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Research Review: Social cognition and everyday social skills in children and adolescents with attention-deficit/hyperactivity disorder: a meta-analysis of case–control studies

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Background: Previous studies that have assessed social cognition in Attention-Deficit/Hyperactivity Disorder (ADHD) have produced inconsistent findings. To summarize these data and shed light upon moderators that may explain observed inconsistencies, we conducted a systematic review and meta-analysis exploring social cognition (Theory of Mind (ToM), Empathy, Facial and Non-Facial Emotion Recognition) and Everyday Social Skills in children and adolescents with ADHD. **Methods:** The current meta-analysis involved 142 studies including 652 effect sizes. These studies compared children and adolescents with ADHD (n = 8,300) and with typical development (n = 7,983). **Results:** Participants with ADHD exhibited moderate to very large deficits in ToM (SMD = 0.84, 95% CI = 0.68–0.99), Facial Emotion Recognition (SMD = 0.63, 95% CI = 0.46–0.81), and Everyday Social Skills (SMD = 1.23, 95% CI = 1.08–1.37). The magnitude of these impairments was similar when considering effect sizes adjusted for some covariates and the methodological quality of the studies. Few studies have investigated Empathy and Non-Facial Emotion Recognition, which precludes definitive conclusions. **Conclusions:** Children and adolescents with ADHD experience robust impairments in ToM, Facial Emotion Recognition and Everyday Social Skills. Future studies should explore whether these deficits are a consequence of difficulties in other areas of cognition (e.g., executive functioning). We have made all our raw data open access to facilitate the use of the present work by the community (e.g., clinicians looking for tools, assessing social impairments, or researchers designing new studies). **Keywords:** Meta-analysis; attention-deficit/hyperactivity disorder; case–control studies; social cognition; everyday social skills.

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by inappropriate levels of inattention and/or hyperactivity-impulsivity. ADHD is one of the most common mental disorders in children and adolescents, with a worldwide estimated prevalence of 5% (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). A growing number of studies report that children with ADHD have difficulties in social functioning (Hoza, 2007; McQuade & Hoza, 2008; Nijmeijer et al., 2008; Nixon, 2001; Ros & Graziano, 2017). They may show relational difficulties with family members (Harpin, 2005), teaching staff (Ewe, 2019) and/or peers (Gardner & Gerdes, 2015; Hoza, 2007; Hoza et al., 2005; McQuade & Hoza, 2008), which can contribute to long-term negative outcomes, such as anxiety or even delinquency (Greene, Biederman, Faraone, Sienna, & Garcia-Jetton, 1997; Mrug et al., 2012).

Among the determinants of everyday social interactions, social cognition is a broad domain composed of several cognitive functions that allow individuals to process social information and interact with others (Beer & Ochsner, 2006; Happé & Conway, 2016; Scourfield, Martin, Lewis, & McGuffin, 1999). These functions include theory of mind (ToM), empathy and emotion recognition (Uekermann et al., 2010). ToM can be defined as the ability to attribute mental states to others, to explain and predict behaviors (Gallagher & Frith, 2003; Singer, 2006). Empathy can be divided into affective and cognitive components. While affective empathy refers to the ability to feel an appropriate emotion in response to another person's mental state, cognitive empathy requires the understanding of others' feelings and overlaps with ToM (Baron-Cohen, 1994; Baron-Cohen & Wheelwright, 2004; Henry, von Hippel, Molenberghs, Lee, & Sachdev, 2016). Emotion recognition can be defined as the ability to identify emotions in facial expressions and other communication cues, such as voice and body position (Graziano & Garcia, 2016; Regenbogen et al., 2012). While many studies have shown that children with ADHD experience difficulties in ToM (Berenguer, Roselló, Colomer, Baixauli, & Miranda, 2018; Bolat, Eyüboğlu, Eyüboğlu, Sargin, & Eliacik, 2016; Demirci & Erdogan, 2016; Maoz,

