Social Cognition in ADHD: A Meta-Analysis

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Abstract

Background: Cumulative evidence has revealed differences in social cognition (SC) between people with and without ADHD. These SC difficulties in people with ADHD were confirmed in Emotion Recognition (ER) and Theory of Mind (ToM) through a meta-analysis in 2016. Since then, numerous studies on the SC in ADHD have been published. Despite findings suggesting SC differences between people with and without ADHD, results are heterogenous in regard to the size of SC differences, the persistence of deficits after childhood, sex differences and social cognitive domains affected. The current meta-analysis updates previous findings.

Method: A total of 32 studies published between 2015 and 2023 was examined. SC in individuals with and without ADHD is compared in the form of overall SC, ER and ToM. Further, the potential moderators sex and age were investigated. Children, adolescents and adults with (n=3080) without (n=4557) ADHD were included.

Results: This review was generally in line with previous research since overall SC differed significantly between the groups with a medium-sized effect (d=-0.63). Both, ER and ToM were significantly affected as well, with differences in ER being less profound (d=-0.23), and ToM differentiating the groups most clearly (d=-0.86). No significant sex differences were detected. An age comparison indicated that SC difficulties are evident in children and adolescents, but become less pronounced in adulthood (adults: d= -0.78 vs. underaged: d= -0.39).

Discussion and Conclusion: Findings indicate that screenings and interventions for individuals with ADHD should be tailored to SC difficulties. Moreover, future research should systematically explore the role of comorbidities on SC.

Keywords: Social cognition, Theory of Mind, ToM, Emotion recognition AND ADHD, Attention-Deficit/ Hyperactivity Disorder

Lay Summary

Many studies have investigated whether people with ADHD experience difficulties in social cognition. This systematic review aimed to find out whether people with and without ADHD differ from each other in this domain. Social cognition is an umbrella term for different aspects of one's understanding of and navigation within the social environment. It includes the ability to recognize that other people have mental states, thus, that others' thoughts and intentions might differ from one's own (Theory of Mind). Other measures of social cognition include recognizing emotions in faces (Emotion Recognition) and inferring what a person might be thinking (mentalizing). Overall, this meta-analysis found that people with ADHD have significant difficulties with social cognition tasks compared to people without the condition. These differences are larger for younger individuals, thus, adults with ADHD perform almost comparable to adults without ADHD. This finding can have implications for people affected, for professional support providers, as well as for family members.

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Introduction

Globally, approximately 5.3% of children meet the diagnostic criteria for Attention-deficit/Hyperactivity Disorder (ADHD), and even more depict some of the symptoms below the clinical threshold (Faheem et al., 2022). This makes ADHD one of the most common neurodevelopmental disorders worldwide (Bolat et al., 2017). ADHD is described in the 5th Edition of the Diagnostic and Statistical Manual of Mental Disorders as a lasting pattern of inattention and/or hyperactivity-impulsivity that interferes with daily functioning or a person's development (DSM-5, 2013). More specifically, three presentations of the neurodevelopmental condition are specified. Firstly, the combined presentation, meaning inattentive *and* hyperactive-impulsive symptoms, secondly, the predominantly inattentive presentation and lastly, the primarily hyperactive-impulsive presentation of ADHD.

Still, the majority of individuals with ADHD function comparably well in daily life, but its long-term course between persons can vary (Bora & Pantelis, 2016). Some symptoms are known to decrease with age in most people, such as hyperactivity and impulsiveness, whereas other aspects like difficulties with sustained attention and executive functioning often persist (Aydin, 2021). Hence, daily life struggles of this population can, amongst others, include difficulties with prolonged concentration, with planning, or organizational demands.

Despite these traditional symptoms of ADHD, the disorder is also associated with differences in the social domain (Thoma et al., 2020). Many children and some adults with ADHD experience functional deficiencies linked to the processing of social information. These are reflected in poorer social skills and can increase interpersonal conflicts, difficulties with developing peer relationships, emotion dysregulation and social rejection (Parke et al., 2021). Thus, some individuals with ADHD face hurdles to successfully navigate within their social environment. The processing of and reaction to social information is guided by a person's social cognition. Social cognitive abilities can be seen as a prerequisite for social interactions (Mehren et al., 2021).

The term social cognition (SC) refers to cognitive processes involved in the perception and understanding of social information. These processes allow people to engage qualitatively with their social environment and help us make sense of the social world (Seyfarth & Cheney, 2015). SC describes a range of social capabilities like interpreting others' emotions and attributing mental states to them. Two subdomains of SC have been thoroughly investigated in relation to ADHD, namely emotion recognition (ER) and Theory of Mind (ToM) (Pitzianti et al., 2017). ER refers to recognizing and understanding another person's emotion from their face, voice, or body posture. ToM describes the ability to acknowledge that other's mental states - such as beliefs, desires, or feelings - differ from one's own, and to comprehend and predict others' behaviour on the basis of these mental states (Bora & Pantelis, 2016).

Profound deviations in social cognition are a widely established finding in Autism Spectrum Disorder (ASD). However, ToM and ER difficulties became a common finding in people with ADHD as well, as demonstrated by Bora & Pantelis' (2016) meta-analysis on this matter. Still, the evidence is heterogenous in regard to the severity and scope of SC differences between people with and without ADHD. Findings on possible sex differences are variable, as well as differences in distinct domains of SC, such as ToM and ER. Also, the question of to what extent these difficulties persist throughout the lifespan is of particular interest. So far, findings hint into the direction of a decrease in SC difficulties with increasing age (Bora & Pantelis, 2016). Clear findings on this matter are further complicated by the high rate of comorbidities in ADHD (Thoma et al., 2020). Frequent comorbidities include amongst others Oppositional Defiant Disorder, Conduct Disorder, ASD, Disruptive Mood Dysregulation Disorder, and Specific Learning Disorder (DSM-5, 2013). Since many common comorbidities of ADHD such as Conduct Disorder and ASD are shaped by deviant social behaviour, they have to be taken carefully into account since it is hard to disentangle the role of ADHD from comorbidities' role on SC difficulties. Still, this remains challenging, since the majority of individuals with ADHD have psychiatric comorbidities.

So far, the link between ADHD and social cognitive difficulties has been established and summarized in Bora & Pantelis' meta-analysis. They found that the performance of people with ADHD on social cognition tasks lies between the one of people with ASD and neurotypical individuals. Since the publication of the meta-analysis in 2016, numerous experimental studies on the matter of social cognition in ADHD have been published. Thus, there is a demand for a meta-analytic update on this matter.

Empirical knowledge on social cognitive difficulties in people with ADHD needs to be up-to-date in order to draw scientific and practical conclusions. Further, the cumulated insights into the nature, scope, and development of potential social cognition differences in this population contribute to the prevention of potential severe negative consequences. Unfavourable side-effects of poor SC abilities include interpersonal conflicts, peer rejection, loneliness and so forth (Jusyte, Gulewitsch & Schönenberg, 2017; Levi-Shachar et al., 2021). Therefore, a systematic update of SC differences in people with and without ADHD bears an essential value in updating our scientific knowledge on the issue.

To establish this goal, this meta-analysis investigated social cognition differences as a whole, and separately in the form of ToM and ER in participants with and without ADHD. Moreover, the potential moderating role of age is explored, in that children and adolescents with and without ADHD are compared to adults with and without the disorder. Lastly, investigating sex as a potential moderator tackles possible differences between females and males. Therefore, scientific papers published between 2015 and 2023 were collected and examined according to specific inclusion criteria. Based on Bora & Pantelis (2016) review, it is expected that the ADHD groups' performance on SC tasks is significantly poorer than the one of the non-ADHD group. More specifically, ER and ToM are predicted to differentiate significantly between the study and non-ADHD group. Further, an age effect is to be expected, with children and adolescents having more difficulties in SC than adults. Lastly, sex differences are difficult to predict and might be minimal, due to the variable outcomes of previous literature.

Methods

Study selection

The study selection of this meta-analysis was guided by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines from 2020. The databases PsycINFO and PubMed were used for the literature research. Since this paper attempts to update the meta-analysis by Bora & Pantelis (2016) which included articles until July 2015, this search only included articles published between August 2015 and September 2023. The language filters applied were English and

German. The following keywords were used to search for articles: Social Cognition, mentalizing, Theory of Mind, ToM, emotion recognition, emotion perception, *and* ADHD or Attention-Deficit/ Hyperactivity Disorder. This filtered search yielded 199 results in total, with 185 papers on PsycINFO and 13 papers on PubMed, this is illustrated in the PRISMA flowchart (Appendix A).

The step-by-step screening procedure of study inclusion and exclusion entailed three major steps: screening for broad content match, searching for retrieval, and specifically assessing a study's eligibility with previously formulated inclusion criteria. More precisely, in the first step, animal studies were excluded and secondary sources were ruled out. Additionally, studies published in 2015 were excluded if released before August. Further, the studies' titles and abstracts were screened for broad content match regarding ADHD and social cognition. The database PubMed was searched first, hence, the first screening step of PsycINFO also included the deletion of duplicates, meaning, studies that were already found through PubMed. Subsequently, the remaining studies' retrievability was inspected in the second step. If access to a source was not granted, I contacted the authors of the study. In cases where access was still not permitted, studies were excluded due to lacking retrievability. Lastly, step three of the screening procedure entailed a more thorough examination of the papers' eligibility with the inclusion criteria. Studies were included in this meta-analysis if they met the following conditions: (i) Social cognition was examined in the form of ToM, mentalizing, emotion recognition, or emotion perception abilities. Moreover, (ii) sufficient quantitative data was provided in the papers so that effect sizes are calculatable. Since the program Review Manager (Version 5.3) was used for data analysis, mean, standard deviation and sample size per group were necessary for the calculation of the mean effect size per study. Thirdly, (iii) social cognition abilities of people with ADHD were compared to the ones of people without ADHD. Finally, (iv) social cognition was measured experimentally, instead of merely through a self- or other-report questionnaire. After the last screening step, 32 studies remained. Namely, 29 PsycINFO and three PubMed studies met the criteria for inclusion in this meta-analysis. The flowchart in Appendix A displays the screening steps of this systematic review visually. Besides, Appendix C depicts a reference list of the 32 studies included in this meta-analysis. Moreover, Table 1 provides an overview of participant characteristics and instruments used to measure social cognition. More precisely, participants are described with regard to age, sex, ADHD and non-ADHD, and comorbidities.

Table 1. Participant characteristics.

