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# Identifying Autistic-Like Symptoms in Children with ADHD: A Comparative Study Using ADOS-2

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**Purpose:** Recent literature has focused attention on the presence of autistic-like symptoms in children with Attention Deficit/Hyperactivity Disorder (ADHD), who often exhibit social difficulties, posing challenges for a distinct clinical diagnosis. The current study aimed to identify the specific pattern of autistic symptoms in subjects with ADHD or Autistic Spectrum Disorder (ASD), examining similarities or differences at both the domain and individual item levels.

**Patients and Methods:** In this study, we enrolled 43 school-age children divided into the following: the ADHD group (n=25) consisted of children initially referred for ASD symptoms but subsequently clinically diagnosed with ADHD, and the ASD group consisted of 18 children with ASD. We used the Autism Diagnostic Observation Schedule, 2nd edition (ADOS-2), to examine relative differences in the presence of symptoms such as deficits in communication and social interaction, and restricted and repetitive behaviors in these two groups. Comparison between groups was conducted to explore differences in IQ, age, ADOS-2 domains, and externalizing and internalizing problems among the groups.

**Results:** We found significant differences between the groups when comparing summary scores of ADOS-2 domains (Social Affect, Restricted and Repetitive Behavior, and Total Score). Interestingly, at the individual item level, the ADHD group exhibited a similar level of atypical behaviors compared to the ASD group in two items related to the social-communication area: "Pointing" and "Gestures". Additionally, the frequencies of "Stereotyped/idiosyncratic words or phrases", "Mannerisms", and "Repetitive interests and behaviors" also showed similarities between groups.

**Conclusion:** These findings indicate the importance of exploring and developing potential transdiagnostic domains that could be targeted for treatments specifically designed for children with ADHD.

**Keywords:** autistic spectrum disorders, attention deficit hyperactivity disorder, autism diagnostic observation schedule-2, autistic-like symptoms, social difficulties

## Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a complex neurodevelopmental disorder characterized by two main psychopathological dimensions: inattention and hyperactivity-impulsivity, causing dysfunction in various social contexts and permeating all spheres of daily life.<sup>1,2</sup>

Recent research findings have increasingly focused on investigating autistic-like symptoms in children diagnosed with ADHD. In the context of the overlap between ADHD and ASD,<sup>3,4</sup> social cognition emerges as a key factor. It encompasses shared psychological mechanisms that influence how individuals with these conditions perceive, ADHD children often struggle with social interactions, display unconventional relationship patterns, and exhibit limited social cognitive abilities.<sup>5-7</sup> Despite clear distinctions in symptom definitions and treatment approaches between Autism

Spectrum Disorder (ASD) and ADHD, both disorders share numerous impairments across various domains related to the interpretation and management of social signals.

Children diagnosed with ADHD often struggle to grasp role distinctions, perceiving themselves as equals to others. They tend to assert their opinions, exhibit a limited understanding of social rules and emotions, struggle with recognizing others' perspectives, display inflexibility, and possess underdeveloped social and non-social skills. Additionally, they may encounter repeated instances of bullying and face challenges in maintaining friendships over time.<sup>8,9</sup> A meta-analysis on social cognition, emotion recognition, and theory of mind demonstrated that the social cognition performance of individuals with ADHD was intermediate between that of ASD subjects and healthy controls, although developmental trajectories of social cognition often improve with age in most ADHD individuals.<sup>10</sup> Other studies comparing children and adolescents with ASD and ADHD demonstrate shared challenges in social cognition, spanning Theory of Mind tasks, tests of emotion recognition, and empathic capacity.<sup>11–13</sup> Overall, the distinctions between ASD and ADHD seem to be more quantitative than qualitative, with ASD showing more severe effects and ADHD holding an intermediate position between typical development and ASD.<sup>13</sup>

Despite these data, it is not always clear whether the social difficulties of children with ADHD are a consequence of this neurodevelopmental disorder or rather autistic-like symptoms. In fact, it is known that inattention and/or hyperactivity/impulsivity cause significant deterioration in academic, social-emotional, and family functioning skills.<sup>8</sup> Difficulties in executive function may result in ADHD children failing to pick up on non-verbal social cues or the feelings/emotions of others. Inattention can inhibit children's ability to notice social cues, while hyperactivity/impulsivity can lead to exaggerated behavior in social life<sup>3</sup>. ADHD core symptoms may explain behaviors such as poor adherence to playtime rules and insensitivity to peer needs.<sup>14</sup> Concurrently, deficits in executive functions have been identified in autism, including challenges in planning, organizing, and regulating behavior.<sup>15</sup> Additionally, cognitive deficits and executive function impairments may represent further overlapping aspects between autism and other related conditions.<sup>16</sup> This suggests that difficulties in higher-order cognitive processes and executive functions might be shared features, contributing to a better understanding of the commonalities between these conditions.

