has examined stimulant efficacy using more rigorous study designs.

The Research Units on Pediatric Psychopharmacology Autism Network conducted a randomized, placebo-controlled, crossover trial of methylphenidate with 72 children (ages, 5–14 years) who were diagnosed with autism who were also characterized with moderate-to-severe hyperactivity. The study design involved a 1-week test dose phase, a 4-week treatment phase, and, for children who had a positive response to double-blind treatment, an 8-week, open-label phase. Results indicated that stimulant medication was effective at reducing hyperactivity and impulsivity in approximately half of the participants, a response rate that is considerably lower than the rates of 70 to 80 % found in studies of methylphenidate for children with ADHD only [24, 38, 39]. More adverse effects were reported in the children with ASD, and the highest tolerated dose was lower than that tolerated in children without ASD [24]. Results also indicated that medication effects were restricted to the target ADHD symptoms (e.g., decreased hyperactivity and impulsivity), and no positive effects were found on other behaviors, such as irritability, social withdrawal, stereotypy, or inappropriate speech [24]. Similar efficacy of methylphenidate was found in a smaller double-blind, randomized, placebo-controlled study of preschool–aged children with a pervasive developmental disorder [40]. A 50 % positive response rate was reported, along with lower optimal dose and higher side effects, as has been described in school-aged children.

Only 1 study to date has directly compared methylphenidate treatment response between children with ADHD and children characterized by ASD plus ADHD [41]. Based on a retrospective analysis of clinic cases and a small prospective clinical trial, Santosh et al. [41] reported overall improvement in ADHD symptoms, with few differences in treatment response between the groups. Although these findings support the use of methylphenidate in children with both ADHD and ASD, the results were also consistent with prior studies that have suggested a greater need for side effect monitoring and lower dosing in the context of ASD.

Nonstimulant Medications

Given the mixed findings associated with stimulant use, other nonstimulant medications have been investigated for co-occurring ADHD and ASD symptoms. Atomoxetine, a nonstimulant medication that functions via norepinephrine and dopamine, has demonstrated better tolerability than stimulant medications in individuals with co-occurring ADHD and ASD [42]. A small placebo-controlled efficacy trial indicated positive effects in terms of the reduction of hyperactivity and impulsivity, but not inattention in youth with ASD, with fewer adverse events as compared to stimulant trials [43]. Additional research using parents and teachers as informants showed significant reductions in ADHD symptoms among children with ADHD and ASD. Approximately half of the participants were classified as responders (i.e., global improvement rating in the "much-to-moderate" range for 6 of 14 participants), and side effects were rated as "minimally present" in 12 of the participants [44]. Despite these promising findings, atomoxetine effectiveness may vary as a function of level of impairment, as measured by either cognitive ability or ASD symptom severity. Positive results for atomextine are more evident among children with ASD who are cognitively higher functioning (defined as IQ >70) [45]. In a separate investigation, atomoxetine treatment yielded no observed symptom reduction in a sample of children with high ASD symptom severity [46].

Guanfacine, an alpha-2 adrenergic agonist approved historically for treating hypertension and more recently approved for use with ADHD in an extended release formulation, Intuniv (Shire; Dublin, Ireland) is used alone and in combination with stimulants to treat children with ADHD [47]. Positive effects have been found in several studies using guanfacine for treatment of children with co-occurring ADHD and ASD symptoms. A retrospective analysis of 80 patients in the clinic indicated reduction in hyperactivity and inattention among children with ASD who were higher cognitively functioning (i.e., not in the cognitively impaired range) [48]. Similarly, positive effects on parent- and teacher-rated hyperactivity were also observed in an open trial examining children who had previously demonstrated lack of success with methylphenidate [49].

Impact of Medication on Other Aspects of Functioning

Reduction in ADHD symptoms has been the primary outcome measure for most medication trials for co-occurring ADHD and ASD. However, 1 secondary analysis of the Research Units on Pediatric Psychopharmacology Autism Network data examined the effects of methylphenidate on social communication skills and self-regulation skills in 33 children with ASD [50]. Weekly observational tasks were coded during the 4-week methylphenidate trial, including a semi-structured caregiver–child interaction and a structured examiner–child interaction. Results indicated that methylphenidate use was associated with several positive social outcomes, including improved initiation for joint attention, improved response to bids for joint attention, better self-regulation, and more regulated affective state [50]. Further study is warranted to determine if these gains can be maintained in time and generalized across settings.