Authors, Year	***Matching and Comorbidities (included/excluded)***	***Sample size: ADHD Non-ADHD***	***Age of participants (in years)***	***Sex of participants***	***Measure(s) of Social Cognition***
Aydin et al., 2022	Non-matched Excluded if Substance Use Disorder (SUD), mental retardation, neurocognitive disorder (i.e. Traumatic Brain Injury (TBI), Alzheimer's Disease), comorbid mental disorder (i.e. Major Depressive Disorder (MDD), Anxiety Disorder)	40 ADHD All Inattentive-type 42 non-ADHD	19-37 ADHD M= 23.1 Non-ADHD M= 21.7	ADHD 23 male 17 female Non-ADHD 22 male 20 female	ToM/ER: RMET
Basile et al., 2021	Non-matched Excluded if ASD diagnosis	39 ADHD, 42 Non-ADHD	8-12 ADHD M = 10 Non-ADHD M = 9 years and 11 months	ADHD 27 male 12 female Non-ADHD 27 male 15 female	Emotion recognition (ERT)
Bednarz et al., 2021	Non-matched Excluded if IQ lower than 70, no driving license, vision inaccurate, comorbid ASD, severe mental disorder (i.e. schizophrenia), epilepsy, intellectual disability, Tourette, history of TBI, currently on antipsychotics, anticonvulsants, benzodiazepines, or chemotherapy agents	17 ADHD 18 Non-ADHD	16-30 ADHD M= 19.99 Non-ADHD M= 20.32	ADHD 12 male 5 female Non-ADHD 11 male 7 female	ToM and SC: -Intention Causality task -ToM Computer Task (TCT)
Berenguer et al., 2018	Age- and IQ-matched Excluded if neurological or genetic disease, brain lesions, visual/auditory/motor impairments, ASD	35 ADHD (without ASD) 37 Non-ADHD	7-11 ADHD M= 9.41 Non-ADHD M= 8.54	ADHD 32 male 3 female Non-ADHD 23 male	ER: NEPSYII

				14 female	
Bolat et al., 2017	Sex-matched Controls Note: High comorbidity rate.	96 96	ADHD 48 -> 8-11 21 ->12-15 Non-ADHD 46 -> 8-11 -> 12-15	48 male, 21 female In both groups (matched)	Basic and advanced ToM: UOT ToM Tasks
Ciray et al., 2021	Age- and sex-matched Excluded if medical illness potentially impairing normal development, ASD diagnosis, mental retardation, epilepsy, brain injury, cerebral palsy, medications interfering with normal development	70 ADHD 64 Non-ADHD	12-17	ADHD 51 male 19 female Non-ADHD 46 male 18 female	ToM: Faces test RMET Faux Pas UOT Comprehension Test
Dan et al., 2020	Non-matched Excluded if psychopathology symptoms, taking medication that could interfere with study, comorbidity of other neurological or psychiatric disorder at present or in the past.	15 ADHD 16 HC	18-30 ADHD M= 23.47 Non-ADHD M= 26.88	All male	EP/ ER: Facial Emotion Expression Morph task
Demirci & Erdogan, 2016	Age- and sex-matched Excluded if IQ below 85, comorbid psychiatric condition like ASD, neurological disorder, vision problems, conduct problems	60 ADHD 60 Non-ADHD	8-15 ADHD M= 10.8 Non-ADHD M= 10.8	ADHD 35 male 25 female Non-ADHD 35 male 25 female	ER: RMET BFRT
Demirci et al., 2016	Age- and sex-matched Excluded if IQ below 85, Oppositional Defiant Disorder (ODD), Obsessive-Compulsive	40 ADHD 16 combined 13 inattentive 11 hyperactive	7-18	All male (matched)	ER/ToM: RMET -for children -for adolescents

	Disorder (OCD), abnormal cortisol levels/thyroid function, history of neurological-, metabolic-, or endocrinological disease, SUD, neurological condition (like epilepsy), head trauma, organic brain disorder	40 Non-ADHD			
Gumustas et al., 2017	Age- and sex-matched Excluded if IQ below 80, unstable or chronic medical illness, history od head trauma, epilepsy, ASD, psychosis, anxiety disorder, oppositional defiant disorder, mood disorder	65 ADHD 61 Non-ADHD	8-14 ADHD M= 10.86 Non-ADHD M= 11.21	ADHD 53 male 12 female Non-ADHD 46 male 15 female	ER: DANVA-2
Helfer et al., 2021	Non-matched. Excluded if intellectual impairment, psychiatric comorbidities, using psychoactive substances, current depression, MDD, Bipolar Disorder, addiction disorder, schizophrenia, antisocial personality disorder, anxiety with panic attacks, psychosis, (hypo-)mania	43 ADHD 46 Non-ADHD	Not provided. ADHD M = 37.16 Non-ADHD M = 29.37	ADHD 27 male 16 female Non-ADHD 20 male 26 female	ER: FERT
Kalyoncu et al., 2019	Non-matched Excluded if IQ below 80, significant medical condition (i.e. epilepsy), ASD, learning disability, specific reading disorder, any depressive disorder, any anxiety disorder, substance abuse at least once	151 ADHD Combined= 51 Inattentive= 50 ADHD+Conduct Disorder= 50 100 Non-ADHD	11-18	ADHD 152 male 35 female ***BUT****: participants could fall into more than one ADHD sub-category.* Non-ADHD 41 male 59 female	ToM/ER: RMET FERT UOT
Kilincel et al., 2021	Education- & age-matched Excluded if neurological disorder, psychiatric disorder, intellectual disability, SUD, using	42 ADHD 41 Non-ADHD	12-16	ADHD 22 male 30 female	ToM: -Smarties Test -Ice Cream Truck Test -Faux Pas

	medication within last 3 months (methyphenidate, antidepressant, benzodiazepine, antipsychotics)			Non-ADHD 23 male 18 female	-Child Eyes Tests
Kis et al., 2017	Age-, sex-, and education-matched Excluded if neurological, neuropsychological or psychiatric comorbidity (esp. MDD, SUD)	28 ADHD 13 inattentive, 15 combined 29 Non-ADHD	ADHD 20-47 M= 33.8 Non-ADHD 19-57 M= 36.5	ADHD 18 male 10 female Non-ADHD 14 male 15 female	EP/ER/ToM: TAB
Kuijper et al., 2017	IQ-matched Excluded if IQ below 75, low- or non-verbal (unable to produce full sentences). Comorbid ASD <u>included</u>.	34 ADHD 18 combined, 10 hyperactive, 6 inattentive 36 Non-ADHD	6.1-12.10 ADHD M= 8.92 Non-ADHD M= 8.92	ADHD 28 male 6 female Non-ADHD 25 male 11 female	ToM: False Belief Task
Kuijper, 2021	Non-matched Excluded only for task-related reasons (i.e. if too many items on test left out), ASD not an exclusion criterion	36 ADHD 19 Combined 6 inattentive 12 Hyperactive 38 Non-ADHD	6.1-12.10 (years, months) ADHD M=8.9 Non-ADHD M=9.0	ADHD 30 male 6 female Non-ADHD 25 male 13 female	ToM: False Belief Task
Levy et al., 2023	Non-matched Excluded if intellectual disability, language disorder, ASD, OCD, psychosis, Bipolar Disorder	236 ADHD, 68 sub-threshold ADHD, 128 Non-ADHD	6-14 ADHD M = 9.7 Non-ADHD M = 11	ADHD 177 male 59 female Sub-threshhold 40 male 28 female	ToM: RMET

				Non-ADHD 79 male 49 female	
Maoz et al., 2019	Non-matched Excluded if estimated IQ below 80, MDD, Bipolar Disorder, psychosis, SUD, conduct disorder, any neurological or medical condition, taking medication	24 ADHD 36 HC	6-12 ADHD M= 10.28 Non-ADHD M= 9.37	ADHD 16 male 8 female Non-ADHD 19 male 17 female	ToM: Faux Pas Test
Mohammadzadeh et al., 2020	Age-, sex-, IQ-, family SES- and education-level-matched	30 30	7-9 Matched	30 male No female Matched	ToM: ATT (Intentionality, Appropriateness)
Noordermeer et al., 2020	Age-, sex-, IQ-matched Excluded if IQ below 80, ASD, Anxiety disorder, MDD, epilepsy, general learning difficulties, brain disorders, genetic disorders, ODD	82 82	Not provided. ADHD M= 16.3 Non-ADHD M= 16.1	67 male 15 female Matched	ER: IFE
Parke et al., 2021	ADHD (both subtypes) Non-matched controls Excluded from ADHD group if comorbid ASD, TBI or other neurological condition	25 16 combined, 9 inattentive-type 25	7-13 ADHD M = 10.57 Non-ADHD M= 10.07	ADHD 19 male 6 female Non-ADHD 15 male 10 female	ER/ToM: NEPSY-II -Affect Recognition -ToM
Pitzianti et al., 2017	Non-matched Excluded if IQ below 85, psychiatric comorbidities, history of neurological or psychiatric disease, learning disability, taking medication known to affect CNS	23 ADHD 10 combined 13 inattentive 20 Non-ADHD	7-15 ADHD M= 10.39 Non-ADHD M= 9.10	ADHD 14 male 9 female Non-ADHD 11 male 9 female	ToM, ER: NEPSY-II

Quintero et al., 2020	Non-matched Excluded if any comorbidity (in ADHD-without-comorbidity group), IQ lower than 70, SUD.	31 ADHD 25 Non-ADHD	Not provided. ADHD M= 41.71 Non-ADHD M= 43.64	ADHD 14 male 17 female Non-ADHD 11 male 14 female	Emotion Perception: MSCEIT -Perceiving Emotions -Understanding Emotions
Serrano et al., 2018	Non-matched No specific exclusion criteria	19 ADHD 26 Non-ADHD	8-12 ADHD M= 9.16 Non-ADHD M= 9.77	ADHD 15 male 4 female Non-ADHD 12 male 14 female	ER: POFA Speed and accuracy
Sevincok et al., 2021	Non-matched Excluded if ASD, Bipolar Disorder, mental retardation, SUD, psychosis, conduct disorder, specific learning disorders, any medical or neurological condition, psychotropic medication 3 less than month prior to study	50 ADHD 40 Non-ADHD	8-14 ADHD M=10 Non-ADHD M=10.3	ADHD 43 male 7 female Non-ADHD 34 male 6 female	ToM: First-order ToM Second-order ToM RMET UOT
Sjöwall & Thorell, 2019	Non-matched Excluded if IQ below 70, cannot withdraw from medication 24h prior to testing	52 ADHD 72 Non-ADHD	4-6 ADHD M= 5.92 Non-ADHD M= 5.52	ADHD 40 male 12 female Non-ADHD 40 male 32 female	ER: ERT
Staff et al., 2021	Non-matched Excluded if IQ lower than 70, ASD, conduct disorder, or took psychotropic medication during last month	83 ADHD 30 Non-ADHD	6-12 ADHD M= 8.34 Non-ADHD M= 8.20	ADHD 68 male 15 female Non-ADHD 13 male 17 female	ER: MFERT

Tatar & Cansiz, 2022	Age-, sex-, and education-matched Excluded if psychosis, Bipolar Disorder, severe neurological pathology (like epilepsy), physical disease, current major depression, current SUD, severe suicidal ideation, pervasive developmental disorders, intellectual disabilities	40 40	Adults ADHD M= 21.72 Non-ADHD M= 21.75	18 female 22 male Matched	ToM: RMET
Thoma et el., 2020	Non-matched? Excluded if (suspected) ASD, neurological disorder, HC (but not ADHD group) excluded if BDI higher than 13 (at least mild depression)	19 ADHD 20 Non-ADHD	Not provided. ADHD M= 36.2 Non-ADHD M= 36.7	ADHD 9 male 10 female Non-ADHD 10 male 10 female	Mentalizing: Mentalistic Interpretation Task
Wells, 2019	Only comorbidity-matched (matched on number of non-ADHD clinical disorders) Excluded if any major neurological, sensory or motor impairment, non-stimulant medication during testing, seizure disorder, psychosis, intellectual disability, ASD, reading comprehension below cut-off (min. 70% correct)	35 ADHD 29 Non-ADHD	8-13 ADHD M=10.29 Non-ADHD M=10.58	ADHD 22 male 13 female Non-ADHD 16 male 13 female	ER: Facial Affect Recognition
Wells, 2021	Non-matched Excluded if marked motor, sensory or neurological impairment, non-stimulant medication during testing, intellectual disability, psychosis, seizure and ASD	42 ADHD 26 Combined 13 Inattentive 3 Hyperactive 35 Non-ADHD	8-13 ADHD M= 10.32 Non-ADHD M= 10.63	ADHD 26 male 16 female Non-ADHD 19 male 16 female	ER/ EP: Emotion Inference Task

Özbaran et al., 2018	Sex-, and age-matched Excluded if psychiatric disorder other than ODD, learning disorder, neurological or serious medical disease, no psychotropic drug or stimulant use within last 6 months	100 100 ADHD: 50 inattentive 50 Combined	11-17	59 male 41 female matched	ToM/ ER: RMET Faces Test UOT

ADHD vs. non-ADHD group characteristics

A total of 32 studies investigating social cognition in people with and without ADHD were examined, 3 identified through PubMed and 29 through PsycINFO. Altogether, N = 3080 participants with and N = 4557 people without ADHD were included. The age span varied from children to adults, ranging from 4-year-olds to elderly adults. 22 studies investigated social cognition in children and/or adolescents, whereas six adult studies examining adults were incorporated in this meta-analysis. The remaining studies investigated large age spans, covering several age groups like adolescents and adults (i.e. Bednarz et al., 2021), without reporting separate results per age. Furthermore, not all, but some studies provided information on the ADHD presentation, however, too few papers reported the outcomes stratified per ADHD-presentation for a moderation analysis of this variable. In sum, if reported, the proportion of ADHD presentation included appears representative of the ADHD-population (DSM-5, 2013), since a majority of participants in the ADHD group had a predominantly inattentive- or combined ADHD presentation, and a minority with a hyperactive/impulsive presentation was included.