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Gvirts, Sheffer, & Bloch, 2019; Mary et al., 2016; Özbaran, Kalyoncu, & Köse, 2018; Şahin et al., 2018), empathy (Braaten & Rosén, 2000; Demirci, Ozmen, Kilic, & Oztop, 2016; Maoz et al., 2019) and emotion recognition (Aspan et al., 2014; Boakes, Chapman, Houghton, & West, 2007; Da Fonseca, Seguier, Santos, Poinso, & Deruelle, 2009; Parke et al., 2021; Pelc, Kornreich, Foisy, & Dan, 2006; Williams et al., 2008), many others reported small differences between groups (Airdrie, Langley, Thapar, & Goozen, 2018; Berggren, Engström, & Bölte, 2016; Charman, Carroll, & Sturge, 2001; Greenbaum, Stevens, Nash, Koren, & Rovet, 2009; Gumustas, Yilmaz, Yulaf, Gokce, & Sabuncuoglu, 2017; Günay Ay & Kılıç, 2019; Noordermeer et al., 2020; Pitzianti et al., 2017; Schwenck et al., 2013; Yang, Zhou, Yao, Su, & McWhinnie, 2009). The evidence regarding the profile of social cognitive deficits is therefore limited and it is not yet clear which functions are impaired in children and adolescents with ADHD.

Given the inconsistencies in the literature, Bora and Pantelis (2016) conducted a meta-analysis exploring ToM and emotion recognition abilities in individuals with ADHD compared with typical development. The results showed that both abilities were significantly impaired in ADHD. However, the authors did not examine effect sizes adjusted for potential confounders (e.g., age, sex, Intelligent Quotient (IQ)) nor the methodological quality of the included studies, although these variables might explain the disparity in previous results. Some studies reported differences in social cognition between individuals with ADHD and with typical development when the analyses were not adjusted for the presence of potential confounders (Boakes et al., 2007; Bolat et al., 2016; Özbaran et al., 2018). However, other studies showed no statistically significant differences when IQ was controlled for (Greenbaum et al., 2009; Gumustas et al., 2017; Yang et al., 2009). Such results suggest that confounding variables can drive part of the between-group differences on social cognition. Therefore, there is a need to conduct meta-analyses that investigate social cognition while considering the adjustment for covariates and the methodological quality of the studies.

Although studies assessing empathy in ADHD reported inconsistent results, no meta-analysis has explored the specificities of individuals with ADHD on this construct. One of the reasons that may explain this gap in the literature lie in the lack of consensus regarding differences between ToM and empathy (Happé, Cook, & Bird, 2017). Yet, robust and more recent evidence from clinical and neuroimaging studies suggests that empathy (i.e., affective empathy) and ToM (i.e., cognitive empathy) are distinct (Happé et al., 2017; Schurz et al., 2021; Singer, 2006), and that one function may be impaired while the other remains intact (e.g., individuals with ASD; Bird et al., 2010; White, Hill, Happé, & Frith, 2009). Thus, investigating empathy independently of ToM in ADHD is an important issue. Another issue is to investigate independently facial and non-facial emotion recognition, in line with recent frameworks that highlight the importance of distinguishing these two components in social cognition (e.g., Research Domain Criteria categorization; Insel et al., 2010; Sanislow et al., 2010).

Compared with mixed evidence regarding social cognition, a substantial number of studies show that children with ADHD experience important deficits in their daily social behaviors (using self−/hetero-reported questionnaires or interviews; Berenguer et al., 2018; Blackman, Ostrander, & Herman, 2005; Charman et al., 2001; Greenbaum et al., 2009; McQuade et al., 2014). Such evaluations of daily social skills do not necessarily target specific processes of social cognition but provide important information for researchers and clinicians on the severity of social impairments in daily life. This is particularly important as it is well-known that neuropsychological tasks yield different conclusions than questionnaires or interviews (Barkley & Fischer, 2011; Barkley & Murphy, 2011), notably in the social domain (Charman et al., 2001).

Here, we aimed at conducting a systematic review and meta-analysis exploring specificities of ToM, Empathy, Facial and Non-Facial Emotion Recognition in children and adolescents with ADHD when compared to typical development. As a comparison measure, we also included Everyday Social Skills (i.e., using self, parent, teacher, or clinician questionnaires/interviews of social skills) as an outcome in our meta-analysis. We considered the adjustment for potential confounders by examining adjusted and unadjusted variables separately, and we assessed the methodological quality of the included studies and investigated its impact on studies' results.

Method

The present meta-analysis was performed and reported according to current international recommendations (Higgins, Davey Smith, Altman, & Egger, 2022; Preferred Reporting Items for Systematic Reviews and Meta-analyses statement, PRISMA; Liberati et al., 2009; Page et al., 2021). The PRISMA checklist is presented in Table S1 and the a priori protocol of this meta-analysis can be found in PROSPERO (ID: CRD42021249191). Supplementary Materials 1 and 2 are available online and Supplementary Materials 3–9 are found at the following link: https://corentinjgosling.github.io/HAZA_ADHD_SOCIAL_2022/.