In the past, there has been speculation about a possible new category of neurodevelopmental disorder distinct from pure ADHD or ASD, namely ADHD-ASD overlap. In ASD patients, there is a prevalence of concurrent ADHD diagnosis ranging from 30% to 80%, while the presence of ASD in patients with ADHD is estimated to be between 20% and 50%.<sup>16</sup> The DSM-IV viewed ADHD as disparate and mutually exclusive to ASD. However, sufficient evidence has accumulated to show that these two neurodevelopmental disorders occur simultaneously to a significant extent, leading to a change in the DSM-5.<sup>6,16,17</sup> In DSM-5, only ASD has specifiers such as association with another neurodevelopmental, mental, or behavioral disorder; this identifier does not appear in the ADHD criteria. In recent years, there has been a growing effort to study the transdiagnostic aspects among ASD, ADHD, and other neurodevelopmental disorders.<sup>18,19</sup> Identifying common features that transcend specific diagnostic categories is aiding in gaining a deeper understanding of the similarities and differences among these various neurodevelopmental conditions, with the goal of developing more effective intervention strategies.

The main limitation in studying ASD symptoms in children with ADHD is the reliance on parent questionnaires or self-report measures, which may not accurately capture ASD symptoms. To address this, a direct observation tool like the Autism Diagnostic Observation Schedule (ADOS-2),<sup>20</sup> is recommended for a comprehensive assessment of ASD symptoms in children with ADHD.

The ADOS-2, considered the “gold standard” for diagnosing ASD, is a highly reliable standardized tool.<sup>20</sup> Its structured administration format, involving direct observation and rigorous training, contributes to its reliability. Tailored for both children and adults from a nonverbal mental age of 12 months, the ADOS-2 comprises five modules based on age and language proficiency. Each module includes tasks covering social, communicative, play, and stereotyped behavior, aiding examiners in assessment. ASD classification relies on algorithm scores from these tasks. In research settings, the ADOS-2 demonstrates approximately 80% specificity and sensitivity across modules.<sup>21</sup>

In this study, we analyzed the pattern of scores obtained from ADOS-2 in a group of children who were referred to ASD-specialty clinics for diagnostic assessments but subsequently were clinically diagnosed with ADHD.

This sample stands out as unique, as the majority of comparative studies comparing ASD and ADHD have predominantly used research samples instead of clinical ones. Our primary objective was to identify the specific pattern of autistic symptoms in ADHD subjects, examining both domain-level and individual item-level differences. We compared these patterns with groups of age, sex, and Intelligent Quotient (IQ)-matched children diagnosed primarily with ASD. Additionally, our goal was to investigate which symptoms were more discriminating or transdiagnostic between the ADHD and ASD.

## Materials and Methods

In this study, we enrolled 43 school-age children divided into 2 groups: the ADHD group (n=25) consisted of children initially referred for ASD symptoms but subsequently clinically diagnosed with ADHD, and the ASD group consisted of 18 children with ASD. Exclusion criteria comprised intellectual disability, neurological disorders with known causes, major physical abnormalities, severe head injuries, and current use of psychotropic drugs during clinical assessment.

The psychologists and child neuropsychiatrists at the recruiting center conducted a thorough neuropsychiatric evaluation, including the administration of the ADOS-2.<sup>20</sup> Additional neuropsychological standardized tools were also utilized during the clinical assessment, chosen based on clinical judgment. All evaluations were thoroughly reviewed in regular reliability meetings, overseen by senior researchers, and psychiatric diagnoses were determined according to DSM-5 criteria. For children initially suspected of ADHD but without an ASD diagnosis, specific standardized tests (Conners Rating Scales, SNAP-IV) were employed based on clinical indications to ensure an accurate diagnosis.