Summary

Research generally supports the use of psychopharmacological treatments for reducing impairing ADHD symptoms in individuals with co-occurring ADHD and ASD, but further study is needed to increase understanding of the effectiveness and to inform clinical practice. For example, if ADHD symptoms are effectively treated (i.e., attention is improved, disruptive activity levels are reduced), then individuals with ASD may benefit more from interventions targeting social and communication deficits. Several specific limitations of the current treatment literature should be addressed in future studies. First, given that past research samples have been primarily restricted to school-aged children, medication trials are needed to determine treatment guidelines for preschoolers, adolescents, and adults. Second, several studies have pointed to possible differential effects based on level of functioning (e.g., cognitive level, ASD severity), and future research should take into consideration both cognitive level and ASD severity when evaluating medication response. Finally, an important next step in medication trials will be to develop and test combined pharmacological and psychosocial treatments for co-occurring ADHD and ASD.

Psychosocial Interventions

Given that co-occurrence of ADHD and ASD is associated with more profound impairments than either ADHD or ASD alone, and considering evidence that medication response is less adequate in the context of co-occurring symptoms, the need for effective psychosocial treatment is evident. Indeed, psychosocial interventions (e.g., behavioral therapies, parent training, social skills training) are key components of treatment for both ADHD and ASD when considered as independent disorders [51, 52]. For ADHD, empirical support exists for behavioral training for parents of children with ADHD [53] and cognitive behavioral therapy for affected adults [54]. In contrast, social skill interventions to reduce social impairments (i.e., social and social communication problems often associated with ASD) for children with ADHD are often clinically indicated but have demonstrated limited treatment effectiveness [55]. For ASD, early intensive behavioral interventions have demonstrated efficacy for improving social communication, language, and cognitive outcomes for young children [51, 56]. Other evidence-based interventions for ASD include behavioral treatments for anxiety and aggression and group social skills training [57]. Current behavioral treatments for ASD do not specifically target impairing ADHD symptoms.

Although no known psychosocial interventions have been developed to target co-occurring ADHD and ASD, there are similarities across approaches that may influence future treatment development. Treatment for both ADHD (and related disruptive behaviors) and ASD originally developed using operant conditioning procedures, which have evolved in time to draw on a social learning theory [58]. Whereas both ADHD and ASD include behaviorally oriented parenting intervention, the role of the family has been conceptualized differently [58]. For ADHD, parent interventions ("parent training") typically involve manual, group-based programs designed to teach parents strategies to manage the behaviors of their children (e.g., reduce impulsive behavior, increase focus on tasks) [59, 60]. In contrast, ASD parent interventions ("parent education") place more emphasis on individualized treatments that provide parents with tools to promote child skills development (e.g., improve social engagement, increase communication attempts) [61]. While developing a bridge between these 2 interventions, traditions may result in an effective intervention for children who present with co-occurring symptoms and treatment needs. Programs traditionally designed for ASD may benefit from systematically teaching parenting skills to address co-occurring disruptive behaviors such as ADHD, and programs designed to address ADHD may benefit from adding a focus on individual skill development, including co-occurring social and communication impairments [58].

Multiple studies have demonstrated that combination pharmacological and psychosocial treatments are particularly effective for ADHD symptom management [26, 62]. This approach may also be indicated for children with co-occurring ADHD and ASD symptoms. To date, 1 published study has used a combined approach for children with ASD, but see clinicaltrials.gov for current ongoing research using combined medication and behavioral approaches [63]. Aman et al. [63] primarily targeted aggression in a trial of risperdone and parent training, but the combined treatment effects on hyperactivity were also examined [63, 64]. A manual, individually administered parent training was developed by enhancing standard behavioral training with ASD-specific strategies, such as using visual strategies, allowing more time for discussion of generalization and maintenance, and allowing 2 individualized sessions [64]. Results indicated that children who received parent training in addition to pharmacological treatment (i.e., risperidone) had lower rates of aggression and greater reductions in hyperactivity as compared to children who only received medication [63].