Search strategy

A systematic literature search was conducted on MEDLINE, PsycINFO and Embase using terms related to the following constructs: ADHD and children/adolescents and social cognition/everyday social skills. Free and controlled vocabulary was adapted for each of these databases (for search strategies, see Table S2). Two reviewers searched independently to identify relevant studies. References of selected studies and review articles were screened to find additional studies.

Eligibility criteria

The inclusion criteria were studies that (a) employed a case–control design; (b) included children and adolescents with a clinical diagnosis of ADHD in accordance with international classifications (e.g., DSM, ICD) and compared them to participants with no known psychiatric disorders; (c) included participants with an average age ranging from 5 to 19 years old; and (d) included at least one outcome assessing social cognition/everyday social skills, as defined below.

No restrictions were applied on language, publication period or publication type (e.g., scientific article, poster, master/PhD dissertation). Studies in which participants with ADHD had comorbid disorders were not excluded (for more details about the excluded studies, see Table S3). Authors were contacted for further information when the data reported were insufficient to calculate an effect size quantifying differences between children with ADHD and those with typical development (Bean, 2013; Coutinho, Farias, Felden, & Cordeiro, 2021; Deschamps, Schutter, Kenemans, & Matthys, 2015; Lázaro et al., 2019; Manteris, 2011; Tehrani-Doost et al., 2017; Temeltürk, Aydın, Güllü, & Kılıç, 2023).

Outcome measures

We transparently reported definitions and concrete examples of the categorization of our outcomes in Table S4. To summarize, included studies assessed at least one of the five following outcomes: (a) ToM; (b) Empathy; (c) Facial Emotion Recognition; (d) Non-Facial Emotion Recognition; and (e) Everyday Social Skills. ToM and Empathy included performance tasks and parents, teachers, or children questionnaires, Facial and Non-Facial Emotion Recognition included only performance tasks, and Everyday Social Skills included only self, parents, teachers, or clinician questionnaires/interviews. As most studies on emotion recognition in ADHD focused on facial emotion recognition, we did not include Non-Facial Emotion Recognition in our a priori protocol. Unexpectedly however, we located a reasonable number of studies investigating Non-Facial Emotion Recognition (n = 9). As the sole non-registered analysis, we thus added this outcome in our meta-analysis.

Study selection and data extraction

Titles and abstracts identified during systematic searches were assessed independently by the two reviewers to identify potentially eligible studies. The full text versions of potentially eligible articles were assessed independently against inclusion and exclusion criteria by two reviewers. Any conflicts were resolved by the other authors.

The following study-level data were extracted independently by the two reviewers from each of the included studies (when available): first author, year of publication, number of participants in each group, mean age (or age range, if not reported), number of girls and IQ score in each group, diagnostic procedure, percentage of each ADHD subtype, presence or absence of comorbidities in the ADHD group, recruitment procedure of the participants in each group, assessments, data allowing to estimate an effect size quantifying differences between children with ADHD and with typical development (see statistical analyses for more details) and list of covariates when authors reported adjusted statistics.

Risk of bias

To evaluate the methodological quality of the included studies, risks of bias were assessed with the Newcastle Ottawa Scale—case control studies (Wells et al., 2000), independently by two reviewers. A larger score on this scale was associated with a better methodological quality.

Statistical analyses

All analyses were conducted in the R environment (version 4.1.1) using the metafor, clubSandwich, robumeta, metaumbrella, esc, compute.es, and ggplot2 packages.

Identified studies reported a wide range of statistics allowing to estimate an effect size. Authors alternatively reported (a) raw means, and either standard deviations, standard errors or 95% confidence intervals of the two groups; (b) effect sizes quantifying the difference between the two groups (e.g., standardized mean difference and partial eta-squared); (c) t-values from Student's t-tests comparing the two groups; (d) F-values from one-way ANOVAs comparing the two groups; (e) minimum, median, and maximum values of the two groups; (f) first quartile, median, and third quartile of the two groups; (g) odds ratio and chi-square values comparing the two groups on a binary outcome (e.g., success or failure); and (h) F-values from ANCOVAs comparing the two groups while controlling for various potentially confounding variables. When authors provided none of these statistics but provided an informative plot (e.g., a bar plot displaying the means and standard errors of the two groups), the information needed to compute an effect size was extracted directly from the plot (using WebplotDigitizer; Drevon, Fursa, & Malcolm, 2017; Moeyaert, Maggin, & Verkuilen, 2016; Rohatgi, 2022). Data extraction from plots was systematically performed in duplicate, and values were averaged across raters. To convert all the input statistics into standardized mean differences (Hedges' g, SMD), we used the metaConvert tool (Gosling et al., 2024). Importantly, we chose that a larger SMD would represent lower performances/more difficulties for children with ADHD than children with typical development.