The approval for this research has been granted by the Local Ethics Committee of Azienda Ospedaliero-Universitaria Policlinico di Bari (identification code CFDADG). This study adhered to the ethical principles outlined in the Helsinki Declaration. Explicit written consent was procured from a parent/guardian for each participant in the study.

## Measures

### Autism Diagnostic Observation Scale (ADOS-2)

We used the ADOS-2,<sup>20</sup> the gold-standard standardized interviewer-rated tool for observing and assessing communication skills, social interaction, play quality, and imagination in children, to validate the clinical diagnosis. This assessment comprises standardized tasks enabling the examiner to observe behaviors pertinent to ASD diagnosis. The ADOS-2 is structured into four distinct modules (from 1 to 4). The choice of the type of ADOS-2 module to be used depends on the patient's chronological age and the degree of language evolution. According to published algorithms,<sup>22–24</sup> the Calibrated Severity Score (CSS) is computed for each participant, incorporating Total Score, Social Affect (SA), and Restricted Repetitive Behaviors (RRB) scores. Ranging from 1 to 10, CSS offers an evaluation of autism symptoms that is unaffected by age or language proficiency, making it better suited than ADOS-2 scores for assessing the severity of ASD.<sup>25</sup>

### Cognitive Assessment and Behavior Functioning

Several standardized tests were employed to assess the Intelligence Quotient (IQ) due to variations in verbal skills and functional levels among the children involved in the research. These measures included the Leiter International Performance Scale-Revised (used for nonverbal children),<sup>26</sup> and either the Italian version of the Wechsler Preschool and Primary Scale of Intelligence<sup>27</sup> Additionally, specific internalizing and externalizing problematic behaviors were evaluated through the Child Behavior Checklist (CBCL),<sup>28</sup> a questionnaire completed by the caregiver measuring a variety of behavioral problems exhibited during childhood. The CBCL has two age-adjusted versions: one for children between the ages of 1.5 and 5 years (99 items) and the other for children between the ages of 6 and 18 years (113 items).

## Statistical Analysis

Descriptive and chi-square analyses were employed to examine both categorical and continuous independent variables. Independent samples *t*-test was conducted to explore differences in IQ, age, ADOS-2 domains, and externalizing and internalizing problems among the groups. To compare ADOS scores across the groups, we focused on the presence or absence of behavioral abnormalities. ADOS-2 item scores were converted to 0 when no symptoms were detected, while scores 1, 2, and 3 were converted to 1, indicating the presence of symptoms. This method facilitated a direct comparison

of the occurrence of atypical behaviors among different groups, employing a technique akin to approaches used in other studies on neurodevelopmental disorders.<sup>25,29–31</sup> Items from different ADOS modules, as recommended by Lord et al<sup>32</sup> and outlined in Table 1, were combined for comparison. The proportions of scores indicating atypical behavior (1) and the absence of abnormality (0) in children with ADHD for each combined item were evaluated and compared with the frequency in the ASD groups, utilizing chi-square analysis to assess the distribution of atypical behavior. Statistical analyses were performed using SPSS Statistics, version 20.0 (IBM Corp., NY, United States).

## Results

The ADHD group, aged between 4 and 9 years, included 2 females (8% of the sample) and 23 males (92% of the sample). The ASD group, aged between 4 and 9 years, included 4 females (22% of the sample) and 14 males (78% of the sample). As showed in Table 2, Chi-square analysis did not reveal a significant difference on gender distribution ( $\chi^2_{(1)}=1.76$ ,  $p=0.18$ ) between the groups.

Furthermore, when examining the differences between the groups, an independent samples *t*-test revealed no significant difference for both age ( $t_{(41)}=0.03$ ,  $p=0.97$ ) and performance IQ (PIQ) ( $t_{(41)}=1.44$ ,  $p=0.15$ ). In the ADHD group module 1 was used for 5 patients (20% of the sample), module 2 for 11 patients (44% of the sample), and module 3 for 9 patients (36% of the sample); in the ASD group module 1 was used for 3 patients (17% of the sample), module 2 for 12 patients (66% of the sample), and module 3 for 3 patients (17% of the sample).