Measurement of Social Cognition

Social cognition was examined through various tasks on distinct sub-domains. Namely, studies covered measures of ToM, facial emotion recognition, emotion perception, and mentalizing. Different tests and assessments were utilized in the studies to operationalize these aspects of SC. Most commonly, emotion recognition was examined through reading emotions from faces visually, whereas mentalizing performance was captured through movie and interpretation tasks. ToM most often involved outcomes on traditionally used ToM tasks, such as the False-Belief task or the Reading-the-mind-from-the-eyes test. The following table provides an overview of the tasks that papers included in this meta-analysis used to capture social cognition, along with the abbreviation of each test (Table 2).

Table 2. List of abbreviations: Measures of Social Cognition in the included studies.

Social Cognition domain	***Abbreviation***	***Name of test***	***Specification***
Mentalizing, ToM	ATT	Animated Triangles test	
ToM	ESCoT	The Edinburgh Social Cognition Test	
ToM	FBT	False Belief Task	
ToM	FPT	Faux Pas Test	
Advanced ToM	HT	Hinting Test	
Mentalizing, ToM	MASC	Movie for Assessment of Social Cognition	
Mentalizing, ToM	MIT	Mentalistic Interpretation Task	
ToM	SO-FBT	Second-order-False belief task Also called: Ice cream Truck test	
ToM	RMET	Reading Mind in the Eyes Test	
ToM	-	Smarties Test	
Advanced ToM	UOT	Unexpected outcomes test	
Emotion Recognition (ER)	AP	Affective Prosody	
Facial ER	FT	Faces Test	
Facial ER	FERT	Facial emotion recognition	
Facial ER	MFERT	Morphed Facial Emotion Recognition Task	
Facial ER	IFE	Identification of Facial Emotions	
Facial ER	-	Dynamic Morph Task	
ER	MSCEIT	Mayer-Salovey-Caruso Emotional Intelligence Test	> Subscales: emotion perception and understanding emotions
ER/ Emotion Perception (EP)	TAB	Tübinger Affect Battery	> Part 1
ER	CERT	Children’s Emotion Recognition Task	
ER	BFRT	Benton Face Recognition Test	
ER	POFA	Pictures of Facial Affect	
Facial ER	DANVA-2	Diagnostic Analysis of Non-verbal Accuracy-2	
ER	NEPSY-II	Development Neuropsychological Assessment-II	Subscale 1
Facial ER	NEPSY-II	Development Neuropsychological Assessment-II	Subscale 2

Statistical analyses

Effect sizes of SC in people with and without ADHD were captured for emotion recognition, emotion perception, ToM, and mentalizing. Access to Review Manager 5.3, a program specialized in systematic reviews, was used for statistical analysis through the desktop of the University of Groningen. For each of the 32 studies, one mean effect size was calculated. To be able to calculate and compare effect sizes in Review Manager, means, standard deviations, and sample sizes of the ADHD and non-ADHD group need to be provided. Some studies covered several measures of SC and thus, reported more than one outcome. In that case, means and standard deviations had to be averaged, so that only one value per study was used. This way, effect size and Confidence Interval per study can be directly compared to each other. Besides the effect size per study, an overall mean effect size of the social cognition difference between the ADHD and the neurotypical group was calculated including all studies. Moreover, effect sizes for ToM and ER differences were reported separately.

Furthermore, the moderation of age and sex was investigated through separate comparisons. For sex, potential differences were computed between male and female only, since no data on diverse participants was provided. Three studies were included for the comparison of sex across groups. The statistical analysis of the effect of age entailed comparing underaged participants as well as adult participants to one another. Thus, children and adolescents with and without ADHD, and adults with and without ADHD were compared. Hence, two mean effect sizes per age group were gathered. For this analysis, the age span of three to 18 was used to include minors in the child and adolescent group, and participants of 18 or above were included in the adults' comparison. Studies reporting results across these age spans had to be excluded from this comparison. 22 studies compared children and adolescents with ADHD to those without, whereas six studies compared adults with and without ADHD to each other.

Table 3. Mean social cognition effect size per study (ER, ToM and total SC).

Study	Test	ADHD Non-ADHD	95% CI	Cohen's d (and Significance)	Participant's age in years	Size of effect
Basile et al., 2021	ER	39 42	[-0.39, 0.48]	0.05 (not significant)	8-12	Small
Berenguer et al., 2018	NEPSY-II -ER	35 37	[-1.68, -0.67]	-1.17 (significant)	7-11	Large
Dan et al., 2020	ER	15 16	[-1.06, 0.36]	-0.35 (not significant)	18-30	Small
Gumustas et al., 2017	DANVA-2 -FERT	65 61	[-0.67, 0.04]	-0.32 (not significant)	8-14	Small
Helfer et al., 2021	FERT	43 46	[-0.83, 0.01]	-0.41 (not significant)	ADHD: M=37.17 Non-ADHD: M= 29.37	Small
Kis et al., 2017	TAB -ER	28 29	[-0.91, 0.13]	-0.39 (not significant)	ADHD: 20-47 Non-ADHD: 19-57	Small
Noordermeer et al., 2020	FERT	78 78	[-0.54, 0.09]	-0.23 (not significant)	ADHD: M= 16.3 Non-ADHD: M= 16.1	Small
Quintero et al., 2020	ER EP	31 25	[-0.38, 0.67]	0.14 (not significant)	ADHD, M= 41.71 Non-ADHD, M= 43.64	Small
Serrano et al., 2018	FERT	19 26	[-1.00, 0.20]	-0.40 (not significant)	8-12	Small
Sjöwall & Thorell, 2019	ER	52 72	[0.07, 0.80]	0.44 (significant, ADHD better)	4-6	Small
Staff et al., 2022	MFERT	83 30	[-0.57, 0.27]	-0.15 (not significant)	6-12	Small

Study	Test	ADHD Non-ADHD	95% CI	Cohen's d (and significance)	Participant's age in years	Size of effect
Wells, 2019	ER	35 29	[-0.57, 0.42]	-0.08 (not significant)	8-13	Small
Wells, 2021	ER	42 35	[-0.83, 0.07]	-0.38 (not significant)	8-13	Small
Total ER (k=13)	**All pure ER tasks.**	**565** **526**	**[-0.44, -0.03]**	**-0.23 (significant)**	**Child-adult**	**Small**
Aydin et al., 2022	RMET	40 42	[-0.48, 0.39]	-0.05 (not significant)	19-37	Small
Bednarz et al., 2021	ToM	17 18	[-0.29, 1.04]	0.38 (not significant)	16-30	Small
Bolat et al., 2017	ToM UOT	69 69	[-1.26, -0.56]	-0.91 (significant)	8-11, 12-15	Large
Demirci et al., 2016	RMET	40 40	[-3.41, -2.16]	-2.79 (significant)	7-18	Large
Kilincel, 2021	Faux Pas	42 41	[-3.24, -2.05]	-2.64 (significant)	12-16	Large
Kuijper et al., 2017	FBT -FB1, FB2	34 36	[-0.98, -0.03]	-0.50 (significant)	6-12	Medium
Kuijper, 2021	FBT -FB1, FB2	36 38	[-1.06, -0.13]	-0.60 (significant)	6-12	Medium
Levy et al., 2023	RMET	236 128	[-0.76, -0.32]	-0.54 (significant)	6-14	Medium
Maoz et al., 2019	Faux Pas	24 36	[-1.33, -0.26]	-0.80 (significant)	6-12	Large
Mohammadzadeh et al., 2020	ATT -ToM	30 30	[-1.46, -0.39]	-0.93 (significant)	7-9	Large
Parke et al., 2021	ToM	25 25	[-1.27, -0.13]	-0.70 (significant)	7-13	Medium

Study	Test	ADHD Non-ADHD	95% CI	Cohen's d (and significance)	Participant's age in years	Size of effect
Tatar & Cansiz, 2022	RMET	40 40	[-1.47, -0.54]	-1.01 (significant)	ADHD: M= 21.72 Non-ADHD: M= 21.75	Large
Thoma et al., 2020	MIT -MIT1, -MIT2	19 20	[-0.82, 0.44]	-0.19 (not significant)	ADHD: M= 36.2 Non-ADHD: M= 36.7	Small
Total ToM (k=13)	**All pure ToM tasks.**	**652** **563**	**[-1.25, -0.47]**	**-0.86 (significant)**	**Child-adult**	**Large**
Ciray et al., 2022	FT RMET Faux Pas UOT CT	70 64	[-0.65, 0.03]	-0.31 (not significant)	12-17	Small
Demirci & Erdogan, 2016	RMET BFRT	60 60	[-2.05, -1.22]	-1.64 (significant)	8-15	Large
Kalyoncu et al., 2019	RMET FERT UOT	151 100	[-1.98, -1.40]	-1.69 (significant)	11-18	Large
Pitzianti et al., 2017	ToM ER	23 20	[-0.74, 0.46]	-0.14 (not significant)	7-15	Small
Sevincok et al., 2021	FO-ToM SO-ToM RMET UOT	50 40	[-1.02, -0.17]	-0.59 (significant)	8-14	Medium
Özbaran et al., 2018	RMET FT UOT	100 100	[-1.61, -1.00]	-1.30 (significant)	11-17	Large
TOTAL SC (k=32, all studies)	**See above.**	**3080** **4557**	**[-0.85, -0.40]**	**-0.63 (significant)**	**Child-adult**	**Medium**

Note: Negative values for Cohen's d indicate a better performance of the non-ADHD group.

Moderators

Table 4. Sex - Male vs. female (across groups)

Study	**Test**	**Male** **Female**	**95% CI**	**Cohen's d (and significance)**	**Participant's age in years**	**Size of effect**
Basile et al., 2021	ER	55 26	[-0.69, 0.24]	-0.23	8-12	Small
Gumustas et al., 2017	DANVA-2-FERT	99 27	[-0.39, 0.46]	0.04	8-14	Small
Staff et al., 2022	MFERT	81 32	[-0.45, 0.37]	-0.04	6-12	Small
TOTAL	**-**	**235** **85**	**[-0.32, 0.18]**	**-0.07**	**6-14**	**Small**

Note: Negative values for Cohen's d indicate a better performance of female participants.