Summary

Limited work has examined psychosocial interventions for co-occurring ADHD and ASD [42, 65]. Continued research is needed to determine which existing psychosocial treatments work best for co-occurring symptoms, including both reduction of ADHD symptoms for children with ASD and improvement in social/communication impairments in children with

ADHD. Further research characterizing the developmental, social, and emotional features of this population may provide some of the missing links for the development and testing of effective psychosocial interventions.

Co-Occurring ADHD and ASD: Key Research Areas

Recognition that developmental and psychiatric disorders rarely manifest as single diagnoses has important implications not only for understanding etiology and risk factors, but also for developing effective interventions [66, 67]. It is widely believed that cases of "pure" ADHD are relatively uncommon, with the majority of individuals also affected by a co-occurring psychiatric disorder (e.g., anxiety, oppositional defiant disorder) or a developmental condition (e.g., learning disability, ASD) [68, 69]. Similarly, ASD is frequently accompanied by co-occurring conditions that are targeted for intervention to minimize the impairments that are more generally associated with ASD [70–72]. Research specifically focusing on co-occurring ADHD and ASD has only emerged recently, and many studies have focused primarily on questions of etiology and phenomenology, with less direct work on intervention development [11]. In the following section, we identify 4 areas of research that have implications for future treatment development. These areas of research include: 1) developmental trajectories, psychiatric comorbidities, deficits in social skills, and executive functioning. For each research area, we pose the main questions associated with that topic, review current research findings, and explore future research directions that may inform effective interventions.

Developmental Trajectories

Key Questions

- How do co-occurring ADHD and ASD symptoms develop in relation to 1 another with time?
- Do these developmental trajectories differ from expected trajectories for a single disorder?
- How will enhanced understanding of co-occurring symptom trajectories inform both pharmacological and psychosocial treatments?

Current Research

Understanding developmental trajectories for a given disorder is critical to treatment planning. Knowledge regarding the development and typical course of symptoms can be used to identify critical periods for intervention, to describe behavioral profiles that predict risk for a specific outcome, and to inform guidelines for pharmacological *versus* psychosocial treatment. Although both ADHD and ASD are defined by childhood onset and persistence into adulthood, the developmental course observed in the 2 disorders differs. Within ADHD, symptoms may emerge early and diagnostic subtypes may not be stable for a period of time [73, 74], but impairment associated with ADHD symptoms typically persists and can be exacerbated by increased demands for independent functioning in adulthood [75, 76]. For ASD, atypical development can be reliability identified by preschool and diagnoses are very stable for a period of time (i.e., individuals do not outgrow the disorder). Whereas intensive ASD intervention services promote communication, social engagement, and adaptive behavior skills, core ASD symptoms typically remain impairing throughout a lifespan.

Whereas most research to date has documented trajectories for ADHD and ASD separately, little is known regarding developmental trajectories when ADHD and ASD co-occur. Only 1 published study has examined the relationships between ADHD and ASD symptoms as they develop for a period of time. St. Pourcain et al. [9] followed over 5000 participants from ages 4 to 17 years and assessed social communication and hyperactive inattentive traits at multiple time points. Risk profiles were determined using latent class growth analysis and supported the presence of 2 social communication trajectories (i.e., low risk and persistently impaired) and 4 hyperactivity inattentive trait trajectories (i.e., low risk, childhood limited symptoms, intermediate level symptoms, persistently impaired). Results indicated that children who were persistently impaired in the domain of social communication were most likely to be classified in the 2 highest risk groups for hyperactive inattentive traits and were least likely to be in the childhood limited group for hyperactivity inattention. Similarly, children with persistently high hyperactive inattentive symptoms were almost exclusively classified as persistently impaired in the area of social communication [9]. Despite several study limitations (e.g., assessment of traits rather than disorder, a lack of social communication data prior to the age of 8 years old), these findings offer a unique perspective on the interrelationships between ASD and ADHD symptomatology during the course of development. Further research using more detailed clinical tools is needed to clarify these relationships. For example, findings suggest that presence of ASD is associated with stability in ADHD symptoms for a period of time. Given that ASD can typically be detected earlier in development than ADHD, it may be important to examine whether early ASD treatment can influence the stability of ADHD symptoms for a period of time.