To examine potential differences among children in different groups across the domains of the ADOS-2, we conducted an independent samples *t*-test that revealed a statistically significant disparity in the summary scores of Calibrated Severity Score (CSS) ADOS domains: Social Affect (CSS-SA  $t_{(41)}=-6.95$ ,  $p<0.0001$ ), Restricted and Repetitive Behavior (CSS-RRB  $t_{(41)}=-3.03$ ,  $p=0.004$ ), and CSS-Total Score  $t_{(41)}=-7.29$ ,  $p<0.0001$ ). The ASD group scored higher than the ADHD group in all comparisons. The analysis of internalizing and externalizing symptoms measured through the CBCL in the two groups shows that the ASD group obtains higher scores in internalizing problems, while the ADHD group records higher scores in externalizing problems. However, comparison not detect statistically significant differences between the two groups (all  $p$ -values $>0.05$ ).

**Table 1** Modules 1–3: Distribution of Items Across Modules, According with Lord et al<sup>32</sup>

	<b>Module 1 Preverbal/Single Words/Simple Phrases</b>	<b>Module 2 Flexible Phrase Speech</b>	<b>Module 3 Fluent Speech Child/Adolescent</b>
<b>Pointing</b>	A7	A6	–
<b>Gestures</b>	A8	A7	A9
<b>Eye Contact</b>	B1	B1	B1
<b>Facial Expression</b>	B3	B2	B2
<b>Shared Enjoyment</b>	B5	B3	B4
<b>Showing</b>	B9	B12	B11
<b>Spontaneous initiation of joint attention</b>	B10	B6	A7
<b>Response to joint attention</b>	B11	B11	B10
<b>Quality of social overtures</b>	B12	B8	B7
<b>Stereotyped/idiosyncratic words or phrases</b>	A5	A4	A4
<b>Unusual sensory behaviors</b>	D1	D1	D1
<b>Mannerisms</b>	D2	D2	D2
<b>Repetitive interests and behaviors</b>	D4	D4	D4

**Table 2** Demographic, PIQ, ADOS-CSS and CBCL Scores Among All Groups

	ADHD Group (n 25)	ASD Group (n 18)	Statistic	p-value
Age (mean $\pm$ SD)	6.58 $\pm$ 2.42	6.56 $\pm$ 2.12	$t_{(41)}=0.03$	0.97
M:F	23:2	14:4	$\chi^2=1.76$	0.18
PIQ (mean $\pm$ SD)	103.92 $\pm$ 15.16	96.50 $\pm$ 18.58	$t_{(41)}=1.44$	0.15
ADOS-2-CSS Total (mean $\pm$ SD)	2.44 $\pm$ 1.22	6.00 $\pm$ 1.22	$t_{(41)}=-7.29$	<b>&lt;0.0001</b>
ADOS-2-CSS SA (mean $\pm$ SD)	2.16 $\pm$ 1.10	5.61 $\pm$ 2.11	$t_{(41)}=-6.95$	<b>&lt;0.0001</b>
ADOS-2-CSS RRB (mean $\pm$ SD)	4.60 $\pm$ 3.10	7.05 $\pm$ 1.69	$t_{(41)}=-3.03$	<b>0.004</b>
CBCL-Internalizing problems (mean $\pm$ SD)	58.62 $\pm$ 13	65.25 $\pm$ 9.90	$t_{(41)}=-1.72$	0.09
CBCL- Externalizing problems (mean $\pm$ SD)	62.66 $\pm$ 12.44	55.43 $\pm$ 12.87	$t_{(41)}=1.77$	0.08

**Notes:** Comparison of Socio-demographic and clinical features (CBCL and ADOS- CSS scores) between ADHD and ASD groups. Significant comparisons are highlighted in bold ( $p < 0.05$ ).

**Abbreviations:** M, male; F, female; PIQ, Performance (non-verbal) intelligence quotient; SD, Standard Deviation; ADOS-CSS- SA, Social Affect; ADOS-CSS- RRB, Repetitive Restricted Behaviour; CSS, Calibrated Severity Score.