Our main analysis sought to examine differences in social cognition and everyday social skills between children and adolescents with ADHD and children with typical development. To do so, all the effect sizes were categorized according to the combination of the outcome assessed (ToM vs. Empathy vs. Facial Emotion Recognition vs. Non-facial Emotion Recognition vs. Everyday Social Skills). Many studies included more than one effect size, because of multiple outcome measures, or inclusion of several subgroups within the same study. To account for non-independence between effect sizes, we employed two approaches. Effect sizes coming from multiple subgroups were first aggregated according to the procedure described by Borenstein (2009). Dependent effect sizes coming from either multiple outcomes or reporting of both raw and adjusted effect sizes were handled by running a random-effects multivariate meta-analysis using the R packages metafor and clubSandwich (model known as subgroup correlated effects; Pustejovsky & Tipton, 2022). Because this model requires the full variance–covariance matrix to be known, we imputed it using the clubSandwich package. We assumed a mean correlation of r = .80 between all effect sizes coming from the same study. We clustered the standard errors at the study-level and we used a restricted maximum likelihood estimator. We ran a model with a diagonal variance structure (the inspection of the profile likelihood plot did not suggest large overparameterization). This model allowed estimating heterogeneity indicators (tau-squared and I^2 statistics) for each combination of outcome.

We conducted several additional analyses. First, we replicated our primary model but using effect sizes generated from adjusted statistics (e.g., adjusted Cohen's d or F-value from an ANCOVA). We did not restrict the set of covariates to specific variables (e.g., demographic variables or IQ). Second, we conducted a sensitivity analysis excluding studies at "high" risk of bias (i.e., retaining only studies with a good methodological quality). We considered a study as at high risk of bias if

(a) the diagnosis of ADHD was not based on a research-validated procedure (e.g., if it was based on a questionnaire, or if no information was given on the diagnostic process) or was not made by a health care specialist and (b) the groups were not matched for both age and IQ. Then, we estimated the presence of small-study effects using the Nakagawa et al. (2022) method, and using the Egger's funnel plot asymmetry test (Egger, Smith, Schneider, & Minder, 1997) independently for each outcome (using the metaumbrella R package, Gosling, Solanes, Fusar-Poli, & Radua, 2023). In addition, we assessed the effect of the type of publication (scientific article vs. dissertation). Last, we assessed the effect of the type of tool used (performance tasks vs. questionnaires) only for ToM, because it was the only outcome that included performance tasks and questionnaires in more than 15 studies. It should be noted that several meta-regressions were conducted but did not reveal important moderators. We did not report the results of these analyses for parsimony.

Data and code availability

Code supporting data analysis, raw data and full results are publicly shared (https://corentinjgosling.github.io/HAZA_ADHD_SOCIAL_2022/).

Results

Search results and characteristics of the studies

The initial search yielded 8,002 results and 249 full texts were reviewed. Overall, 142 unique studies, including 152 independent samples (8,300 children and adolescents with ADHD and 7,983 children and adolescents with typical development), were included in the meta-analysis. Figure 1 depicts the search flow diagram, Table S5 presents the characteristics for the included studies and Table S3 the reasons for exclusions for each study.

The 142 included studies (reported in 127 scientific articles, 12 dissertations and 3 posters) generated a total of 652 effect sizes, assessing group differences about ToM (k Unadjusted = 161; k Adjusted = 19), Empathy (k Unadjusted = 25; k Adjusted = 6), Facial Emotion Recognition (k Unadjusted = 168; k Adjusted = 20), Non-Facial Emotion Recognition (k Unadjusted = 25; k Adjusted = 3) and Everyday Social Skills (k Unadjusted = 209; k Adjusted = 16). Table 1 and Supplementary Results 6 depict the number of studies, participants and effect sizes included.

Main analyses

As shown in Figure 2 and in Supplementary Results 7 and 8, results pooling unadjusted effect sizes showed that children with typical development performed better than children with ADHD on the five social outcomes: (a) ToM: SMD = 0.84, 95% CI = 0.68–0.99, $p < .001$; (b) Empathy: SMD = 0.56, 95% CI = 0.10–1.03, $p = .18$; (c) Facial Emotion Recognition: SMD = 0.63, 95% CI = 0.46–0.81, $p < .001$; (d) Non-Facial Emotion Recognition: SMD = 0.31, 95% CI = 0.02–0.60, $p = .32$; and (e) Everyday Social Skills: SMD = 1.23, 95% CI = 1.08–1.37, $p < .001$. We showed moderate—but no statistically significant—pooled effect sizes for Empathy and Non-Facial Emotion Recognition. However, the number of studies was small ($n < 12$).