Unlike the longitudinal research by St. Pourcain et al. [9], most current understanding of co-occurring ADHD and ASD for the course of development stems from cross-sectional studies. The earliest evidence for ADHD-ASD

co-occurrence was reported in a community sample of more than 300 pairs of 2-year-old twins. Results indicated modest but statistically significant correlations (r=0.23-0.26) between ASD and ADHD symptoms, as measured by the Child Behavior Checklist, with associations apparent in both social and nonsocial autistic-like traits [10]. Similar associations were reported in a survey of more than 6000 families of 8-year-old twins. Results indicated that associations between ASD and ADHD symptoms ranged from r= 0.51 (teacher report) to r=.054 (parent report) [77, 78]. Reiersen et al. have also reported phenotypic correlations in a series of studies examining ADHD-ASD traits in young adults [15, 65, 79].

Within clinical samples, co-occurring symptoms of ADHD and ASD have been documented from preschool through adulthood [2, 5, 80]. Multiple studies have found ASD traits in individuals diagnosed with ADHD, including deficits in social communication, social skills, and repetitive behaviors [8, 18]. There is some evidence that hyperactivity is more commonly associated with younger as compared to older children with ASD [81], which is consistent with the observed decline in hyperactivity for individuals with ADHD and in the general population. Similarly, in a sample of older school-aged children and adolescents with ASD, hyperactivity was found to generally diminish in time, but greater levels of hyperactivity were associated with more severe ASD symptoms [82]. At the same time, co-occurrence has also been reported in a clinical sample of adults who experienced ADHD and ASD along with high rates of other psychiatric comorbidity [83, 84].

Future Research Directions

Current understanding of developmental trajectories in co-occurring ADHD and ASD is limited by a paucity of longitudinal studies. Although work by St. Pourcain et al. [9] suggests associations between impairing symptoms in the domains of ADHD and ASD, further research is needed to understand how severity of symptoms in 1 domain may influence the emergence of symptoms in the other domain. Perhaps more importantly, it is not known whether the observed associations between ADHD and ASD symptoms can be altered by specific interventions. For example, developmental differences associated with ASD can be observed prior to 2 years of age [85], whereas distinguishing typical from atypical behaviors in the context of ADHD may be more challenging at very young ages. Given that early intensive ASD interventions can have a substantial impact on ASD symptoms, it will be important to determine whether these early interventions can also mitigate the later development of impairing ADHD symptoms. Conversely, research has not yet explored whether effective intervention for ADHD (perhaps even when symptoms might be considered subthreshold for Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition diagnosis) may reduce some of the impairments associated with co-occurring ASD symptoms (e.g., improving social functioning).

Further research is also needed to examine the developmental changes within each set of symptoms for a period of time. For example, the presentation of adult ADHD is characterized by a slightly different profile than childhood ADHD (i.e., less hyperactivity; more inattention) [54]. It is not yet known whether similar changes in ADHD symptoms take place for a period of time in the context of co-occurrence with ASD given that much past research has focused on hyperactivity in children with less emphasis on inattentive symptoms and less consideration of older adolescents and adults. Establishing a better understanding of how ADHD changes for a period of time as a function of co-occurrence with ASD would have important implications for intervention. Whereas cognitive behavioral strategies are commonly used to treat adult ADHD, these techniques may need to be altered in the context of ASD in which individuals may have less insight and self-awareness [54].

Psychiatric Comorbidities

Key Questions

- What psychiatric comorbidities are commonly associated with co-occurring ADHD and ASD?
- How do co-occurring psychiatric problems influence treatment needs?
- Are standard medications or psychosocial treatments for these psychiatric problems effective in the context of ADHD and ASD?