Then at the individual item level, we compared the frequency of atypical behaviors on ADOS-2 items between groups. Table 3 compares the proportion of non-zero scorers on each ADOS-2 item between the ADHD and ASD groups. Chi-square analysis revealed that eight ADOS-2 items differentiated the two groups, in which children with ASD were endorsed significantly more frequently than the ADHD group on Eye contact (61%vs8%), Facial expressions (61% vs20%), Shared Enjoyment (61%vs12%), Showing (94%vs28%), Spontaneous initiation of joint attention (55%vs12%),

**Table 3** Distribution of Atypical Behavior (Score of 1 or More) and Statistical Comparison (Chi-Square Analysis) Between the Percentage Frequencies of Individual Scores for Each Item of the ADOS-2 Between Groups

ADOS 2 items	ADHD	ASD	$\chi^2$ (p-value)
	n (%)	n (%)	
Pointing	3 (19%)	3 (20%)	$\chi^2=0.008$ (0.93)
Gestures	10 (40%)	7 (38%)	$\chi^2=0.005$ (0.94)
Eye contact	2 (8%)	11 (61%)	<b><math>\chi^2=13.99</math> (&lt;0.0001)</b>
Facial expressions	5 (20%)	11 (61%)	<b><math>\chi^2=7.57</math> (0.006)</b>
Shared Enjoyment	3 (12%)	11 (61%)	<b><math>\chi^2=11.49</math> (0.001)</b>
Showing	7 (28%)	17 (94%)	<b><math>\chi^2=18.73</math> (&lt;0.0001)</b>
Spontaneous initiation of joint attention	3 (12%)	10 (55%)	<b><math>\chi^2=9.41</math> (0.002)</b>
Response to joint attention	9 (36%)	13 (72%)	<b><math>\chi^2=5.49</math> (0.02)</b>
Quality of social overtures	8 (32%)	16 (88%)	<b><math>\chi^2=13.73</math> (&lt;0.0001)</b>
Stereotyped/idiosyncratic words or phrases	8 (32%)	11 (61%)	$\chi^2=3.56$ (0.06)
Unusual sensory behaviors	10 (40%)	13 (72%)	<b><math>\chi^2=4.36</math> (0.03)</b>
Mannerisms	10 (40%)	12 (66%)	$\chi^2=2.97$ (0.08)
Repetitive interests and behaviors	14 (56%)	11 (61%)	$\chi^2=0.11$ (0.73)

**Notes:** Data are frequency (proportions (%)). Significant comparisons are highlighted in bold ( $p < 0.05$ ).

Response to joint attention (72%vs36%), Quality of social overtures (88%vs32%) and Unusual sensory behaviors (72% vs40%). On the other hand, ADHD children showed a percentage frequencies of ASD-like symptoms on ADOS-item that not differentiated them from ASD children, such as Pointing (19%vs20%), Gestures (38%vs40%), Stereotyped/idiosyncratic words or phrases (36%vs61%), Mannerisms (66%vs40%) and Repetitive interests and behaviors (61%vs56%), that may represent the overlapping behaviors between the two groups.

## Discussion

Given the high comorbidity (50–70%),<sup>23,33,34</sup> distinguishing a child with ASD from a child with ADHD in clinical assessment settings can be challenging for clinicians. In this study, we investigated ASD symptoms in a sample of children referred to ASD clinics who subsequently received a diagnosis of ADHD without ASD. We compared them with a similarly referred group of children who received a diagnosis of ASD. Our approach was to explore and compare autistic symptoms globally between the two groups, initially using the domain scores of the ADOS-2, then proceeding to a more specific level by analyzing scores on individual items that compose the ADOS-2.

At the global level, we compared the ADOS-2 domains between the two groups. As might be expected, we found higher composite scores on ADOS 2- Total, ADOS 2- AS and ADOS 2- RRB in the group of children diagnosed with ASD, with a significant difference compared to children diagnosed with ADHD. Our results confirmed what has been highlighted by other authors<sup>3–5</sup> in terms of social difficulties of children with ADHD, but also explored new areas of continuity between ADHD and ASD, through the use of ADOS-2. All three areas of ADOS-2, examined together, were sufficiently different between the two groups, confirming the diagnosis formulated during the specialistic evaluations, and therefore sufficiently discriminating.