Age – Children/Adolescents vs. Adults

Table 5. Age - Children/Adolescents (4-18 years).

Study	**Test**	**ADHD** **Non-ADHD**	**95% CI**	**Cohen's d (and Significance)**	**Participant's age in years**	**Size of effect**
Basile et al., 2021	ER	39 42	[-0.39, 0.48]	0.05 (not significant)	8-12	Small
Bolat et al., 2017 *Children*	ToM UOT	48 46	[-1.38, -0.52]	-0.95	8-11	Large
Bolat et al., 2017 *Adolescents*	ToM UOT	21 23	[-1.34, -0.12]	-0.73	12-15	Medium

Study	Test	ADHD Non-ADHD	95% CI	Cohen's d (and Significance)	Participant's age in years	Size of effect
Ciray et al., 2022	FT RMET Faux Pas UOT CT	70 64	[-0.65, 0.03]	-0.31 (not significant)	12-17	Small
Demirci & Erdogan, 2016	RMET BFRT	60 60	[-2.05, -1.22]	-1.64 (significant)	8-15	Large
Demirci et al., 2016	RMET	40 40	[-3.41, -2.16]	-2.79 (significant)	7-18	Large
Gumustas et al., 2017	DANVA-2 -FERT	65 61	[-0.67, 0.04]	-0.32 (not significant)	8-14	Small
Kalyoncu et al., 2019	RMET FERT UOT	151 100	[-1.98, -1.40]	-1.69 (significant)	11-18	Large
Kilincel, 2021	Faux Pas	42 41	[-3.24, -2.05]	-2.64 (significant)	12-16	Large
Kuijper et al., 2017	FBT -FB1, FB2	34 36	[-0.98, -0.03]	-0.50 (significant)	6-12	Medium
Kuijper, 2021	FBT -FB1, FB2	36 38	[-1.06, -0.13]	-0.60 (significant)	6-12	Medium
Levy et al., 2023	RMET	236 128	[-0.76, -0.32]	-0.54 (significant)	6-14	Medium
Maoz et al., 2019	Faux Pas	24 36	[-1.33, -0.26]	-0.80 (significant)	6-12	Large
Mohammadzadeh et al., 2020	ATT -ToM	30 30	[-1.46, -0.39]	-0.93 (significant)	7-9	Large
Parke et al., 2021	ToM	25 25	[-1.27, -0.13]	-0.70 (significant)	7-13	Medium
Pitzianti et al., 2017	ToM ER	23 20	[-0.74, 0.46]	-0.14 (not significant)	7-15	Small

Study	**Test**	**ADHD Non-ADHD**	**95% CI**	**Cohen's d (and Significance)**	**Participant's age in years**	**Size of effect**
Serrano et al., 2018	FERT	19 26	[-1.00, 0.20]	-0.40 (not significant)	8-12	Small
Sevincok et al., 2021	FO-ToM SO-ToM RMET UOT	50 40	[-1.02, -0.17]	-0.59 (significant)	8-14	Medium
Sjöwall & Thorell, 2019	ER	52 72	[0.07, 0.80]	0.44 (significant, ADHD better)	4-6	Small
Staff et al., 2022	MFERT	83 30	[-0.57, 0.27]	-0.15 (not significant)	6-12	Small
Wells, 2019	ER	35 29	[-0.57, 0.42]	-0.08 (not significant)	8-13	Small
Wells, 2021	ER	42 35	[-0.83, 0.07]	-0.38 (not significant)	8-13	Small
Özbaran et al., 2018	RMET FT UOT	100 100	[-1.61, -1.00]	-1.30 (significant)	11-17	Large
TOTAL Children/Adolescents	-	**1360** **1159**	**[-1.06, -0.49]**	**-0.78 (significant)**	**4-18**	**Medium to large**

Table 6. Age - Adults (18+ years).

Study	Test	ADHD Non-ADHD	95% CI	Cohen's d (and Significance)	Participant's age in years	Size of effect
Dan, 2020	ER	15 16	[-1.06, 0.36]	-0.35 (not significant)	18-30	Small
Helfer, 2021	FERT	43 46	[-0.83, 0.01]	-0.41 (not significant)	ADHD M=37.16 Non-ADHD: M=29.37	Small
Kis, 2017	TAB -ER	28 29	[-0.91, 0.13]	-0.39 (not significant)	ADHD: 20-47 Non-ADHD: 19-57	Small
Quintero, 2020	ER EP	31 25	[-0.38, 0.67]	0.14 (not significant)	ADHD: M=43.64 Non-ADHD: M=41.71	Small
Tatar & Cansiz, 2022	RMET	40 40	[-1.47, -0.54]	-1.01 (significant)	ADHD: M=21.72 Non-ADHD: M=21.75	Large
Thoma, 2020	MIT -MIT1, -MIT2	19 20	[-0.82, 0.44]	-0.19 (not significant)	ADHD: M=36.2 Non-ADHD: M=36.7	Small
TOTAL Adults	**-**	**176** **176**	**[-0.71, -0.06]**	**-0.39 (significant)**	**Adults**	**Small**

Results

Social Cognition, Emotion Recognition and Theory of Mind

Social Cognition

The total of 32 studies yielded a mean weighted effect size of d = -0.63 for the comparison of social cognition in ADHD and non-ADHD (Table 3). The negative sign of the effect size indicates a worse performance of the ADHD group on social cognitive tasks. The corresponding forest plots for all comparisons can be found in the Appendix (Appendix B: A-F). All ToM and ER measures across sex and age groups are included in this overall outcome. This resulting effect size is significant with a 95% Confidence Interval (CI) of [-0.85, -0.40] and depicts a medium effect. The corresponding test for overall effect ($Z = 5.40$, $p < 0.00001$) was therefore significant as well. Besides, a significant heterogeneity was evident, with a high $I^2 = 89\%$ for $Chi^2 = 291.36$, df = 32 ($P < 0.00001$), suggesting a substantial heterogeneity among the studies included. The effect sizes of the 32 studies included ranged from small to large. 15 out of these 16 study's effect sizes indicated a significantly better performance of the non-ADHD group, whereas only one study found a significantly higher outcome of the ADHD group on measures of social cognition.

Emotion Recognition

Overall, the ADHD group performed significantly worse on pure emotion recognition tasks compared to the non-ADHD group. The effect was small (d = -0.23) with a 95% CI of [-0.44, -0.03]. Thus, emotion recognition could differentiate participants with ADHD from those without ADHD, however, the effect size is smaller than the mean effect size of overall social cognition. The heterogeneity of the emotion recognition comparison between the studies is statistically significant and they are moderately heterogenous with $Tau^2 = 0.09$, $Chi^2 = 32.60$ with df = 12 ($P = 0.001$) and $I^2 = 63\%$. In the analysis of emotion recognition, 13 studies that reported data on ER tasks only were included. This comprised 565 participants with and 526 without ADHD. Both sexes were included and age varied from childhood to adulthood.

Theory of Mind

Participants with ADHD also performed worse on ToM tests compared to those without ADHD, with a large significant effect size (d = -0.86) and a corresponding 95% CI of [-1.25, -0.47]. The overall effect of ToM was larger than the one of ER and the mean effect size of social cognition. Hence, ToM reached the largest significant effect in this meta-analysis. A high, statistically significant heterogeneity between the studies that investigated ToM was present with $Tau^2 = 0.44$, $Chi^2 = 111.19$ with df = 12 ($P < 0.00001$) and $I^2 = 89\%$. Accordingly, studies on ToM were highly variable. The analysis of ToM entailed a set of 13 studies that examined pure ToM, meaning that no measures of other aspects of social cognition were included in the outcome. 652 participants were in the study group and 563 in the non-ADHD group and again, both sexes and all age groups were included (Table 3).

Moderator Age

Children and Adolescents vs. Adults

Both group comparisons, the adults' as well as the children/adolescents' comparison revealed significant differences between the ADHD and the non-ADHD group on SC tasks. A trend for an age effect is apparent (minors d= -0.78 vs. adults: d= -0.39), with a larger effect between people with and without ADHD in the underaged group comparison. In particular, the effect size of the difference between children/adolescents with and without ADHD was medium to large (d = -0.78). This effect was also significant with a 96% CI of [-1.06, -0.49]. The adult comparison, on the other hand, revealed a small significant effect (d = -0.39) with a 95% CI of [-0.71, -0.06]. As for the other mean effect sizes, the negative sign indicates a better performance of the neurotypical group. Hence, a larger difference was found between younger participants with and without ADHD, than between older participants with and without ADHD. Participant's age in the underaged group ranged from four-18 years, whereas the adults were above 18 years old. The sample was larger for the younger group and comprised 1360 minors with and 1159 without ADHD, compared to 176 adults in both, the ADHD and the non-ADHD group. Moreover, the heterogeneity was significant for both, the minor as well as the adult's comparison. Heterogeneity for the children/adolescents' comparison was high with Tau^2 = 0.44, Chi^2 = 248.28 with df = 23 ($P < 0.00001$) and I^2 = 91%. The heterogeneity in the adult sample was lower, but also significant with Tau^2 = 0.09, Chi^2 = 11.02 with df = 5 ($P = 0.05$) and I^2 = 55%.

Moderator Sex

Female vs. Male

No significant differences in social cognition across groups were observed between female and male participants. The insignificant effect size (d = -0.07) was very small with a 95% CI of [-0.32, 0.18]. The negative sign of the effect size suggests a very slight trend for higher social cognition scores of female participants. The insignificant heterogeneity for the comparison of social cognition between sexes is minimal or absent with Tau^2 = 0.00, Chi^2 = 0.70 with df = 2 ($P = 0.70$), and I^2 = 0%, suggesting a relatively homogenous set of studies in this analysis. The study sample was small, with only three studies considered for the moderator sex. Overall, 235 male and 85 female participants were included in the comparison. However, it is important to note that a majority of studies included in this meta-analysis, but excluded for the comparison of sex, did report the absence of a statistically significant difference of sex between the ADHD and the non-ADHD group qualitatively. Still, no quantitative results stratified for sex were provided in these studies, which is why the comparison analysis of sex only included data from three studies.

Discussion

The aim of this meta-analysis was to systematically compare people with and without ADHD on their social cognition abilities. The overarching number of studies (K= 185) published on PsycINFO on this particular subject since the meta-analysis of Bora and Pantelis in 2016 reflects the growing interest in the issue of SC in ADHD. Altogether, the results of this meta-analysis align closely with this previous meta-analysis, with only minor deviations. This meta-analysis found a slightly larger effect size of overall social cognition in people with and without ADHD than Bora and Pantelis found in 2016. Also, both, ToM and ER were significant in this review, which aligns with the outcomes of the previous meta-analysis. Besides, this paper found more pronounced SC differences between younger participants with and without ADHD, than between adults with and without the disorder. Similarly, Bora and Pantelis found evidence for an age effect, suggesting that social cognitive differences become less pronounced with increased age. Hence, this meta-analysis provides confirmatory information for this, suggesting that SC differences between individuals with ADHD and without ADHD are likely less distinctive when they get older.