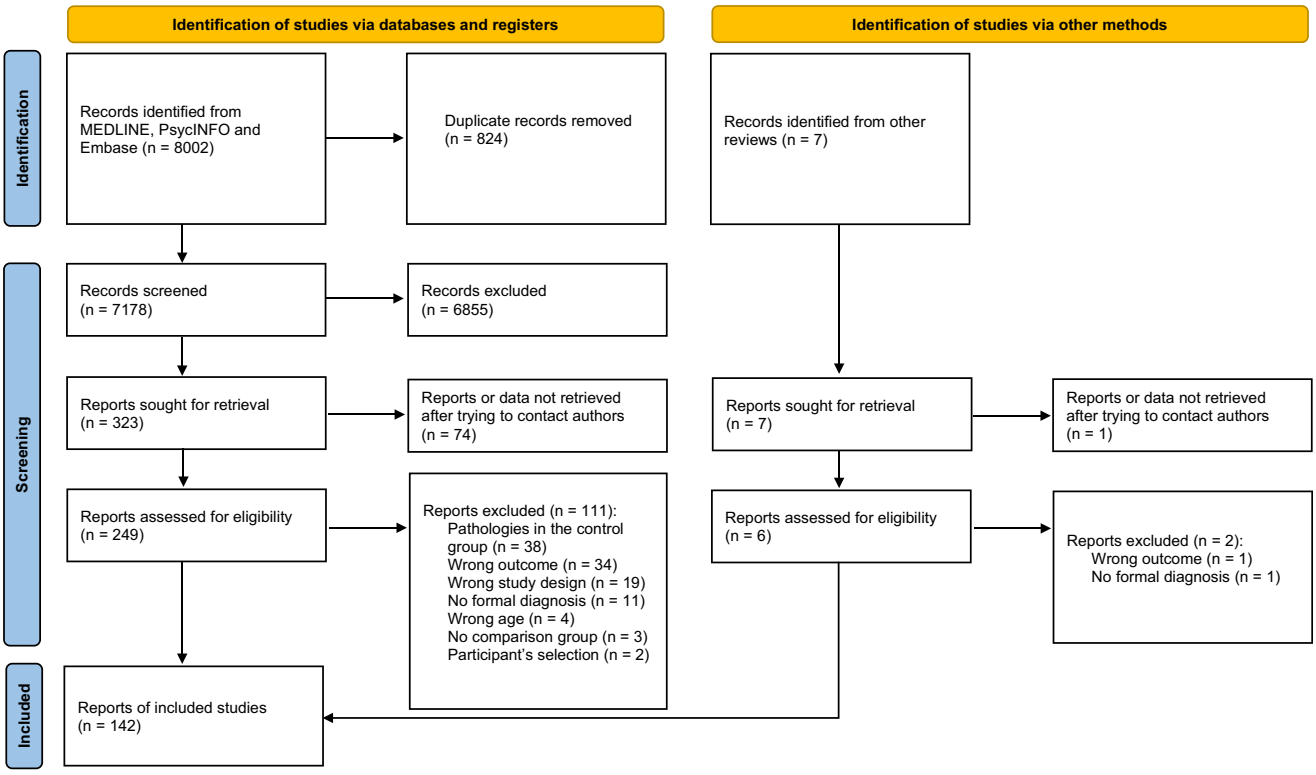

Figure 1 Flow diagram of study selection, as specified by the PRISMA statement (Page et al., 2021)

Table 1 Number of studies, effect sizes and participants for each adjusted and unadjusted outcome

Outcome	Adjustment of effect sizes	Number of studies (number of effect sizes)	Number of participants	
			ADHD	Typical development
ToM	Unadjusted	49 (161)	2,284	2,165
	Adjusted	8 (19)	258	290
Empathy	Unadjusted	12 (25)	436	480
	Adjusted	3 (6)	71	80
Facial emotion recognition	Unadjusted	42 (168)	1,712	1,657
	Adjusted	7 (20)	442	571
Non-facial emotion recognition	Unadjusted	8 (25)	381	326
	Adjusted	2 (3)	141	254
Everyday social skills	Unadjusted	82 (209)	5,570	5,200
	Adjusted	9 (16)	607	519