At the individual level, the examination of individual scores for each item on the ADOS-2 within the two groups revealed a more pronounced occurrence of atypical behaviors in the ASD group compared to the ADHD group. These items are the ones that significantly differentiate the two groups in the present study and primarily pertain to the areas of social reciprocity (Showing, Shared Enjoyment, Spontaneous initiation of joint attention, Response to joint attention, Quality of social overtures), and to some extent, non-verbal communication (Eye contact, Facial Expression). Interestingly, the ADHD group showed similar level of atypical of behaviors compared with ASD group in two items referring to the social-communication area “Pointing” and “Gestures” which focus on the communicative and social behavior of the individual, particularly when they are in interactive situations during the assessment. These findings are in line with previous literature data highlighted impaired social communication or autistic symptoms in ADHD subjects.<sup>3,8–10,14,35–37</sup> However, it should be considered that authors who studied such topic mainly used tests administered to parents or psychopathological rating scales nonspecific for ASD symptoms.<sup>3,8,9,38</sup> Indeed, our results are similar Grzandinski and colleagues<sup>30</sup> attempted to characterize autistic symptoms in ADHD children by comparing them with ASD children using the previous version of the ADOS and ADI-R. The authors of this study focused on ASD symptoms that best discriminated between the two conditions, including only symptoms that were present in  $\geq 66\%$  of the group with an ASD and  $\leq 33\%$  of the group with an ADHD, not considering restricted and repetitive behaviors. Four ADOS items in the social communication domain (ie, amount of reciprocal social communication, quality of social overtures, unusual eye contact, and facial expressions directed towards others) were identified, while no ADI-R items met this criterion for adequate discrimination.

Other studies that pursued the same objectives were conducted on adult ADHD subjects.<sup>31</sup>

In this study, the researchers investigated the presence of ASD symptoms in adults diagnosed with ADHD using the ADOS-2. The findings reveal that around 20% of adults with ADHD who did not exhibit childhood ASD symptoms met the criteria for ASD based on their ADOS-2 scores. Notably, the analysis of domain scores showed that the higher Social Affect (SA) score was the main contributor to the elevated total ADOS-2 score, suggesting that communication and reciprocal social interaction issues were more prevalent in adults with ADHD than restricted and repetitive behaviors and interests. These results may indicate a symptom overlap between ADHD and ASD and highlight the presence of social difficulties in ADHD.

Our results suggest that, even from school age, children with ADHD exhibit differences and difficulties in certain domains of social interaction compared to those with neurotypical development. These social difficulties may not solely

be a consequence of the core symptoms of ADHD<sup>39</sup> indicating the potential need to adopt dimensional analysis to explore the etiology of neurodevelopmental disorders. Rommelse proposed a hypothetical model in which individuals with ADHD exhibit a range of social and communicative deficits, progressing towards the more severe end of the spectrum characterized by ASD, which presents as the most severe subtype with additional marked social difficulties.<sup>16</sup> Although clinically distinct, difficulties in certain domains of social communication may present transdiagnostic aspects that warrant attention for interventions not only in autism but also in ADHD. Thus, further research is needed to explore the frequency, nature, intensity, and evolution of social communication peculiarities in children with ADHD. This deeper investigation aims to gain a more detailed understanding of the boundaries and overlaps with ASD during the developmental process. Moreover, this in-depth inquiry would be particularly valuable for characterizing ASD-like traits in children with ADHD, contributing to a better understanding of the neurobiological and genetic causes of these neurodevelopmental disorders within the context of neurological development.