In sum, this paper provided cumulative evidence that overall social cognition performance of individuals with ADHD was significantly poorer than the non-ADHD group. Moreover, both, emotion recognition (ER) and Theory of Mind (ToM) capabilities differed significantly between the groups, with a poorer outcome of the ADHD group. The group difference in social cognition tasks taken together was medium in comparison to the non-ADHD group. The significant effect (d = -0.63) of this difference in SC abilities is larger, but comparable to the one found previously (d = -0.44, Bora & Pantelis, 2016) which was also of medium size. Between-group differences in emotion recognition accuracy were less pronounced than overall SC and revealed a small significant effect. The difference in ToM abilities of the ADHD sample compared to the neurotypical one, however, was large. Hence, ToM was the measure of social cognition that differentiated between study and non-ADHD group the best. Even though, both, ER and ToM are sub-domains of social cognition, the size of their effect differed markedly when comparing the two groups. This difference is genuine, since the statistical analyses of the two domains had an equal sample size of studies (k=13) and both presented a statistically significant heterogeneity between those studies. Interestingly, the previous review did not indicate a noticeable difference between ER and ToM tasks in differentiating ADHD- versus non-ADHD participants (Bora & Pantelis, 2016). Thus, this meta-analysis suggests that measures testing ToM (Table 2) potentially differentiate better between people with and without ADHD than other social cognition tasks, such as ER. Therefore, in practice, administering ToM tests might be most informative to verify whether an individual with ADHD may benefit from interventions tailored to social cognition deficiencies.

In addition to ToM and ER, the moderators age and sex were examined. The comparison between underaged participants in the ADHD and neurotypical group was significant with a medium to large effect size. The significant effect size comparing adults with and without ADHD however, was only small. This lower effect of the SC difference between the adult group is in line with the previous meta-analysis. Bora and Pantelis (2016) also found a small effect size for the adults' comparison, as opposed to a medium effect for the comparison of children with and without ADHD (underaged d= 0.52 vs. adults d= 0.22). Thus, it appears that SC performance of children with ADHD differs from non-ADHD children's performance more than SC between adults with and without ADHD. Hence, the difficulty of the ADHD sample in SC may become less pronounced with increasing age. Still, adults with ADHD might face some SC difficulties as indicated by the small but significant effect found in this meta-analysis. However, these difficulties in adults with ADHD appear to be less profound since their SC performance approximates the one of people without ADHD.

Furthermore, the moderator sex compared males and females across both groups to each other. The very small, insignificant effect should be considered in the context of the small sample size of three studies. However, a majority of studies included in this meta-analysis, which did *not* provide quantitative data on sex differences, did describe insignificant differences between females and males in-text. Thus, it appears plausible that sex differences could be minimal or absent, however, more studies need to be investigated to explore this. It has been reported that social difficulties do not merely affect males, but also females with ADHD (Kok et al., 2016). Despite qualitative differences in social cognition between boys and girls with ADHD, this meta-analysis could have provided insight into potential *quantitative* differences. This finding would have shed light on the size of the possible SC differences between boys and girls with ADHD. Thus, an interpretable outcome on present or absent quantitative sex differences could have provided insight into the detection and screening of social cognition difficulties in boys and girls with ADHD. Yet, no significant quantitative difference in SC was observed between the sexes in this review. Even though, in general, insignificant outcomes should not be disregarded, one should be careful with drawing conclusions based on this comparison. Rather than indicating an absence of sex differences, this comparison illustrates that more data is needed to make meaningful inferences on potential quantitative sex differences in social cognition in ADHD.

Strengths and limitations

The strengths of this meta-analysis cluster mainly around its adding value to research and practice, and its transparency in reporting the data. This meta-analysis replicated and confirmed the previous review by Bora and Pantelis (2016) and established findings that update the previous literature. More so, this paper indicates that the SC differences in people with and without ADHD might be larger than presumed in previous literature, as indicated by the slightly larger overall effect size. Hence, subsequent research might focus less on investigating the presence of SC differences and more towards testing the effectiveness of different SC trainings for this population. Similarly, in practice, with this meta-analytic update on SC difficulties in ADHD, the focus might shift from the mere identification of potential SC difficulties in ADHD patients towards more widely applied interventions tailored to these SC deficiencies. Thus, this paper emphasizes and updates the actuality of the issue in theory and practice.

In addition, all quantitative outcomes are presented transparently and per study in this meta-analysis, which is not necessarily the case for systematic reviews. This way, the contribution of each study to the overall effect size can be understood and retraced. Also, the data provided is then accessible for both, further calculations and its incorporation in future research. This adds further to the value of this meta-analysis, since conclusions can firstly, be based upon the evident findings of this review, and secondly, the reported data could be used for further investigations. One could for example, use the data provided in this meta-analysis to combine it with the previous research findings to explore its cumulative outcomes.

Nevertheless, this meta-analysis also bears several limitations. Firstly, the exploration of sex differences is limited. Too few studies were included in the comparison between females' and males' performance to draw meaningful conclusions. Therefore, the comparison of potential sex differences is of limited usefulness. However, this issue emphasizes the importance of reporting data for males and females separately. Interestingly, many papers commented on the absence of a difference in performance per sex, but did not report this quantitatively. Hence, future research needs to address this issue by reporting outcomes separately, thus, stratified per sex. This way, theoretical and practical inferences could be made on potential sex differences in SC in ADHD and non-ADHD samples.

Moreover, the findings of this meta-analysis are limited by a heterogenous study sample. In particular, the studies included handled the exclusion of comorbidities differently from one another. Whereas some studies excluded almost all potential psychiatric, neurological and medical comorbidities of the participants (Helfer, 2021; Özbaran, 2018), other studies merely excluded participants with comorbid ASD (Basile, 2021; Staff, 2021). This means that the participants included were not merely diverse in regard to age, sex and ADHD presentation, but also heterogeneous in regard to present comorbid disorders. This high heterogeneity between the people with ADHD included could imply that the SC difficulties are not restricted to ADHD, but might be more general to psychiatric disorders. Hence, the distinct comorbidities included could have played a confounding role in the relationship between ADHD and social cognition. However, this limitation is undermined by the fact that firstly, not all, but many study samples in this meta-analysis did exclude psychiatric comorbidities. And secondly, most studies that did exclude almost all comorbidities still found differences in SC performance between people with and without ADHD. Additionally, the various comorbidities included in some studies represent the diverse appearance of individuals with ADHD, since the majority of people with ADHD do have one or more comorbid condition. Thus, despite the constraints introduced by the heterogenous inclusion of comorbidities, it also adds to the representativeness of the findings of this meta-analysis.

Future Directions

In order to neither overlook nor overestimate the social cognitive difficulties of individuals with ADHD, future research should focus on the role of comorbidities in people with ADHD. More research on the degree to which psychiatric or neurodevelopmental comorbidities influence social cognition in this population could uncover more differentiative findings that are useful for interventions in practice. A future systematic review could provide more insight by comparing SC in people with ADHD excluding any comorbidity, to people with ADHD including comorbid psychiatric conditions. Yet, due to the high proportion of comorbidities in ADHD, this comparison might not be very feasible in practice, explaining why studies often do not exclude all comorbid disorders.

Altogether, the adding value of meta-analyses in theory and practice is well-established (Tak et al., 2010). Still, this practical value could have been enhanced, if more studies in the general analysis, as well as in sub-analyses of moderators (age and sex) were included. However, the statistical part of meta-analyses requires accessibility to transparently reported results of previous studies. In other words, studies need to provide quantitative results openly and separately. For a meta-analysis, the measures for calculating an effect size (mean, standard deviation, and sample size) need to be provided for the whole sample, as well as for sub-groups (i.e. adolescents and adults). These values, however, were not provided in some papers, leading to the exclusion of numerous studies. Hence, future studies should make their data more accessible, by reporting all outcomes transparently. If possible, data should also be stratified, meaning separate results should be provided per subgroup (i.e. per age or sex). This does not only contribute to open access to research and transparent reporting of results, but also enables meta-analyses to integrate as much data as possible on the population of interest. This way, transparency, generalizability, and methodological quality can be augmented essentially. Therefore, future research should provide all outcomes openly and separately, whenever possible. This is a step towards more transparent reporting of data, which contributes to the practical significance of meta-analyses in the future.

Clinical implications

Still, this systematic review bears valuable clinical implications. Core symptoms of ADHD cluster around inattentiveness and impulsivity, whereas social difficulties are more obviously associated with other conditions like ASD. However, this meta-analysis clearly confirmed the presence of SC differences between individuals with and without ADHD. Therefore, professional support for people with ADHD should not overlook the SC difficulties that many individuals with ADHD experience. Thus, screening for potential social cognition issues is crucial. Also, results underscore that screening should emphasize measures of ToM, since ToM tasks produced the most differentiating outcomes in this meta-analysis. Besides, testing for SC difficulties should not only be conducted in children, but across all age groups and regardless of sex. Once identified, interventions tailored to people with ADHD and SC can deliberately target their difficulties. Tailored interventions to SC in ADHD can take the form of a social skills trainings, for example. Social skills trainings for children with ADHD can effectively increase domains of the child's social competence (Antshel & Remer, 2003) and those for adolescents with ADHD can ameliorate their social functioning (Willis et al., 2019). These are examples of tailored interventions that aim to enhance and facilitate navigation within the social environment of people with ADHD.

Conclusion

Due to the major focus on attention and impulsivity aspects of ADHD, difficulties in the social cognitive domain can be overlooked. However, this meta-analysis replicated and confirmed the significantly poorer SC performance of the ADHD group, particularly in the domain of ToM. Since unaddressed issues in SC can negatively impact the daily social functioning of individuals with ADHD, the significant findings of this review emphasize the importance of screening for and targeting potential SC difficulties in this population.

References

American Psychiatric Association., & American Psychiatric Association. DSM-5 Task Force. (2013). Diagnostic and statistical manual of mental disorders : DSM-5. American Psychiatric Association.

Antshel, K. M., & Remer, R. (2003). Social Skills Training in Children With Attention Deficit Hyperactivity Disorder: A Randomized-Controlled Clinical Trial. Journal of Clinical Child & Adolescent Psychology, 32(1), 153–165. https://doi.org/10.1207/S15374424JCCP3201_14

Aydın, O., Balıkçı, K., Sönmez, İ., Ünal-Aydın, P., & Spada, M. M. (2022). Examining the roles of cognitive flexibility, emotion recognition, and metacognitions in adult Attention Deficit and Hyperactivity Disorder with predominantly inattentive presentation. Clinical Psychology and Psychotherapy, 29(2), 542–553. https://doi.org/10.1002/cpp.2645

Basile, A., Toplak, M. E., & Andrade, B. F. (2021). Using Metacognitive Methods to Examine Emotion Recognition in Children With ADHD. Journal of Attention Disorders, 25(2), 245 257. https://doi.org/10.1177/1087054718808602

Bednarz, H. M., Kana, R. K., Svancara, A. M., Sherrod, G. M., & Stavrinos, D. (2021). Neuropsychological predictors of driving hazard detection in autism spectrum disorder and ADHD. Child Neuropsychology, 27(7), 857–887. https://doi.org/10.1080/09297049.2021.1908531

Berenguer, C., Roselló, B., Colomer, C., Baixauli, I., & Miranda, A. (2018). Children with autism and attention deficit hyperactivity disorder. Relationships between symptoms and executive function, theory of mind, and behavioral problems. Research in Developmental Disabilities, 83, 260–269. https://doi.org/10.1016/j.ridd.2018.10.001

Bolat, N., Eyüboğlu, D., Eyüboğlu, M., Sargin, E., & Eliaçik, K. (2017). Dikkat eksikliği ve hiperaktivite bozukluğu olan çocuk ve ergenlerde zihin kuramı ve duygu tanıma. Anadolu Psikiyatri Dergisi, 18(3), 250–256. https://doi.org/10.5455/apd.237695