Current Research

Co-morbid psychiatric and developmental disorders are commonly reported in individuals with ADHD and in individuals with ASD (e.g., mood disorders, anxiety disorders, oppositional defiant disorder, learning disabilities) [68, 70, 71, 86–88]. As research on co-occurring ADHD and ASD has increased, recent studies have revealed a higher risk for psychopathology in the context of co-occurring ADHD and ASD [89]. In a series of studies with school-aged children with ASD, Gadow et al. [19] reported that children with ASD plus ADHD have more severe anxiety as compared to children with ADHD only, and as compared to children with ASD only [90]. Analyses examining rates of oppositional defiant disorder (ODD) have been more mixed, with some evidence suggesting that characteristics of ODD are more common among children with ASD who have specific ADHD symptom profiles, but not all cases of co-occurring ADHD [7]. Other evidence supports higher ODD symptoms

in children with ASD plus ADHD when using teacher ratings rather than parent ratings [20]. Finally, some evidence suggests high rates of substance use disorders, which are common in ADHD, but are rarely observed in ASD, in cases of co-occurring ADHD and ASD [91].

Similar findings have been reported in cases using ADHD, rather than ASD, as the target or primary disorder. Mulligan et al. [8] examined ASD symptoms in 800 children with ADHD and their siblings using the Social Communication Questionnaire. Among children with ADHD, higher levels of ODD and conduct disorder were associated with more ASD symptoms (Mulligan et al. [8]). Using a smaller but more rigorously ascertained sample of children with ADHD, Grzadzinski et al. [18] used multiple methods to categorize children with ADHD with respect to autism features, including symptoms from each of these 3 ASD categories: 1) social impairment, 2) communication impairment, and 3) restricted/repetitive interests. Of the children classified in the ADHD, plus the ASD group, significantly more problematic behaviors were also reported including oppositional behavior, withdrawn/depressed, and total problems as measured by the Child Behavior Checklist (CBCL) [18].

Future Research Directions

Existing research provides compelling evidence that combined psychiatric problems and co-occurring ADHD and ASD are associated with greater impairment, both during childhood and adulthood [92]. Clinically, it is clear that treatment considerations are more complex in the context of greater psychopathology. Because past research samples have generally excluded participants with complex psychopathology, there is little data to inform treatment decision-making for the majority of patients. Many patients present with multiple comorbid psychiatric symptoms or meet full diagnostic criteria for another psychiatric condition. However, it is not fully understood whether comorbid psychopathology (e.g., mood disorder, anxiety) has the same clinical features when in the context of co-occurring ADHD and ASD. Similarly, some co-occurring psychiatric symptoms may cause significant impairment, but may not be readily placed within traditional diagnostic categories. For example, affect regulation in the context of ADHD and irritability in the context of ASD share some common features, but in both cases it can be difficult to determine if these are true comorbidities rather than features of ADHD or ASD. Although some research has addressed these diagnostic classification issues in each disorder alone [86, 93], further research is needed on categorizing these psychiatric symptoms in the context of co-occurring ADHD and ASD.

Additional research is also needed to better understand the role of symptom severity and developmental trajectory on co-occurring psychiatric disorders. Cross-sectional research suggests that comorbid psychiatric conditions may be present from childhood into adulthood, but it is not clear when different problems emerge in the course of development. In the case of ADHD, Taurines et al. [68] proposed that different co-occurring conditions arise and influence ADHD differentially during the course of development. Certain disorders may be present before ADHD symptom onset (e.g., ASD), whereas for other disorders the onset is likely concurrent with ADHD symptoms (e.g., learning disabilities) and post-ADHD onset (e.g., depression, anxiety, substance abuse) [68]. Determining when symptoms of psychiatric comorbidities manifest in the context of co-occurring ADHD and ASD would inform both assessment procedures and treatment planning. Future studies should also examine whether adequate treatment of ADHD and ASD symptoms reduces the likelihood of other psychiatric problems emerging during the course of time and/or mitigates the impairment caused by these problems. Conversely, research is needed to understand whether early treatment of co-occurring psychiatric conditions (e.g., medication management for anxiety) may reduce the impairment associated with ADHD and ASD symptoms.