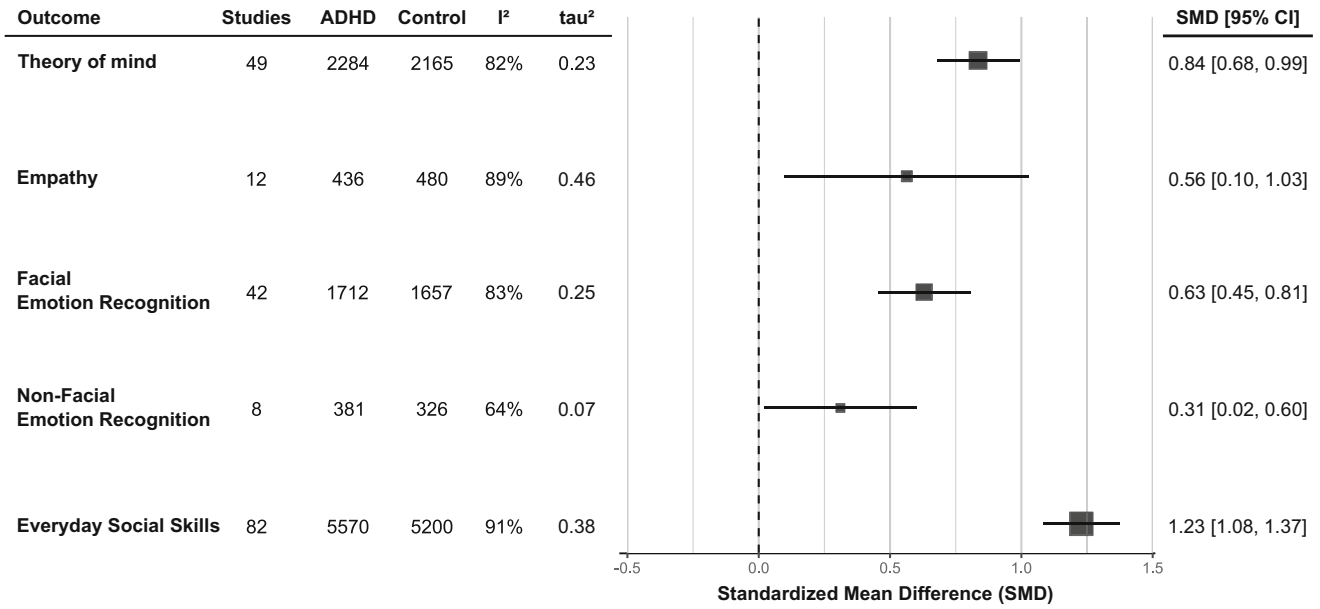

Figure 2 Forest plot of the five unadjusted outcomes (Theory of Mind, Empathy, Facial Emotion Recognition, Non-Facial Emotion Recognition and Everyday Social Sills). For each outcome, we provided the following information: the number of included studies, the number of participants in the ADHD and control groups, and the heterogeneity indicators (I^2 statistics and tau-squared). We also indicated the Standardized Mean Differences (SMD) comparing children in the ADHD and control groups, along with their corresponding 95% confidence intervals (95% CI)

The tau^2 and I^2 values for each of the comparisons tended to indicate the presence of a high heterogeneity for all outcomes: (a) ToM: $I^2 = 81.74\%$, $tau^2 = 0.23$; (b) Empathy: $I^2 = 89.36$; $tau^2 = 0.46$; (c) Facial Emotion Recognition: $I^2 = 83.45$; $tau^2 = 0.25$; (d) Non-Facial Emotion Recognition: $I^2 = 63.55$, $tau^2 = 0.07$; and (e) Everyday Social Skills: $I^2 = 91.23$, $tau^2 = 0.38$.

Additional analyses

Adjustment for covariates. When pooling effect sizes adjusted for covariates, the results were similar than when they were not adjusted: (a) ToM: SMD = 0.85, SE = 0.15, $p < .001$; (b) Empathy: SMD = 0.70, SE = 0.43, $p = .24$; (c) Facial Emotion Recognition: SMD = 0.53, SE = 0.21, $p < .05$; (d) Non-Facial Emotion Recognition: SMD = 0.17, SE = 0.03, $p = .11$; and (e) Everyday Social Skills: SMD = 1.42, SE = 0.20, $p < .001$. For more details, see Supplementary Results 9.1.

