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Delayed autism spectrum disorder recognition in children and adolescents previously diagnosed with attention-deficit/hyperactivity disorder

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Abstract

Phenotypic elements of autism spectrum disorder can be masked by attention-deficit/hyperactivity disorder symptoms, potentially leading to a misdiagnosis or delaying an autism spectrum disorder diagnosis. This study explored differences in the age of autism spectrum disorder diagnosis between participants with previously diagnosed attention-deficit/hyperactivity disorder versus autism spectrum disorder–only respondents. Children and adolescents, but not adults, initially diagnosed with attention-deficit/hyperactivity disorder received an autism spectrum disorder diagnosis an average of 1.8 years later than autism spectrum disorder–only children, although the findings regarding the adult sample should be interpreted with caution. Gender differences were also explored, revealing that the delay in receiving an autism diagnosis was 1.5 years in boys and 2.6 years in girls with pre-existing attention-deficit/hyperactivity disorder, compared with boys and girls without prior attention-deficit/hyperactivity disorder. No significant gender differences were observed in the adult sample. We argue that overlapping symptoms between autism spectrum disorder and attention-deficit/hyperactivity disorder might delay a formal diagnosis of autism either by leading to a misdiagnosis of attention-deficit/hyperactivity disorder or by making it difficult to identify the presence of co-occurring autism spectrum disorder conditions once an initial diagnosis of attention-deficit/hyperactivity disorder has been obtained. Current findings highlight the need to recruit multidimensional and multidisciplinary screening procedures to assess for potential emerging autism spectrum disorder hallmarks in children and adolescents diagnosed or presenting with attention-deficit/hyperactivity disorder symptoms.

Keywords

age, attention-deficit/hyperactivity disorder, autism, autism spectrum disorder, diagnosis

Autism spectrum disorder (ASD) comprises a continuum of heterogeneous neurodevelopmental conditions typified by early-onset, persistent social deficits, and restricted as well as repetitive behavioral patterns (American Psychiatric Association (APA), 2013). Attention-deficit/hyperactivity disorder (ADHD) constitutes the most-frequently diagnosed co-occurring disorder in children with autism (Belardinelli and Raza, 2016) and is further characterized by patterns of inattention, hyperactivity, and impulsivity (APA, 2013). Although according to current diagnostic practices a co-occurring presentation would permit the concurrence of autism and ADHD, a misdiagnosis of ADHD would necessitate the withdrawal of the original ADHD diagnosis to be replaced by a diagnosis of ASD. Until recently, however, the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; DSM-IV-TR; APA, 2000) prohibited a co-occurring diagnosis of ADHD and autism. As a result, there exists a general absence of research directly comparing the two disorders by systematically investigating the presence of symptoms of hyperactivity and inattention in children with autism, or impaired social communication and/or stereotyped behaviors

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in children with ADHD. However, this ADHD exclusion criterion was modified in the fifth and latest version of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM; APA, 2013), and more recent studies now demonstrate overlapping traits between ASD and ADHD, possibly signifying the existence of a combined phenotype (Craig et al., 2015). On one hand, a significant proportion of children with autism present with co-occurring ADHD, with reported rates ranging from 30% (van der Meer et al., 2012) to 78% (Lee and Ousley, 2006). On the other hand, the overlapping symptomatology could lead to an initial misdiagnosis of ADHD, ultimately delaying the timing of ASD diagnosis. This study therefore aimed to explore potential differences in the age of ASD diagnosis between participants with a prior diagnosis of ADHD and ASD-only participants.

Although caution should be exercised when interpreting conclusions from assessments of very young children or infants in light of the changing trajectory of autistic symptom manifestation (Charman et al., 2005) and the type of assessments used (Kleinman et al., 2008), reliable autism diagnoses are possible in early childhood or even infancy (Charman and Baird, 2002). Nevertheless, autism often remains undiagnosed until school age (Mandell et al., 2005), delaying access to specialized intervention. This could be due to the phenotypic overlap between ASD and additional concurrent developmental concerns, particularly ADHD (Mayes et al., 2012). Approximately half of the children who received a late ASD diagnosis were previously diagnosed with another neurodevelopmental disorder (Jónsdóttir et al., 2011) or showed ADHD symptoms during initial assessments, resulting in the conclusion that ADHD symptoms may mask emerging ASD features (Davidovitch et al., 2015). Other studies have further indicated that children with co-occurring ADHD receive their ASD diagnosis approximately 1 (Frenette et al., 2013) to 3 years (Miodovnik et al., 2015) later than children without a co-occurring ADHD diagnosis.