Deficits in Social Skills

Key Questions

- What is the nature of social impairments in cases of co-occurring ADHD and ASD?
- How are deficits in social skills in co-occurring ADHD and ASD similar to deficits observed in ADHD or ASD alone?
- What type of intervention will adequately address the social skill needs of individuals with co-occurring ADHD and ASD?

Current Research

Although initial interest in co-occurring ADHD and ASD focused on hyperactivity in the context of ASD, more recent work has examined commonalities in observed social deficits. Social problems are not part of the core diagnostic criteria for ADHD; however, social challenges are routinely recognized in individuals with ADHD. Research suggests that children with ADHD are rejected more often by their peers [94] and have fewer friends than typically developing peers [95]. In many cases, social deficits associated with ADHD are viewed as a direct result of ADHD core symptoms: inattentive behaviors may lead a child to miss social cues during an activity with peers; impulsive behavior may result in a child speaking out inappropriately and upsetting peers; hyperactive behaviors interfere with organized activities and lead to avoidance of peers. This profile of deficits in social skills differs from that observed in ASD, in which

impairment in the realm of social functioning is central to the diagnosis. Social deficits in ASD are characterized by features, such as a lack of interest or enjoyment in social engagement, inability to reciprocally participate in interactions, and lack of emotional engagement with others [96]. At the same time, heterogeneity is also observed among individuals with ASD, and some individuals with higher functioning ASD are better described as having interest but lacking the skills need to be socially successful.

Recent research suggests that many individuals with ADHD may experience social impairments that are more consistent with those observed in ASD. One study categorized the social impairments in children with ADHD as either associated with relationship difficulty (e.g., conduct and affective problems) or associated with social communication difficulty. Children with the social communication type of impairments were more likely to experience repetitive behaviors, speech/language impairment, and developmental problems similar to ASD [97]. Furthermore, specific social cognition deficits (e.g., facial affect recognition, empathy) that are typically observed in ASD, are often present in individuals with ADHD [98, 99]. These findings not only add to the discussion of shared etiology between the disorders but also highlight the types of deficits in social skills that may characterize co-occurring ADHD and ASD. However, little research has examined specific deficits in social skills (e.g., social problem solving, emotion identification) in children characterized by co-occurring ADHD and ASD.

Currently, the treatment literature suggests that neither pharmacotherapy treatment nor social skills training has a positive effect on social outcomes for children with ADHD alone [55, 100, 101]. In contrast, emerging evidence suggests that social skills training for children with a diagnosis of ASD can be effective [51, 102, 103]. It is likely that studies have included children with co-occurring ADHD and ASD, given the high prevalence of co-occurring symptoms, yet only 1 study has examined the effect of ADHD on treatment outcomes. Results of a 10-week group social skills training intervention for school-aged children with ASD showed that co-occurring ADHD negatively impacted program efficacy. Outcomes of social skills were rated using the Social Skills Rating System (SSRS), a broad measure of social skills, and were compared among children with ASD, ASD plus anxiety, and ASD plus ADHD. Children with ASD and co-occurring ADHD failed to gain social skills, whereas children with ASD without ADHD and children with ASD and anxiety both increased in overall social skills after the intervention [23]. These findings raise a number of questions for future social skills research with this population. Specifically, it is not clear from this study how much of the content of the intervention addressed the specific deficits of the children with ASD and ADHD (e.g., relative emphasis on ASD deficits in conversation skills *vs* ADHD-deficit in impulsive social behavior). In addition, social skills outcome measures vary in the degree to which they examine ASD-specific social impairments as compared to the social deficits commonly observed in ADHD. Developing measures that are more specific to the impairments associated with ADHD *versus* ASD may be needed to better understand outcomes from future interventional studies. Nonetheless, results of this study suggest that the deficits in social skills associated with ADHD, whether co-occurring with ASD or alone, appear to be very difficult to change via structured group social skills intervention, such as those described in the literature [55].