Risk of bias. We found that 14.08% of the included studies gave very little information about the diagnosis. Moreover, 53.52% of the included studies did not control for age and IQ by using matching procedures. Indeed, 45.77% of the studies included matching procedures for age, but only 11.97% used matching procedures for IQ. Overall, 59.16% of the studies were excluded from this analysis because they were considered to have a high risk of bias (i.e., they gave very little information about the diagnosis procedure and/or they did not use matching procedures for age and IQ). As shown in Supplementary Results 9.2, the results were similar to our main results when excluding studies with high risk of

bias: (a) ToM: SMD = 0.90, SE = 0.13, $p < .001$; (b) Empathy: SMD = 0.81, SE = 0.46, $p = .15$; (c) Facial Emotion Recognition: SMD = 0.77, SE = 0.15, $p < .001$; (d) Non-Facial Emotion Recognition: SMD = 0.30, SE = 0.21, $p = .29$; and (e) Everyday Social Skills: SMD = 1.39, SE = 0.12, $p < .001$.

Small-study effects. The Nakagawa et al. (2022) approach showed a statistically significant small-study effect across outcomes ($p < .05$). However, on a more nuanced note, we found that the PhD dissertations yielded effect sizes at least as large as those from journal articles, in both social cognition outcomes and everyday social skills. For more details about these results, see Supplementary Results 9.3 and 9.4.

Type of tools. The effect of the type of tool used was assessed for ToM. As shown in Supplementary Results 9.5, we found that the type of tool was a probable moderator of group differences in ToM (Performance tasks: SMD = 0.78, SE = 0.08; Questionnaires: SMD = 1.26, SE = 0.23), although the difference did not reach statistical significance (SMD = 0.48, SE = 0.23, $p = .08$).

Discussion

The aim of this systematic review and meta-analysis was to quantify the differences between children and adolescents with ADHD and with typical development in social cognition and everyday social skills. For the first time, we synthesized group comparisons that were both adjusted and unadjusted for potentially confounding variables, and we assessed the methodological quality of previous studies. Our findings suggest that children with typical development had higher performances on ToM, Facial Emotion Recognition and Everyday Social Skills than children with ADHD. Although we also found higher performances in Empathy and Non-Facial Emotion Recognition, the group differences were not statistically significant. Critically, results were similar when considering adjusted and unadjusted effect sizes and when excluding studies with low methodological quality. Overall, our study allows us to confirm the robustness and importance of the social deficits experienced by children and adolescents with ADHD.

Our meta-analysis shows that differences between children with ADHD and with typical development were significant for Facial, but not Non-Facial Emotion Recognition. This finding suggests that difficulty processing emotions might be specific to facial expressions, which is congruent with atypical face scanning patterns reported in children with ADHD (Airdrie et al., 2018; Muszkat et al., 2015). In addition, our results showed that group differences were significant for ToM, but not Empathy. A possible explanation for this finding is that ToM and Empathy do not require the same cognitive demands. Empathy is considered to be an automatic, spontaneous, and fast response with minimal consciousness. By contrast, ToM is described as a more complex function that requires supplemental attention and cognitive resources (Yu & Chou, 2018), which are precisely reduced in ADHD (Seidman, 2006; Sjöwall, Roth, Lindqvist, & Thorell, 2013; Sjöwall & Thorell, 2022; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). We conclude that, while Facial Emotion Recognition and ToM are robustly impaired in ADHD, skills in Non-Facial Emotion Recognition and Empathy are more inconsistent in that condition. However, in our data, the lack of significance might still be explained by the limited number of studies conducted on Non-Facial Emotion Recognition and Empathy. Future studies investigating these domains are needed to support our conclusions.

We showed that Everyday Social Skills present a large effect size. This confirms the view that ADHD is associated with robust difficulties in social functioning (Hoza, 2007; McQuade & Hoza, 2008; Nijmeijer et al., 2008; Nixon, 2001; Ros & Graziano, 2017). In addition, these results highlight the high ecological validity of indirect measures in ADHD (e.g., questionnaires). In line with this view, we showed that performance tasks assessing ToM tended to produce smaller group differences than questionnaires. Previous works suggest that performance tasks probably capture less complex information than everyday life situations. For example, Barkley (Barkley, 2015; Barkley & Fischer, 2011; Barkley & Murphy, 2011) showed that rating scales of executive functions better predict adaptive and daily life functioning than neuropsychological tasks. Conclusions about the social functioning of individuals with ADHD may thus vary depending on the methods of assessment used. Our work underlines the need for using different types of tools (e.g., observation, interviews, questionnaires, tests) when assessing social functioning of children with ADHD in clinical practice.