Autism severity may be an important confounder in the relationship between prior ADHD diagnosis and age of ASD diagnosis (Mandell et al., 2005). That is, autism severity might be lower in children with a prior diagnosis of ADHD at the time of ASD diagnosis, resulting in later diagnosis (Shattuck et al., 2009). This would be consistent with findings that children with more severe ASD symptoms are diagnosed considerably earlier than those with milder symptoms (Mandell et al., 2005). Therefore, autism severity should be considered when comparing the mean age of ASD diagnosis in children with versus without a prior ADHD diagnosis.

This study used data from a survey conducted with 2212 individuals with ASD to investigate the difference in age of ASD diagnosis between individuals with and without a prior ADHD diagnosis, after controlling for autism severity and participants' current age. It was hypothesized that children with an ADHD diagnosis received prior to a subsequent ASD diagnosis would obtain an ASD diagnosis at a significantly later time, relative to children without a previous ADHD diagnosis, even after controlling for current age and autism severity.

Method

Participants

The sample included 2212 participants (1009 adults and 1126 children). Among those individuals, 770 (35.3%) were female. Participants were recruited via the Netherlands Autism Register (NAR), a longitudinal database containing approximately 2500 respondents with ASDs, who provide information on a variety of domains, including general demographics, diagnosis, comorbidity, treatment, education, employment, well-being, social skills, and relationships, as well as on topics such as sensory perception, sexuality, special interests, and cognitive functioning. Data are collected from both children/adolescents and adults, resulting in an age range from 4 to 85 years. Respondents older than 16 years provide self-report answers (62% of cases), whereas in the case of children and adolescents, responses are obtained from parents or caregivers (33%). It is also possible for a legal representative to respond on behalf of an adult (5%). All the information presented in the research was directly extracted from the NAR, such that existing participants were not contacted anew to get information on their ADHD diagnoses or administer the AQ. Additional information can be found at https://www.nederlandsautismeregister.nl/english. All participants provided informed consent. Additional demographic characteristics are shown in Table 1.

Materials

Previous ADHD diagnoses. Information regarding participants' diagnostic history was obtained by asking whether they had received a diagnosis of attention deficit disorder (ADD)/ADHD prior to receiving an ASD diagnosis.

Autism Quotient–Short. The Autism Quotient (AQ) was used to quantify autistic traits. The current sample was administered the abridged 28-item Autism Quotient–Short (AQ-Short), which comprises two higher order factors, one tapping into a broad range of social functioning deficits (Social Behavior factor) and one assessing fascination with patterns (Numbers/Patterns factor). The Social Behavior factor is further subdivided into four lower order factors tapping into Social Skills, Routine, Switching, and Imagination (Hoekstra et al., 2011). Participants respond using a 4-point Likert scale, ranging from "1 = definitely agree" to "4 = definitely disagree." Higher scores indicate a higher degree of autistic traits. Overall, the AQ-Short has shown

Table 1. Demographic characteristics.

	Total sample ($N = 2212$)	Children ($n = 1139$)	Adults ($n = 1072$)
Current age	25.93 ($SD = 17.68$)	11.30 (3.16)	41.46 (12.88)
Males (%)	64.8	80.2	48.5
Autistic traits (total AQ-short)	82.7 ($SD = 11.25$)	80.65 (10.82)	83.19 (11.42)
ADHD diagnosis prior to ASD diagnosis (%)	11.3	12.10	10.3
Age of ASD diagnosis	18.77 ($SD = 17.64$)	5.68 (2.52)	34.56 (14.93)

ADHD: attention-deficit/hyperactivity disorder; ASD: autism spectrum disorder; AQ: Autism Quotient; SD: standard deviation.