Future Research Directions

Given the high degree of impairment associated with the deficits in social skills in children with both ADHD and ASD, and the negative long-term outcomes associated with poor social skills [104], gaining a better understanding of the social skills profile of children with co-occurring symptoms is critical for identifying effective treatment. Future research is needed to examine the social skill competencies and deficiencies among children with ADHD, ASD, and co-occurring ADHD and ASD. Optimal social skills treatment for co-occurring ADHD and ASD may require a combination of techniques that addresses specific areas of impairment and the unique learning style of these individuals. Treatment features, such as content of the intervention, mode of delivery, and methods of reinforcement, need to be better understood with respect to the needs of individuals with co-occurring ADHD and ASD. For example, children with co-occurring ADHD and ASD may benefit from explicit teaching of foundational social skills (e.g., promoting basic social interest/engagement) in a setting with practice opportunities among positive peer models (e.g., typical classroom) and accompanied by a specially designed reward system for behavioral reinforcement (e.g., frequent, immediate, powerful feedback when skills are used).

One promising area for social skills training for these children includes using parents to support the development of peer friendships. For children with ADHD and children with ASD (specifically high functioning ASD), the social skills training combined with teaching parents to promote friendship skills (e.g., coaching the child to call a peer) may be effective for improving social skills [95, 105–107]. Further research on the role of parents in promoting social skills in the context of co-occurring ADHD and ASD may be particularly important. The treatment literature for both disorders has emphasized parental involvement in contrasting ways; either the parents provide environmental contingencies to promote behavioral change (ADHD) or they coach child skill development (ASD). Optimal parent involvement to promote social skills development for

co-occurring ADHD and ASD may involve a marriage of these approaches.

Executive Functioning

Key Questions

- Are there unique deficits in executive functioning associated with co-occurring ADHD and ASD in comparison with ADHD and ASD alone?
- How can greater knowledge of neuropsychological strengths and weaknesses in co-occurring ADHD and ASD influence treatment development?

Current Research

Neuroimaging and neuropsychological studies have shown that executive functioning deficits are common in both ADHD and ASD, with slightly different areas of impairment observed [11, 108–111]. The presence of ADHD is consistently associated with impaired performance on inhibition tasks (e.g., Stroop tasks) and sustained attention tasks (e.g., continuous performance task) [110]. With respect to ASD, impaired performance is typically observed on tasks that require planning and flexibility of thought (e.g., shifting attention) [112]. Overall, past research has suggested that ADHD and ASD can be differentiated from 1 another on a neuropsychological level during childhood and adulthood [109, 113]. However, there may be evidence for variability even within diagnostic categories. Corbett et al. [114] examined executive functioning in children with ADHD, ASD, and typical development and found that a subset of children with ASD had cognitive profiles consistent with those observed in ADHD (e.g., deficits in vigilance and inhibitory control). These findings raise questions about possible co-occurrence of ADHD and ASD.

Relatively few studies have specifically examined executive functioning profiles among individuals with co-occurring ADHD and ASD. Results from 2 recent studies suggest that children with co-occurring ADHD and ASD may have a unique cognitive profile. Yerys et al. [115] found greater overall cognitive impairments, including poor overall global executive control, cognitive flexibility, and verbal working memory, in children with ASD who also had hyperactivity. Similarly, Sinzig et al. [116] found disorder-specific impairments consistent with past research, but noted that children with ASD who had ADHD symptoms also displayed deficits in inhibition. In contrast to these findings among children, results from a recent study of adults with ADHD, ASD, and co-occurring ADHD/ASD found overall impairment in executive functioning in these groups, but there was no evidence that co-occurring ADHD and ASD was associated with greater deficits [83]. Clearly, further research is needed to understand the developmental nature of executive function in this population.

Some researchers have advocated that executive functions can be enhanced through diverse intervention programs, such as computerized training, exercise, mindfulness, and specially designed school curricula [117]. With respect to ADHD, there is emerging support for computer-based attention training programs at improving specific skills, however, findings are still mixed with respect to generalization and sustained benefit [118]. Several recent studies have demonstrated support for school-based exercise interventions in promoting executive functioning [119], along with 1 identified study that showed positive effects of mindfulness training on executive function [120, 121]. Even fewer studies have been published on intervention specifically to address executive function in the context of ASD, and no known studies have examined this question in individuals with co-occurring ADHD and ASD symptoms [122].