The present systematic review and meta-analysis comes with notable strengths. First, we are the first to synthesize the field of social functioning in children and adolescents with ADHD while considering the methodological quality of the studies and whether confounding variables were accounted for. Other strengths were, for example, the comprehensiveness of our search strategy, leading to the inclusion of both published and unpublished research (i.e., articles, posters, and dissertations), and the methodological rigor of our approach (our protocol was registered a priori, all the selection of studies and data extraction was done in duplicate). Finally, in line with the open-access philosophy, our data analysis R script is publicly available.

Our meta-analysis also reveals several weaknesses in current research on social functioning in ADHD. First, it is noteworthy that our analyses were run on

averages of patient characteristics and that the outcomes included in this meta-analysis showed great heterogeneity among participants. It would be an error (i.e., an "ecological bias") to apply such results to individual profiles (Berlin, Santanna, Schmid, Szczech, & Feldman, 2002; Riley, Lambert, & Abo-Zaid, 2010). We thus encourage authors of future studies to share individual data to conduct meta-analyses on individual participant data (IPD). Second, the diagnosis procedure was often inconsistent. Some studies included children with ADHD who were previously formally diagnosed, while others used interviews, observation, and/or parent or teacher questionnaires in the inclusion procedure. However, we tried to limit the impact of this variable by excluding all studies that presented children with subthreshold symptoms or no formal diagnosis. Third, only 15 studies reported the presence of children with ASD comorbidity. Given that this does not exclude the presence of ASD comorbidity in all other studies, this prevented us from exploring the effects of this variable. It is crucial that future studies exploring social cognition in people with ADHD systematically report the presence of an ASD comorbidity in their sample.

Finally, a major question remains unanswered to date: are the social difficulties a direct consequence of ADHD or are they comorbid with other core ADHD symptoms? One may argue that social difficulties are inherent to other cognitive impairments (e.g., attention or executive difficulties; Barkley, 2015; Mary et al., 2016; Sinzig, Morsch, & Lehmkuhl, 2008), rather than a specific difficulty in social cognition. Our results show that the differences between children with ADHD and those with typical development were similar when effect sizes were adjusted for at least one critical covariate, including IQ. However, the limited number of studies that enabled us to compute adjusted effect sizes (ToM: $n = 8$; Empathy: $n = 3$; Facial Emotion Recognition: $n = 7$; Non-Facial Emotion Recognition: $n = 2$; Everyday Social Kills: $n = 9$) precludes drawing definitive conclusions about the link between IQ and social cognition. Studies investigating the specificity of social challenges among other cognitive functions (e.g., executive functioning) are emerging (Gosling et al., 2023) and constitute a very promising research direction.

Conclusion and clinical implications

Our findings show that children and adolescents with ADHD have deficits in ToM, Facial Emotion Recognition and Everyday Social Skills, three domains that warrant clinical attention. These deficits appear when considering both adjusted and unadjusted effect sizes and when excluding studies with low methodological quality. Limitations in the current research prevent to draw a firm conclusion about Empathy and Non-Facial Emotion Recognition. More studies are needed to delve deeper into this question.

Social cognition deficits can explain some difficulties encountered by children with ADHD in daily life interactions (Uekermann et al., 2010). However, contrary to the large number of interventions targeting specific social cognition components in ASD (Fletcher-Watson, McConnell, Manola, & McConachie, 2014; Gosling et al., 2022), psychosocial interventions for children with ADHD mostly focus on social impairments in daily life (Mikami, Smit, & Khalis, 2017). Based on our findings, a promising research direction will be to develop (or adapt) interventions targeting the different components of social cognition in people with ADHD.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Table S1. PRISMA checklist.

Table S2. Search strategy.

Acknowledgements

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Data availability statement

The data that support the findings of this study are openly available at https://corentinjgosling.github.io/HAZA_ADHD_SOCIAL_2022/.

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Key points

- Previous studies showed mixed results about social cognition impairments in Attention Deficit/Hyperactivity Disorder (ADHD).
- We conducted a meta-analysis including 142 unique studies comparing children and adolescents with ADHD on key components of social cognition and on everyday social skills.
- Large and robust group differences were found on Theory of Mind, Facial Emotion Recognition and Everyday Social Skills. These differences were of similar magnitude when considering effect sizes generated from statistics adjusted for some confounding variables, or studies with a high methodological quality.
- All social domains warrant clinical and research attention in children and adolescents with ADHD. It is important for authors of future studies to share their raw data to enable meta-analyses on individual participant data.

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