high reliability scores ($\omega_h = 0.86$) similar to the full 50-item version (Murray et al., 2017), in addition to correlating highly ($r = 0.95$) with the original measure (Hoekstra et al., 2011). Results have shown the AQ to have reasonably high sensitivity (0.77), correctly identifying 76% of individuals with ASD at a cutoff score of 26, as well as moderately high specificity (0.74), when applied to a referred clinical sample. Booth et al. (2013) similarly evaluated the discriminative power of the AQ based on sensitivity, specificity, and area under the curve (AUC), finding that both the original AQ-50 and the AQ-short could reliably discriminate between individuals with and without a clinical diagnosis of ASD. Specifically, a cutoff point of 26 yielded a sensitivity of 87.9% and a specificity of 79.9%, as well as an AUC of 91.38%, which is generally indicative of good validity. In this study, the total AQ-Short scores were used to control for severity of autistic traits.

Results

Separate analyses were performed for children/adolescents (aged <18 years) and adult participants, co-varying for current age and AQ scores. Stratification on the basis of age was deemed necessary due to the substantial gap in the average age of ASD diagnosis between children/adolescents ($M = 5.68$ years) and adults ($M = 34.56$ years).

Children

In total, 12.1% of children had obtained an ADHD diagnosis before being subsequently diagnosed with autism. A General Linear Model (GLM) analysis was performed, using gender and the presence of a diagnosis of ADD/ADHD prior to the ASD diagnosis as independent variables (IVs), and age of ASD diagnosis as the dependent variable (DV) while controlling for current age and autism severity. We observed a main effect of ASD severity ($F(1, 443) = 5.35$, $p = 0.021$), as well as a main effect of current age ($F(1, 443) = 123.189$, $p < 0.001$). A main effect of previous ADHD diagnosis was also observed ($F(1, 443) = 28.77$, $p < 0.001$). Crucially, however, results also revealed a statistically significant main effect of gender on the timing of ASD diagnosis ($F(1, 443) = 15.17$, $p < 0.001$), such that boys were diagnosed on average at 5.53 years (standard deviation (SD) = 2.42), while girls were diagnosed on average at 6.31 years of age ($SD = 2.82$). Finally, results revealed a marginally significant interaction between gender and previous ADHD diagnosis ($F(1, 443) = 2.92$, $p = 0.088$).

Aiming to further probe this interaction, the sample was then split by gender. For males, a total of 310 children reported no ADHD diagnosis prior to ASD, whereas 43 did. A GLM analysis, conducted to investigate the effect of a pre-existing ADHD diagnosis on the timing of a subsequent ASD diagnosis, controlling for current age and ASD symptom severity, revealed that boys with pre-existing ADHD were diagnosed with autism 1.52 years later ($M = 6.72$, $SD = 2.03$), relative to boys without prior ADHD ($M = 5.19$, $SD = 2.08$). This difference was statistically significant ($F(1, 349) = 15.49$, $p < 0.001$). Regarding girls, 82 reported that they had not received a previous ADHD diagnosis, whereas only 14 reported that they had. Results revealed that girls with prior ADHD received an autism diagnosis on average 2.64 years later ($M = 8.43$, $SD = 3.39$) relative to girls who did not report having obtained an ADHD diagnosis sometime prior to their ASD diagnosis ($M = 5.79$, $SD = 2.37$). This difference also emerged as statistically significant ($F = 10.73$, $p = 0.001$).

Adults

In total, 10.3% of adult participants reported having obtained a diagnosis of ADHD prior to receiving a diagnosis of autism. A GLM analysis was performed, using gender and diagnosis of ADD/ADHD prior to the ASD diagnosis as IVs, and age of ASD diagnosis as the DV, while controlling for current age and autism symptom severity. Adult participants who reported obtaining a diagnosis for ADD/ADHD prior to receiving an ASD diagnosis ($M = 36.48$, $SD = 14.80$, adj $M = 37.10$, standard error of the mean (SEM) = 0.708) did not differ in the timing of ASD diagnosis ($F(1, 550) = 0.31$, $p = 0.643$), compared to adult participants without a pre-existing ADHD diagnosis ($M = 36.75$, $SD = 14.08$). We nevertheless also observed a main effect of autism symptom severity ($F(1, 550) = 13.26$, $p < 0.001$), as well as a main effect of current age ($F(1, 550) = 3433.43$, $p < 0.001$). The interaction between gender and previous ADD/ADHD diagnoses failed to reach statistical significance ($F(1, 550) = 0.015$, $p = 0.903$).