Future Research Directions

Current understanding of the executive functioning profile associated with co-occurring symptoms is limited, given that few studies have included individuals with co-occurring ADHD and ASD and limited work has been done to integrate findings into a developmental perspective. Specifically, it is not yet known whether co-occurring ADHD and ASD is associated with a unique, and potentially more impairing, set of neuropsychological deficits as compared to ADHD or ASD alone. Another outstanding gap in the literature relates to examining the association between performance on laboratory tasks and everyday functioning [123]. Until understanding of executive impairment moves beyond discrete laboratory measures to more real-world applications, it will be challenging to develop highly specialized interventions that can provide sustained benefit.

Summary and Future Directions

Interest in the co-occurrence of ADHD and ASD has grown tremendously in the last decade, with multiple published studies addressing questions of heritability and shared etiology [13, 15, 124], as well as common phenotypic and endophenotypic features [17, 42]. The majority of treatment-focused research has examined pharmacological treatment via traditional ADHD medication [35]. With respect to psychosocial treatment, very few studies have examined behavioral interventions that directly address co-occurring symptoms, and existing treatment studies have rarely examined outcomes based on co-occurring symptoms profiles [23]. Based on these studies and others, many clinicians and researchers have advocated for changes to

the diagnostic criteria to allow co-diagnosis of ADHD and ASD [2, 18]. These changes are currently being considered for the upcoming revision of the Diagnostic and Statistical Manual and will likely be incorporated into the Diagnostic and Statistical Manual, Fifth Edition [125–127]. Permitting co-diagnosis will facilitate advances in research by eliminating the exclusion of many patients and allowing more heterogeneous samples. Clinically, DSM-5 changes will provide diagnostic clarification for clinicians who are already treating patients with both ADHD and ASD symptoms and will facilitate pharmacological and psychosocial treatment studies to guide care.

Given the paucity of treatment research on this population, this review focused on 4 key topics: 1) developmental trajectories, 2) comorbid psychiatric conditions, 3) deficits in social skills, and 4) executive functioning, which may provide future intervention development for co-occurring ADHD and ASD. Specifically, better understanding of developmental trajectories in co-occurring ADHD and ASD will provide key information as to how symptoms interact and change and when interventions may be most indicated for the course of development. As highlighted in the review of comorbid psychiatric conditions, these additional challenges influence impairment and should be considered in treatment decisions. Social skill interventions, which have shown promise for ASD but little benefit for ADHD, may require novel treatment approaches in cases of co-occurring ADHD and ASD. Finally, unique executive function profiles may characterize individuals with co-occurring ADHD and ASD, but further investigation is needed to translate this understanding into intervention.

In addition to the 4 topics that were highlighted in this review, several other issues should be considered in future research on co-occurring ADHD and ASD. Heterogeneity in functioning is a hallmark feature of both ADHD and ASD, with wide variability in presentation among individuals within each diagnostic category. Individuals diagnosed with ADHD can differ tremendously based on symptom presentation (i.e., inattentive, hyperactive impulsive) and level of impairment. For ASD, heterogeneity is observed in each of the core diagnostic areas, along with respect to language (ranging from nonverbal to normal speech) and cognitive level (ranging from intellectual disability to superior range intelligence). The next phase of research on co-occurring ADHD and ASD should take into consideration the influence of this heterogeneity on treatment.

Although co-diagnosis of ADHD and ASD is not currently permitted through the current diagnostic system, clinicians who work with this population frequently observe overlapping symptoms and routinely treat them in their practice. Treatment research from the fields of ADHD and ASD suggest benefits of early identification and intervention, and this is also likely to be critical for cases of co-occurrence [51, 128]. However, early identification relies on improved diagnostic measures to facilitate assessment procedures and identification of co-occurring symptoms. Recent efforts to move toward dimensional approaches to defining impairment may be beneficial for cases of co-occurring ADHD and ASD, given the multiple outstanding questions about co-occurrence. Regardless, further research will yield needed information to inform intervention development and maximize benefits for affected individuals.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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