Bora, E., & Pantelis, C. (2016). Meta-analysis of social cognition in attention-deficit/hyperactivity disorder (ADHD): Comparison with healthy controls and autistic spectrum disorder. In Psychological Medicine (Vol. 46, Issue 4, pp. 699–716). Cambridge University Press. https://doi.org/10.1017/S0033291715002573

Çiray, R. O., Özyurt, G., Turan, S., Karagöz, E., Ermiş, Ç., Öztürk, Y., & Akay, A. (2022). The association between pragmatic language impairment, social cognition and emotion regulation skills in adolescents with ADHD. Nordic Journal of Psychiatry, 76(2), 89–95. https://doi.org/10.1080/08039488.2021.1938211

Dan, O., Haimov, I., Asraf, K., Nachum, K., & Cohen, A. (2020). The Effect of Sleep Deprivation on Recognition of Ambiguous Emotional Facial Expressions in Individuals With ADHD. Journal of Attention Disorders, 24(4), 565–575. https://doi.org/10.1177/1087054718785473

Demirci, E., & Erdogan, A. (2016). Is emotion recognition the only problem in ADHD? effects of pharmacotherapy on face and emotion recognition in children with ADHD. ADHD Attention Deficit and Hyperactivity Disorders, 8(4), 197–204. https://doi.org/10.1007/s12402-0160201x

Demirci, E., Ozmen, S., Kilic, E., & Oztop, D. B. (2016). The relationship between aggression, empathy skills and serum oxytocin levels in male children and adolescents with attention deficit and hyperactivity disorder. Behavioural Pharmacology, 27(8), 681–688. https://doi.org/10.1097/FBP.0000000000000234

Faheem, M., Akram, W., Akram, H., Khan, M. A., Siddiqui, F. A., & Majeed, I. (2022). Gender-based differences in prevalence and effects of ADHD in adults: A systematic review. In Asian Journal of Psychiatry (Vol. 75). Elsevier B.V. https://doi.org/10.1016/j.ajp.2022.103205

Gumustas, F., Yilmaz, I., Yulaf, Y., Gokce, S., & Sabuncuoglu, O. (2017). Empathy and facial expression recognition in children with and without attention-deficit/hyperactivity disorder: Effects of stimulant medication on empathic skills in children with attention deficit/hyperactivity disorder. Journal of Child and Adolescent Psychopharmacology, 27(5), 433–439. https://doi.org/10.1089/cap.2016.0052

Helfer, B., Boxhoorn, S., Songa, J., Steel, C., Maltezos, S., & Asherson, P. (2021). Emotion recognition and mind wandering in adults with attention deficit hyperactivity disorder or autism spectrum disorder. Journal of Psychiatric Research, 134, 89–96. https://doi.org/10.1016/j.jpsychires.2020.12.059

Jusyte, A., Gulewitsch, M. D., & Schönenberg, M. (2017). Recognition of peer emotions in children with ADHD: Evidence from an animated facial expressions task. Psychiatry Research, 258, 351–357. https://doi.org/10.1016/j.psychres.2017.08.066

Kalyoncu, T., Özbaran, B., Köse, S., & Onay, H. (2019). Variation in the Oxytocin Receptor Gene Is Associated With Social Cognition and ADHD. Journal of Attention Disorders, 23(7), 702 711. https://doi.org/10.1177/1087054717706757

Kilincel, S. (2021). The relationship between the theory of mind skills and disorder severity among adolescents with adhd. Anadolu Psikiyatri Dergisi, 22(1), 7–11. https://doi.org/10.5455/apd.126537

Kis, B., Guberina, N., Kraemer, M., Niklewski, F., Dziobek, I., Wiltfang, J., & Abdel-Hamid, M.

(2017). Perception of emotional prosody in adults with attention deficit hyperactivity disorder. Acta Psychiatrica Scandinavica, 135(6), 506–514. https://doi.org/10.1111/acps.12719

Kok, F. M., Groen, Y., Fuermaier, A. B. M., & Tucha, O. (2016). Problematic Peer Functioning in Girls with ADHD: A Systematic Literature Review. PLOS ONE, 11(11), e0165119. https://doi.org/10.1371/journal.pone.0165119

Kuijper. (2017). Supplemental Material for Narrative Production in Children With Autism Spectrum Disorder (ASD) and Children With Attention-Deficit/Hyperactivity Disorder (ADHD): Similarities and Differences. Journal of Abnormal Psychology. https://doi.org/10.1037/abn0000231.supp

Kuijper, S. J. M., Hartman, C. A., & Hendriks, P. (2021). Children's Pronoun Interpretation Problems Are Related to Theory of Mind and Inhibition, But Not Working Memory. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.610401

Levi-Shachar, O., Gvirts, H. Z., Goldwin, Y., Bloch, Y., Shamay-Tsoory, S., Boyle, D., & Maoz, H. (2021). The association between symptom severity and theory of mind impairment in children with attention deficit/hyperactivity disorder. Psychiatry Research, 303. https://doi.org/10.1016/j.psychres.2021.114092

Levy, T., Dupuis, A., Andrade, B. F., Crosbie, J., Kelley, E., Nicolson, R., & Schachar, R. J. (2023). Facial emotion recognition in children and youth with attention-deficit/hyperactivity disorder and irritability. European Child and Adolescent Psychiatry, 32(11), 2271–2280. https://doi.org/10.1007/s00787-022-02033-3

Maoz, H., Gvirts, H. Z., Sheffer, M., & Bloch, Y. (2019). Theory of Mind and Empathy in Children With ADHD. Journal of Attention Disorders, 23(11), 1331–1338.

https://doi.org/10.1177/1087054717710766

Mehren, A., Thiel, C. M., Bruns, S., Philipsen, A., & Özyurt, J. (2021). Unimpaired social cognition in adult patients with ADHD: Brain volumetric and behavioral results. Social Cognitive and Affective Neuroscience, 16(11), 1160–1169. https://doi.org/10.1093/scan/nsab060

Mohammadzadeh, A., Khorrami Banaraki, A., Tehrani Doost, M., & Castelli, F. (2020). A new semi nonverbal task glance, moderate role of cognitive flexibility in ADHD children's theory of mind. Cognitive Neuropsychiatry, 25(1), 28–44. https://doi.org/10.1080/13546805.2019.1681951

Noordermeer, S. D. S., Luman, M., Buitelaar, J. K., Hartman, C. A., Hoekstra, P. J., Franke, B., Faraone, S. v., Heslenfeld, D. J., & Oosterlaan, J. (2020). Neurocognitive Deficits in Attention-Deficit/Hyperactivity Disorder With and Without Comorbid Oppositional Defiant Disorder. Journal of Attention Disorders, 24(9). https://doi.org/10.1177/1087054715606216

Özbaran, B., Kalyoncu, T., & Köse, S. (2018). Theory of mind and emotion regulation difficulties in children with ADHD. Psychiatry Research, 270, 117–122. https://doi.org/10.1016/j.psychres.2018.09.034

Parke, E. M., Becker, M. L., Graves, S. J., Baily, A. R., Paul, M. G., Freeman, A. J., & Allen, D. N. (2021). Social Cognition in Children With ADHD. Journal of Attention Disorders, 25(4), 519 529. https://doi.org/10.1177/1087054718816157

Pitzianti, M., Grelloni, C., Casarelli, L., D'Agati, E., Spiridigliozzi, S., Curatolo, P., & Pasini, A. (2017). Neurological soft signs, but not theory of mind and emotion recognition deficit distinguished children with ADHD from healthy control. Psychiatry Research, 256. https://doi.org/10.1016/j.psychres.2017.06.029

Quintero, J., Vera, R., Morales, I., Zuluaga, P., & Fernández, A. (2020). Emotional Intelligence as an Evolutive Factor on Adult With ADHD. Journal of Attention Disorders, 24(10), 1462–1470. https://doi.org/10.1177/1087054716688251

Serrano, V. J., Owens, J. S., & Hallowell, B. (2018). Where Children With ADHD Direct Visual Attention During Emotion Knowledge Tasks: Relationships to Accuracy, Response Time, and ADHD Symptoms. Journal of Attention Disorders, 22(8), 752–763. https://doi.org/10.1177/1087054715593632

Sevincok, D., Avcil, S., & Ozbek, M. M. (2021). The relationship between theory of mind and sluggish cognitive tempo in school-age children with attention deficit and hyperactivity disorder. Clinical Child Psychology and Psychiatry, 26(4), 1137–1152. https://doi.org/10.1177/13591045211030665

Seyfarth, R. M., & Cheney, D. L. (2015). Social cognition. Animal Behaviour, 103, 191–202. https://doi.org/10.1016/j.anbehav.2015.01.030

Sjöwall, D., & Thorell, L. B. (2019). A critical appraisal of the role of neuropsychological deficits in preschool ADHD. Child Neuropsychology, 25(1), 60–80. https://doi.org/10.1080/09297049.2018.1447096

Staff, A. I., Luman, M., van der Oord, S., Bergwerff, C. E., van den Hoofdakker, B. J., & Oosterlaan, J. (2022). Facial emotion recognition impairment predicts social and emotional problems in children with (subthreshold) ADHD. European Child and Adolescent Psychiatry, 31(5), 715 727. https://doi.org/10.1007/s00787-020-01709-y

Tak, L. M., Meijer, A., Manoharan, A., de Jonge, P., & Rosmalen, J. G. M. (2010). More Than the

Sum of Its Parts: Meta-Analysis and Its Potential to Discover Sources of Heterogeneity in Psychosomatic Medicine. Psychosomatic Medicine, 72(3), 253–265. https://doi.org/10.1097/PSY.0b013e3181d714e1

Tatar, Z. B., & Cansız, A. (2022). Executive function deficits contribute to poor theory of mind abilities in adults with ADHD. Applied Neuropsychology: Adult, 29(2). https://doi.org/10.1080/23279095.2020.1736074

Thoma, P., Sonnenburg, S., Marcinkowski, N., Juckel, G., Edel, M. A., & Suchan, B. (2020). Social problem solving in adult patients with attention deficit hyperactivity disorder. Psychiatry Research, 285. https://doi.org/10.1016/j.psychres.2019.112721