Similar to the child/adolescent sample, in order to ascertain whether the delays in ASD diagnoses differed between males and females, the sample was then split by gender, and the effect of previous ADHD diagnosis on the age of ASD diagnosis was re-examined. The sample consisted of 247 adults without a prior ADHD diagnosis, while the remaining 19 reported previously diagnosed ADHD. Adult male participants without prior ADHD were diagnosed with autism at an average age of 40.06 years ($SD = 14.42$), whereas males with pre-existing ADHD received an ASD diagnosis on average at 42.51 years ($SD = 10.40$). This difference, however, did not emerge as statistically significant ($F = 0.065$, $p = 0.800$). Moreover, the sample consisted of 290 adult female participants, 258 of which did not have pre-existing ADHD and 32 of which did. Females with a prior ADHD diagnosis were given a formal ASD diagnosis on average at 32.90 years of age ($SD = 12.59$), whereas those without previously diagnosed ADHD obtained an ASD diagnosis on average at 33.68 years ($SD = 13.08$). The difference in age of ASD diagnosis between the two groups, however, failed to reach statistical significance ($F = 0.065$, $p = 0.799$).

Finally, considering that our hypothesis relied largely on the assumption that several cases of participants with a prior ADHD diagnosis would in essence reflect misdiagnosed cases of autism, we sought to extract the proportion of participants with a previous ADHD diagnosis but no current co-occurring diagnosis. Of those with a previous ADHD diagnosis ($N = 242$), 144 (59.5%) participants reported having a co-occurring ASD/ADHD diagnosis, whereas the remaining 98 (40.5%) participants did not reflect cases of co-occurring ASD/ADHD despite their initial ADHD diagnosis. This proportion was then examined separately for the child and adolescent sample, revealing similar findings. The child/adolescent sample consisted of 43 (33.3%) participants who reported no co-occurring ASD/ADHD despite having been initially diagnosed with ADHD prior to receiving an ASD diagnosis, whereas the adult sample contained 52 (50%) participants with a previous ADHD diagnosis but no current ASD/ADHD co-occurrence.

Discussion

Children and adolescents, but not adults, who had previously received an ADHD diagnosis were diagnosed with autism on average 1.8 years later than children without a pre-existing ADHD diagnosis. The delay in ASD diagnosis for the group of children with pre-existing ADHD persisted regardless of ASD severity and their current age. Subsequently, in order to investigate whether the observed delays in ASD diagnoses differed between males and females, the current sample was stratified by gender. Boys with a pre-existing ADHD diagnosis experienced an average delay of approximately 1.5 years in obtaining a diagnosis of autism, relative to boys without prior ADHD. By contrast, we observed a delay of approximately 2.6 years in girls with pre-existing ADHD, relative to girls without prior ADHD.