Another aspect of current study concerned the RRB area which, in the total score, appeared to be the least discriminating between the two groups of patients. In fact, in ADHD group, the frequencies of the “Stereotyped/ idiosyncratic words or phrases”, “Mannerisms” and “Repetitive interests and behaviors” items were similar when compared with the ASD group. This finding supported data obtained by previous studies, which emphasized that a certain number of ADHD individuals exhibited symptoms such as restricted and repetitive behaviors similar to ASD patients.<sup>30,31,40</sup> In a noteworthy study, Sokolova and colleagues<sup>41</sup> conducted a mediation analysis on a large sample encompassing both ASD and ADHD individuals. The study revealed a direct association between ASD and ADHD traits, particularly linking hyperactivity to stereotyped, repetitive behavior. This implies that individuals characterized by hyperactivity, and consequently exhibiting diminished inhibition of motor behaviors, may be more prone to engaging in various motor activities during clinical observation. These activities are often classified as stereotypic, such as flapping arms or hands in moments of excitement or displaying peculiar and rapid movements with fingers or hands. The similarity of symptoms between the two disorders aligns with recent research suggesting that, rather than being distinct, ASD and ADHD represent different manifestations of a broader and global.<sup>42,43</sup> These researchers have hypothesized the existence of a unique continuum, exploring the idea of a broader framework that encompasses the observed heterogeneity in these conditions.<sup>43</sup> This perspective is supported by common genetic and neurobiological mechanisms that underline both disorders; indeed, the observed phenotypic similarity between ADHD and ASD seems to stem, at least in part, from a shared etiological origin, especially concerning the common genetic influences on characteristics associated with both disorders. For example, individuals with ADHD and their siblings exhibit a greater number of ASD symptoms compared to non-sibling controls, indicating a shared familial connection.<sup>17</sup> Further, in the biopsychological framework of RRBs observed in autism and potentially in ADHD, there are multiple and common contributing factors.<sup>44</sup> From a neurobiological perspective, changes in neurotransmitters (such as decreased GABA, increased serotonin and glutamate), alterations in brain volume, inappropriate growth factor levels, and hypo- or hyperconnectivity among different brain regions are implicated. At the neuropsychological level, deficits in behavioral inhibition, cognitive flexibility, and response monitoring contribute to challenges in adapting to dynamic environments, fostering non-adaptive behaviors. At the behavioral level, lower-level RRBs may stem from a desire for stimulation, and environments lacking stimulation can exacerbate these behaviors. Notably, the phenomenon is not exclusively explained by stimulation; auto- or hetero-reinforcement seems to amplify the frequency of RRBs. Grasping the intricate nature of RRBs across different levels is vital for formulating effective strategies—both behavioral and pharmacological—to alleviate the frequency and intensity of this symptomatic domain. Ultimately, these interventions can improve social and familial adaptation in individuals with ASD or ADHD.

## Limitations of the Study

This study is subject to several limitations, foremost among them being the small sample size, which may have compromised the statistical power and precision of our results. It is crucial to acknowledge that our relatively modest cohort of children diagnosed with ADHD represents a specific subset within the ADHD population—specifically, those whose parents expressed sufficient concern about ASD to seek evaluation at an ASD-specialized clinic for a definitive diagnosis. Moreover, the method employed for categorizing ADOS scores as either “symptoms present” or “not present”



enables comparisons between groups in terms of symptom occurrence but does not provide data on potential differences in the actual frequency or intensity of behaviors. This additional information could be valuable for clinicians seeking to distinguish between ADHD and autism. Additional validation of subtypes is necessary, involving longitudinal tracking of the prognosis for various subtypes. This validation should incorporate comprehensive neuroimaging techniques and neurocognitive testing. The addition of the combination with the ADI-R interview should be done in the future to better discriminate symptoms between the two groups, using parent-report description and direct observation by the clinician. It is important to note that the absence of a neurotypical control group limits our ability to highlight differences between groups comprehensively. Future research with larger and more diverse samples would be essential to address these limitations and enhance the generalizability of our findings.

## Conclusion

In conclusion, our findings highlight the presence of autistic-like symptoms in children with ADHD, encompassing difficulties in functional gestures, the display of simple or complex finger/hand gestures, and the manifestation of limited and repetitive behaviors. This emphasizes the necessity to recognize that such challenges are not exclusive to ASD but also extend to ADHD. Consequently, it becomes imperative to develop more targeted and effective treatments that account for these shared features. Acknowledging the nature of social deficits and autistic characteristics within the ADHD population is crucial for tailoring treatments that are genuinely effective. Unlike the well-supported positive effects of social skills interventions for individuals with ASD, empirical evidence supporting similar interventions for young people with ADHD is limited. This underscores the importance of exploring and developing targeted treatments specifically designed for individuals with ADHD. Certain behavioral interventions, focusing on the enhancement of executive functions such as inhibitory control, problem-solving, and organization/planning, hold promise for improving the social functioning of children with ADHD. Additionally, mindfulness-based interventions have the potential to enhance attention regulation, thereby contributing to improved social functioning. In light of these considerations, future research and the development of interventions tailored to the unique needs of individuals with ADHD are essential for advancing our understanding and enhancing therapeutic outcomes.

## Ethics and Consent Statements

The study was conducted according to Local Ethics Committee of Azienda Ospedaliero-Universitaria Policlinico di Bari (identification code CFDADG), Italy. Informed consent was obtained from all subjects involved in the study.

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## Disclosure

The authors declare no conflicts of interest in this work.

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