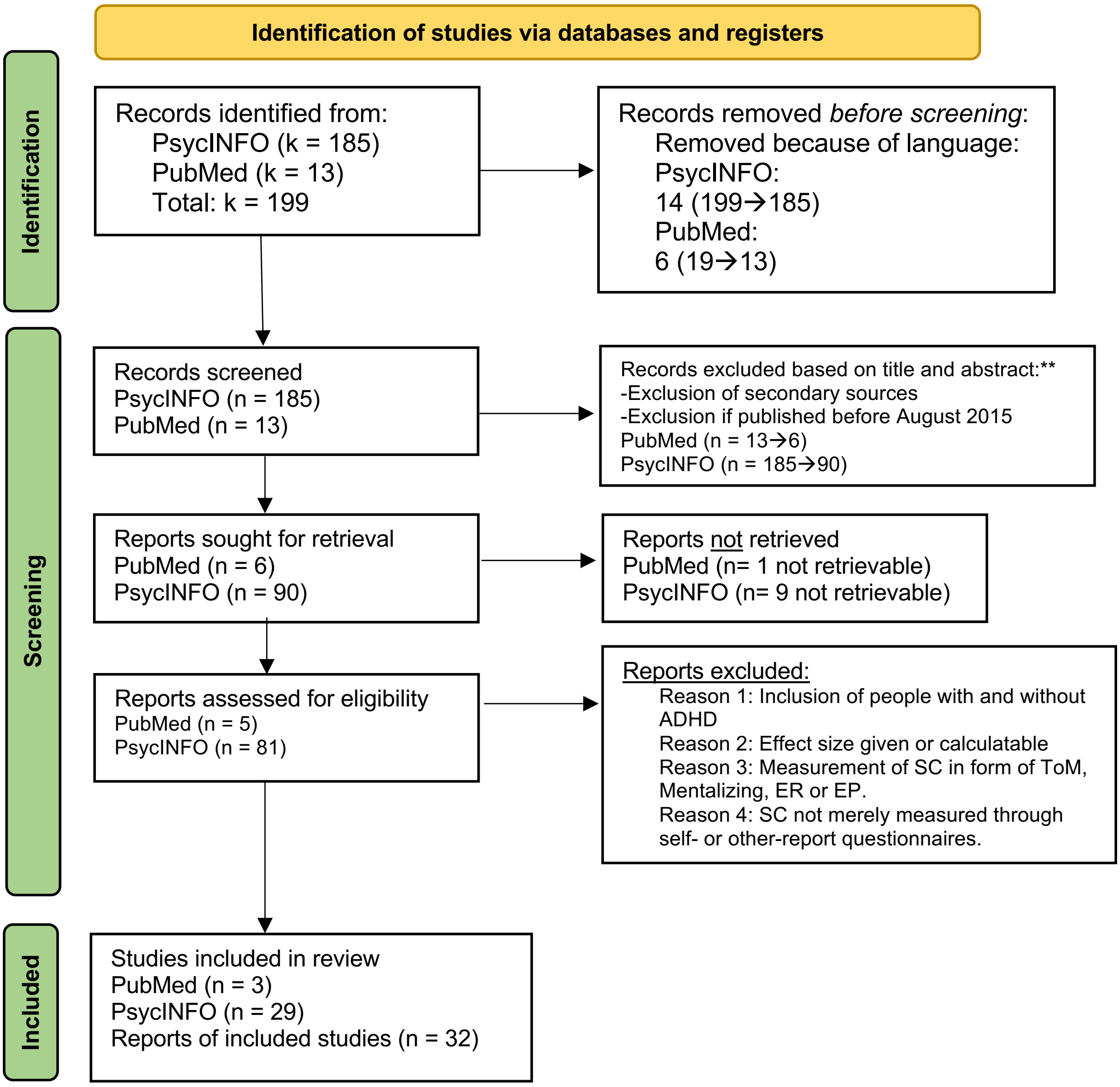
Wells. (2019). Supplemental Material for Are Emotion Recognition Abilities Intact in Pediatric ADHD? Emotion. https://doi.org/10.1037/emo0000520.supp

Wells. (2021). Supplemental Material for Evidence Against Emotion Inference Deficits in Children With ADHD. Emotion. https://doi.org/10.1037/emo0000732.supp

Willis, D., Siceloff, E. R., Morse, M., Neger, E., & Flory, K. (2019). Stand-Alone Social Skills Training for Youth with ADHD: A Systematic Review. In Clinical Child and Family Psychology Review (Vol. 22, Issue 3, pp. 348–366). Springer New York LLC. https://doi.org/10.1007/s10567-019-00291-3

Appendices

Appendix A. PRISMA Flowchart for Meta-Analysis.



Search string:
(TI(“Social Cognition” OR “Mentalizing” OR “Theory of Mind” OR “ToM” OR “Emotion Recognition” OR “Emotion Perception”**) OR AB(**“Social Cognition” OR “Mentalizing” OR “Theory of Mind” OR “ToM” OR “Emotion Recognition” OR “Emotion Perception”**) OR SU(**“Social Cognition” OR “Mentalizing” OR “Theory of Mind” OR “ToM” OR “Emotion Recognition” OR “Emotion Perception”**)) AND (TI(**“ADHD” OR “Attention-Deficit/ Hyperactivity Disorder”**) OR AB(**“ADHD” OR “Attention-Deficit/ Hyperactivity Disorder”**) OR SU(**“ADHD” OR “Attention-Deficit/ Hyperactivity Disorder”**))**

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

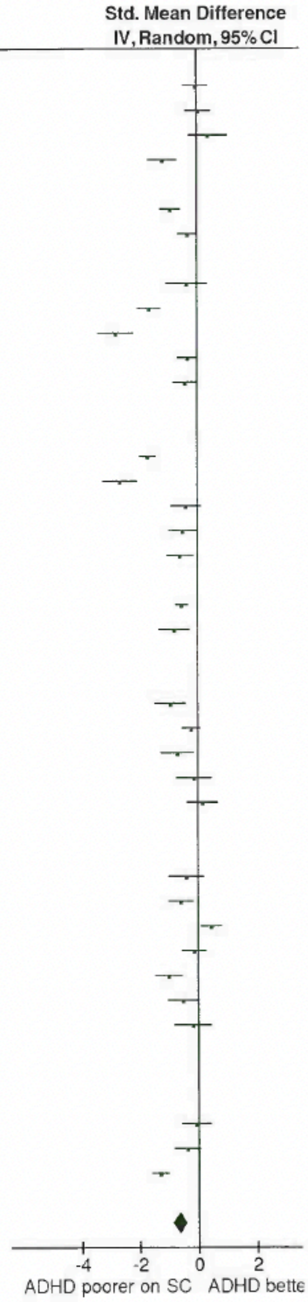
Appendix B. Forest Plots per Comparison (Review Manager outputs)

Appendix B:A. Comparison on overall SC of ADHD vs. non-ADHD.

1.1 Social Cognition performance (ADHD vs non-ADHD)

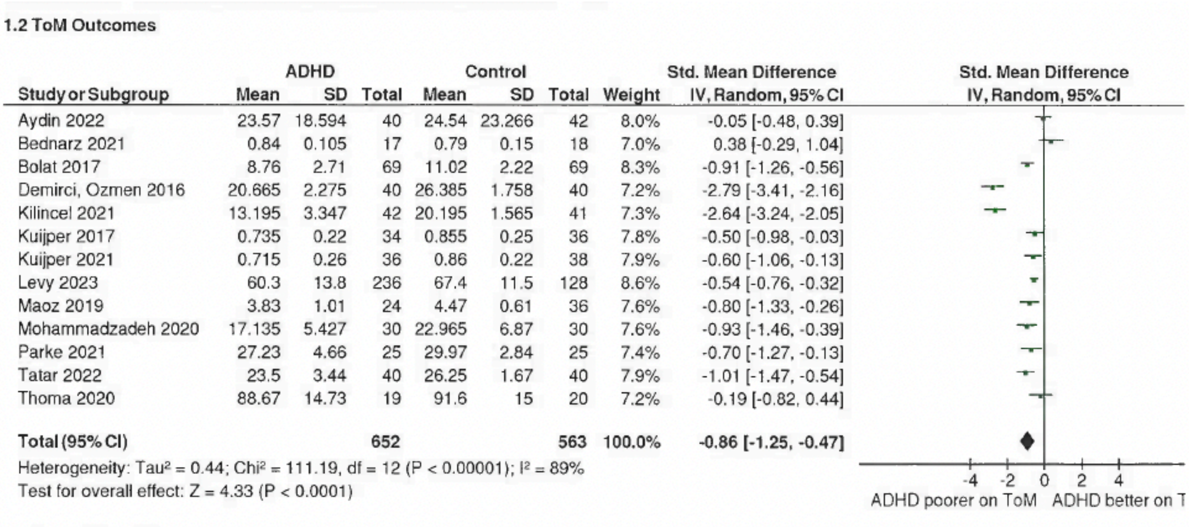
	ADHD			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Airdrie 2018	0	0	0	0	0	0		Not estimable
Aydin 2022	23.57	18.594	40	24.54	23.266	42	3.1%	-0.05 [-0.48, 0.39]
Basile 2021	34.02	2.58	39	33.9	2.42	42	3.1%	0.05 [-0.39, 0.48]
Bednarz 2021	0.84	0.105	17	0.79	0.15	18	2.7%	0.38 [-0.29, 1.04]
Berenguer 2018	24.11	4.38	35	28.41	2.73	37	3.0%	-1.17 [-1.68, -0.67]
Bisch 2016	0	0	0	0	0	0		Not estimable
Bolat 2017	8.76	2.71	69	11.02	2.22	69	3.2%	-0.91 [-1.26, -0.56]
Ciray 2022	16.104	1.42	70	16.534	1.33	64	3.2%	-0.31 [-0.65, 0.03]
Dagdelen 2020	0	0	60	0	0	60		Not estimable
Dan 2020	33.81	10.186	15	36.97	7.32	16	2.6%	-0.35 [-1.06, 0.36]
Demirci 2016	22.994	3.001	60	27.787	2.811	60	3.1%	-1.64 [-2.05, -1.22]
Demirci, Ozmen 2016	20.665	2.275	40	26.385	1.758	40	2.8%	-2.79 [-3.41, -2.16]
Gumustas 2017	14.13	5.9	65	15.76	4.12	61	3.2%	-0.32 [-0.67, 0.04]
Helfer 2021	-626.463	189	43	-554.953	158.5596	46	3.1%	-0.41 [-0.83, 0.01]
Honrath 2021	0	0	907	0	0	2504		Not estimable
Jusyte 2017	0	0	26	0	0	26		Not estimable
Kalyoncu 2019	24.586	3.616	151	30.489	3.263	100	3.3%	-1.69 [-1.98, -1.40]
Kilincel 2021	13.195	3.347	42	20.195	1.565	41	2.8%	-2.64 [-3.24, -2.05]
Kis 2017	87.02	10.887	28	90.82	8.17	29	3.0%	-0.39 [-0.91, 0.13]
Kuijper 2017	0.735	0.22	34	0.855	0.25	36	3.0%	-0.50 [-0.98, -0.03]
Kuijper 2021	0.715	0.26	36	0.86	0.22	38	3.1%	-0.60 [-1.06, -0.13]
Levi-Shachar 2020	0	0	50	0	0	40		Not estimable
Levy 2023	60.3	13.8	236	67.4	11.5	128	3.4%	-0.54 [-0.76, -0.32]
Maoz 2019	3.83	1.01	24	4.47	0.61	36	2.9%	-0.80 [-1.33, -0.26]
Mary 2016	0	0	31	0	0	31		Not estimable
Mehren 2021	0	0	26	0	0	26		Not estimable
Mohammadzadeh 2020	17.135	5.427	30	22.965	6.87	30	2.9%	-0.93 [-1.46, -0.39]
Noordermeer 2020	90.6	8.33	78	92.4	7.25	78	3.3%	-0.23 [-0.54, 0.09]
Parke 2021	27.23	4.66	25	29.97	2.84	25	2.9%	-0.70 [-1.27, -0.13]
Pitzianti 2017	23.935	2.97	23	24.3	2.16	20	2.8%	-0.14 [-0.74, 0.46]
Quintero 2020	107.45	14.61	31	105.46	12.28	25	2.9%	0.14 [-0.38, 0.67]
Schneidt 2019	0	0	65	0	0	49		Not estimable
Schönenberg 2019	0	0	25	0	0	25		Not estimable
Serrano 2018	70.21	9.3	19	74.01	9.36	26	2.8%	-0.40 [-1.00, 0.20]
Sevincok 2021	7.95	2.18	50	9.13	1.66	40	3.1%	-0.59 [-1.02, -0.17]
Sjöwall 2019	3.52	2.58	52	2.61	1.62	72	3.2%	0.44 [0.07, 0.80]
Staff 2022	-11	6.918	83	-9.97	6.838	30	3.1%	-0.15 [-0.57, 0.27]
Tatar 2022	23.5	3.44	40	26.25	1.67	40	3.1%	-1.01 [-1.47, -0.54]
Tehrani-Doost 2017	0.733	0.298	28	0.853	0.126	27	2.9%	-0.51 [-1.05, 0.02]
Thoma 2020	88.67	14.73	19	91.6	15	20	2.8%	-0.19 [-0.82, 0.44]
Thoma, Bauser 2020	0	0	19	0	0	25		Not estimable
Viering 2022	0	0	61	0	0	51		Not estimable
Waddington 2018	0	0	111	0	0	220		Not estimable
Wells 2019	0.858	0.075	35	0.864	0.079	29	3.0%	-0.08 [-0.57, 0.42]
Wells 2021	0.837	0.079	42	0.865	0.064	35	3.1%	-0.38 [-0.83, 0.07]
Özbaran 2018	25.75	3.014	100	29.99	3.465	100	3.3%	-1.30 [-1.61, -1.00]
Total (95% CI)			**3080**			**4557**	**100.0%**	**-0.63 [-0.85, -0.40]**

Heterogeneity: Tau² = 0.38; Chi² = 291.36, df = 32 (P < 0.00001); I² = 89%
Test for overall effect: Z = 5.40 (P < 0.00001)



Note: Zero values indicated for studies that met all inclusion criteria but could not be included in the Review Manager analysis due to the lack of reporting means and standard deviations.