Current results parallel previous research revealing a substantial delay in the identification of autism in children with an earlier diagnosis of ADHD. A large proportion of children with autism remain undiagnosed until school age (Mandell et al., 2005), while parents of children with co-occurring ASD and ADHD diagnoses have also been found to express initial concerns regarding suspicion of autism and seek professional help at a significantly later time, leading to a substantial 2-year delay in the diagnosis of autism (Stevens et al., 2016). Previous research has also revealed that approximately half of children with a late diagnosis of autism initially receive additional developmental diagnoses (Jónsdóttir et al., 2011), in line with our current findings. On one hand, both conditions often encompass deficits in communication and attention, as well as varying degrees of impulsivity, restlessness, or hyperactivity (Carrascosa-Romero and De La Vega, 2015). Children with a diagnosis of ADHD have shown elevated ratings of core ASD traits that could not be accounted for by ADHD symptoms or additional behavioral problems, supporting the presence of social and communication deficits in children with ADHD (Cooper et al., 2014). Moreover, children diagnosed with ADHD have shown limited awareness of the feelings of others, difficulties in forming relationships, stereotyped body movements, impaired nonverbal communication, and repetitive speech (Clark et al., 1999). Although some of the above symptoms can inarguably be attributed to ADHD, the high frequencies in which they occurred led Clark et al. (1999) to speculate that some children diagnosed with ADHD could reflect misdiagnosed cases of autism. Children characterized by an ASD phenotype have shown greater numbers of ADHD symptoms relative to controls, suggesting that inattentive and hyperactive symptoms can be present in individuals with ASD (Craig et al., 2015). Within this context, it is therefore likely that inattentive and/or hyperactive symptoms might be camouflaging emerging social communication difficulties and/or restricted and repetitive behaviors and interests. On the other hand, although ADHD symptoms are common in autism, symptoms of autism are rather uncommon in ADHD, making the two groups easy to distinguish (Mayes et al., 2012). Despite contending with the presence of overlapping symptomatology between ASD and ADHD, Mayes et al. (2012) nevertheless noted that due to the high frequency of ADHD symptoms in autism, children may initially be misdiagnosed with ADHD, raising the example that children in clinical practice eventually diagnosed with autism often have a previous diagnosis of ADHD. Taking this into account, the authors recommended that children referred for or diagnosed with ADHD should be evaluated or, at the very least, screened for autism.

By contrast, the presence of an ADHD diagnosis preceding a formal diagnosis of autism was not found to delay the timing of ASD diagnosis in the adult sample, although the lack of research concerning adults does not allow us to compare current findings with those of previous studies. In retrospect, however, the absence of differences in the age of ASD diagnosis might not be surprising given that the adult participants in our current sample received an overall delayed diagnosis for autism relative to younger child or adolescent participants, irrespective of the presence of a prior diagnosis of ADD/ADHD or the absence thereof. This raises potential questions about the representativeness of the adult sample and therefore necessitates that we interpret these findings with caution. Even though a previous diagnosis of ADHD did not impact the age of ASD diagnosis in adults, the nature of the present data does not allow us to rule out this hypothesis.

Taking the aforementioned research on overlapping symptomatology into account, we put forth two potential explanations for current findings regarding the child sample. Overlapping symptoms have the potential to delay a formal diagnosis of ASD either by leading to a misdiagnosis with a condition such as ADHD, when upon closer inspection a diagnosis of autism is actually warranted, or by making it difficult to identify the presence of additional co-occurring conditions once a primary diagnosis has been obtained. Previous research indeed suggests that overlapping features possibly increase the risk of a misdiagnosis by complicating differential diagnosis or concealing emerging ASD traits. In line with the aforementioned reasoning, we observed that approximately 40% of our total sample did not maintain their initial diagnosis of ADHD as a co-occurring condition after they were subsequently found to qualify for a diagnosis of autism, raising the possibility that such cases might have represented initial misdiagnoses. To illustrate, although an extremely hyperactive child referred for evaluation of ADHD might appear to be a straightforward case, it is not uncommon for a main diagnosis of autism to be given after a full, detailed appraisal (Gillberg, 2010). Failure to provide a comprehensive battery of assessments could thus prevent the discovery of ASD, whereas reducing barriers to early diagnosis is especially critical in the face of mounting evidence showing intensive and specialized interventions to improve prognosis when implemented in younger ages (Lord, 1995).

On the contrary, ASD often does not occur in isolation, but is accompanied by co-occurring disorders in as much as 70% of cases (Simonoff et al., 2008). Our findings showed that, although a non-negligible proportion of children did not maintain the initial ADHD diagnosis, the majority of participants (59.5%) nevertheless met the criteria for co-occurring ADHD/ASD. Therefore, children initially diagnosed with ADHD may not always reflect misdiagnosed cases, but instead qualify for a co-occurring diagnosis. This reasoning could account for the delay in obtaining an ASD diagnosis observed in this study, without implying that a diagnosis of ADHD is always made despite ample evidence of symptoms of autism. By contrast, it is highly likely that children who later go on to receive a diagnosis of autism are initially diagnosed with conditions such as ADHD not only because symptoms of autism are present but missed, neglected, or misattributed to ADHD but because children may not yet manifest the full spectrum of ASD symptoms necessary to qualify for a formal diagnosis. This might make clinicians more inclined to ascribe existing symptoms to conditions other than autism or refrain from diagnosing autism until clear and undisputed symptoms are present. In other words, previously diagnosed conditions can mask emerging ASD symptomatology, biasing attribution of progressively increasing impairment toward existing diagnoses (Belardinelli and Raza, 2016). Our findings highlight the challenge of successfully identifying overlapping symptoms as facets of distinct yet co-occurring disorders, while this challenge in turn reflects the growing realization that ADHD and ASD may not constitute entirely discrete disorders, but rather stem from potentially shared genetic etiology and neurodevelopmental sources that reflect circuitry breakdown, impaired functional networks, or aberrant connectivity (Gillberg, 2010). Successful identification of co-existing conditions remains of paramount importance, especially given evidence that children with co-occurring ASD/ADHD presentations demonstrate greater clinical impairment relative to children with a single diagnosis (Ashwood et al., 2015). Therefore, when additional symptoms are identified as manifestations of co-occurring conditions rather than isolated behaviors, the necessary additional treatment can be provided.

Irrespective of whether current findings are due to missed cases of comorbidity or misdiagnosed cases, a timely diagnosis of autism was hindered to a substantially greater degree in girls relative to boys. What is more, this finding emerged despite the fact that 80% of participants who made up the child sample were male. The small proportion of girls is, however, not a new observation in light of evidence supporting the presence of a "female" ASD phenotype less likely to be identified by clinicians. Teachers of children with ASD report greater psychopathology for male relative to female students, indicating that, since concerns about a child's social communication are often first raised at school, girls with autism may receive delayed clinical attention or may even be overlooked entirely (Mandy et al., 2012). Thus, many females who if thoroughly assessed would meet the full diagnostic criteria for autism fail to receive a timely diagnosis and are identified later than equivalent males (Bargiela et al., 2016). Gender differences in ASD-related behaviors suggest that it might be easier to detect ASD behaviors in boys (Dean et al., 2017). Girls with autism are hypothesized to exhibit superficial social skills by mimicking

socially acceptable behaviors more efficiently than their male counterparts (Lai and Baron-Cohen, 2015). This coping strategy, termed "camouflaging," might involve making eye contact during conversation, mirroring social behaviors, imitating facial expressions, and adhering closely to social scripts (Lai and Baron-Cohen, 2015). Indeed, using playground observations, Dean et al. (2017) highlighted that the social challenges of boys with ASD were more evident than those of girls. Girls with autism employed otherwise subtle compensatory behaviors to gain and maintain access to peer groups by camouflaging their social challenges. Nevertheless, they were often unable to maintain continuous mutual engagement within social groups. By contrast, boys with ASD were more prone to isolation and demonstrated significantly more restrictive and repetitive behaviors which may readily strike others as atypical (Dean et al., 2017). Boys with autism may also exhibit greater externalizing symptomatology (Mandy et al., 2012), whereas girls may show increased risk of experiencing internalizing problems without exhibiting externalizing behaviors (Bargiela et al., 2016; Oswald et al., 2016). In the event that teachers are more inclined to notice overt and easily observable behaviors, boys are therefore more likely to be identified and diagnosed. This differential manifestation of social struggles in boys and girls with ASD highlights a male bias in our perception of children's peer interactions and could also be partly responsible for the disproportionate male-to-female ratio seen in our sample.

Limitations

This study was not without limitations. Although the sample included participants who had obtained formal diagnoses, information on earlier and current conditions was retrospective and self-reported. Individuals diagnosed with autism also often receive earlier diagnoses other than ADHD, making it highly likely that respondents in the ASD-only group had also obtained a previous diagnosis for another condition. It is possible that respondents had multiple previous diagnoses, although this was also not taken into consideration. Another point worth considering is that, rather than simply using questionnaire measures to assess whether participants would have qualified for an earlier ADHD diagnosis, the current sample instead consisted of participants who reported a clinical diagnosis of ADHD. This resulted in lower numbers of children with prior ADHD diagnoses, relative to previous studies (Lee and Ousley, 2006; Simonoff et al., 2008). What is more, information such as the age of ADHD diagnosis or the severity of ADHD symptoms was not available, as we did not directly measure ADHD traits. Importantly, although the severity of ASD traits was controlled for using participants' scores on the AQ-Short (Hoekstra et al., 2011), the measure itself also has limitations. The AQ was not designed as a diagnostic measure of ASD traits and may lack the necessary specificity and sensitivity to be used as a diagnostic instrument (Brugha et al., 2012; Ruzich et al., 2015). The measure may also not be appropriate for individuals with low intellectual functioning, since it assumes reading comprehension skills (Baron-Cohen et al., 2001). These limitations notwithstanding, this study did not use the AQ as a diagnostic tool but as a way of measuring symptom severity in individuals already diagnosed using established clinical measures. It is also worth reflecting on the gender differences we observed in the current study. Current diagnostic practices emphasize core ASD characteristics that have been traditionally derived from the behavioral manifestation of autism in males (Hiller et al., 2016). Females not meeting male-typical behavioral manifestations of autism are therefore likely to be diagnosed late or be missed altogether (Hiller et al., 2016). When diagnostic assessments exclusively emphasize ASD traits that are predominant in males, such diagnostic biases may also result in biased research samples. It is therefore highly likely that this gender bias was also present in our sample and could be responsible for the lower proportion of female relative to male participants. Finally, we did not have any available data regarding the medication status of our participants. It is, however, worth considering the potential influence of ADHD medication on the manifestation of ASD traits. Recent years have seen a significant increase in the use of psychoactive medications in autism, due partially to an increase in the use of ADHD medication in ASD children presenting with concurrent ADHD symptoms (Leitner, 2014). Methylphenidate and atomoxetine, which constitute the most-frequently used medications in the treatment of ADHD, also seem to be effective in ASD. Research comparing stimulant responsiveness between children with ADHD-only and children with co-occurring ASD and ADHD showed that subjects in both groups significantly improved with regard to hyperactivity, impulsivity, inattention, and oppositionality (Santosh et al., 2006), while methylphenidate administration in children with co-occurring ASD and ADHD was also associated with improved initiation of joint attention, improved response to calls for joint attention, and improved affective and self-regulation (Leitner, 2014). Nevertheless, a comprehensive review of the available research on the treatment of ADHD symptoms in children with ADHD concluded that, despite considerable support for the efficacy of ADHD medication in ADHD-only individuals, the available evidence is considerably weaker in children with ASD, who instead showed less robust treatment responses accompanied by higher probability of experiencing side-effects (Handen et al., 2011). In the event that ADHD medication does to some extent ameliorate ASD symptoms, it would pose an additional barrier in the timely recognition of emerging symptoms of autism. Seeing as we could not address this issue in this study, future research is warranted

to reveal any potential implications of ADHD medication in the timing of ASD diagnosis.

Future directions

The present results bring to the forefront a multitude of outstanding questions. At this stage, our current understanding of the precise extent to which ADHD symptomatology impacts the presentation of ASD traits warrants further elucidation. Future prevalence studies would be well-suited to better address the current research question, while further longitudinal research monitoring the stability of earlier diagnoses in children later diagnosed with autism would also be highly beneficial. Prospective, longitudinal exploration of developmental psychopathology from infancy throughout childhood is necessary to clarify the timing and progression of disruption in social, communication, attention, and cognitive profiles of children at high risk of developing an ASD/ADHD phenotype. The overrepresentation of males in the ASD population has resulted in predominantly male samples and motivated a rather narrow research focus on the etiology and clinical presentation of ASD in boys. Enhancing our understanding of the ASD profile in females by collecting comprehensive assessment reports from parents, peers, and teachers bears critical implications for the quality of diagnosis. Adjusting diagnostic protocols and instruments to reduce gender biases necessitates further research to pinpoint the precise nature of these biases. Finally, improving our understanding of camouflaging is needed to further facilitate the identification of masked symptoms and enhance timely diagnosis and support (Lai et al., 2017). Early and accurate diagnosis allows the selection of individualized treatment strategies and specialized interventions, whereas a young child with recognized developmental concerns but without a formal autism diagnosis is likely to receive generic treatment. Based on current findings, we therefore propose that a multidisciplinary approach to screening and diagnosis be adopted when assessing children presenting with developmental concerns.

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