Appendix B:B. Comparison on ToM of ADHD vs. non-ADHD.

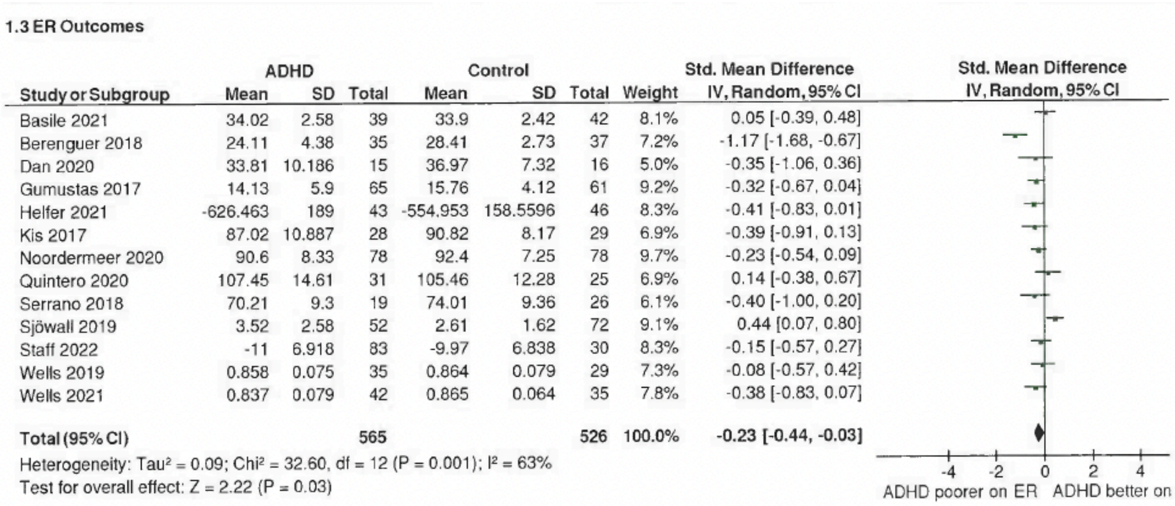


1.2 ToM Outcomes

Study or Subgroup	ADHD Mean	ADHD SD	ADHD Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Aydin 2022	23.57	18.594	40	24.54	23.266	42	8.0%	-0.05 [-0.48, 0.39]
Bednarz 2021	0.84	0.105	17	0.79	0.15	18	7.0%	0.38 [-0.29, 1.04]
Bolat 2017	8.76	2.71	69	11.02	2.22	69	8.3%	-0.91 [-1.26, -0.56]
Demirci, Ozmen 2016	20.665	2.275	40	26.385	1.758	40	7.2%	-2.79 [-3.41, -2.16]
Kilincel 2021	13.195	3.347	42	20.195	1.565	41	7.3%	-2.64 [-3.24, -2.05]
Kuijper 2017	0.735	0.22	34	0.855	0.25	36	7.8%	-0.50 [-0.98, -0.03]
Kuijper 2021	0.715	0.26	36	0.86	0.22	38	7.9%	-0.60 [-1.06, -0.13]
Levy 2023	60.3	13.8	236	67.4	11.5	128	8.6%	-0.54 [-0.76, -0.32]
Maoz 2019	3.83	1.01	24	4.47	0.61	36	7.6%	-0.80 [-1.33, -0.26]
Mohammadzadeh 2020	17.135	5.427	30	22.965	6.87	30	7.6%	-0.93 [-1.46, -0.39]
Parke 2021	27.23	4.66	25	29.97	2.84	25	7.4%	-0.70 [-1.27, -0.13]
Tatar 2022	23.5	3.44	40	26.25	1.67	40	7.9%	-1.01 [-1.47, -0.54]
Thoma 2020	88.67	14.73	19	91.6	15	20	7.2%	-0.19 [-0.82, 0.44]
Total (95% CI)			**652**			**563**	**100.0%**	**-0.86 [-1.25, -0.47]**

Heterogeneity: Tau² = 0.44; Chi² = 111.19, df = 12 (P < 0.00001); I² = 89%
Test for overall effect: Z = 4.33 (P < 0.0001)

Appendix B:C. Comparison on ER of ADHD vs. non-ADHD.



1.3 ER Outcomes

Study or Subgroup	ADHD Mean	ADHD SD	ADHD Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Basile 2021	34.02	2.58	39	33.9	2.42	42	8.1%	0.05 [-0.39, 0.48]
Berenguer 2018	24.11	4.38	35	28.41	2.73	37	7.2%	-1.17 [-1.68, -0.67]
Dan 2020	33.81	10.186	15	36.97	7.32	16	5.0%	-0.35 [-1.06, 0.36]
Gumustas 2017	14.13	5.9	65	15.76	4.12	61	9.2%	-0.32 [-0.67, 0.04]
Helfer 2021	-626.463	189	43	-554.953	158.5596	46	8.3%	-0.41 [-0.83, 0.01]
Kis 2017	87.02	10.887	28	90.82	8.17	29	6.9%	-0.39 [-0.91, 0.13]
Noordermeer 2020	90.6	8.33	78	92.4	7.25	78	9.7%	-0.23 [-0.54, 0.09]
Quintero 2020	107.45	14.61	31	105.46	12.28	25	6.9%	0.14 [-0.38, 0.67]
Serrano 2018	70.21	9.3	19	74.01	9.36	26	6.1%	-0.40 [-1.00, 0.20]
Sjöwall 2019	3.52	2.58	52	2.61	1.62	72	9.1%	0.44 [0.07, 0.80]
Staff 2022	-11	6.918	83	-9.97	6.838	30	8.3%	-0.15 [-0.57, 0.27]
Wells 2019	0.858	0.075	35	0.864	0.079	29	7.3%	-0.08 [-0.57, 0.42]
Wells 2021	0.837	0.079	42	0.865	0.064	35	7.8%	-0.38 [-0.83, 0.07]
Total (95% CI)			**565**			**526**	**100.0%**	**-0.23 [-0.44, -0.03]**

Heterogeneity: Tau² = 0.09; Chi² = 32.60, df = 12 (P = 0.001); I² = 63%
Test for overall effect: Z = 2.22 (P = 0.03)

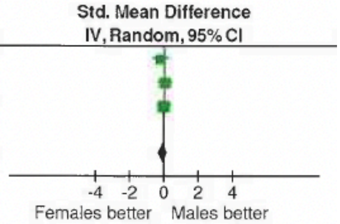
Appendix B:D. Sex comparison across groups: females vs. males.

5 Moderator-Gender

5.1 Gender

Study or Subgroup	Male Mean	Male SD	Male Total	Female Mean	Female SD	Female Total	Weight	Std. Mean Difference IV, Random, 95% CI
Basile 2021 Gender	84.45	6.5	55	85.87	5.52	26	28.4%	-0.23 [-0.69, 0.24]
Gumustas 2017_Gender	14.995	5.101	99	14.79	5.516	27	34.4%	0.04 [-0.39, 0.46]
Staff 2022 - Gender	60.51	9.34	81	60.92	9.54	32	37.2%	-0.04 [-0.45, 0.37]
Total (95% CI)			**235**			**85**	**100.0%**	**-0.07 [-0.32, 0.18]**

Heterogeneity: Tau² = 0.00; Chi² = 0.70, df = 2 (P = 0.70); I² = 0%
Test for overall effect: Z = 0.53 (P = 0.60)



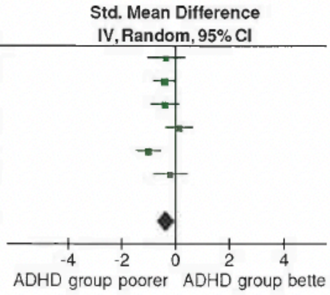
Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Appendix B:E. Comparison of adults on SC of ADHD vs. non-ADHD.

4.1 ADULTS - Mod.

Study or Subgroup	ADHD Mean	ADHD SD	ADHD Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dan 2020	33.81	10.186	15	36.97	7.32	16	12.4%	-0.35 [-1.06, 0.36]
Helfer 2021	-626.483	189	43	-554.953	158.56	46	20.4%	-0.41 [-0.83, 0.01]
Kis 2017	87.02	10.887	28	90.82	8.17	29	17.1%	-0.39 [-0.91, 0.13]
Quintero 2020	107.45	14.61	31	105.46	12.28	25	17.0%	0.14 [-0.38, 0.67]
Tatar 2022	23.5	3.44	40	26.25	1.67	40	18.9%	-1.01 [-1.47, -0.54]
Thoma 2020	88.67	14.73	19	91.6	15.001	20	14.3%	-0.19 [-0.82, 0.44]
Total (95% CI)			**176**			**176**	**100.0%**	**-0.39 [-0.71, -0.06]**

Heterogeneity: Tau² = 0.09; Chi² = 11.02, df = 5 (P = 0.05); I² = 55%
Test for overall effect: Z = 2.34 (P = 0.02)

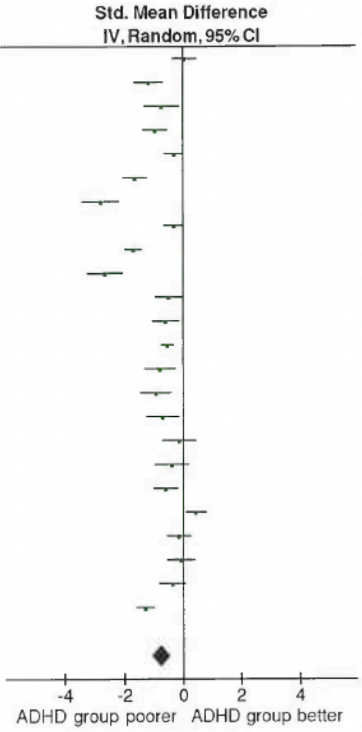


Appendix B:F. Comparison of underaged on SC of ADHD vs. non-ADHD.

7.1Childr+AdolescMODERATOR

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Basile 2021	34.02	2.58	39	33.9	2.42	42	4.2%	0.05 [-0.39, 0.48]
Berenguer 2018	24.11	4.38	35	28.41	2.73	37	4.1%	-1.17 [-1.68, -0.67]
Bolat 2017	9.633	2.526	21	11.347	2.072	23	3.9%	-0.73 [-1.34, -0.12]
Bolat 2017 - Age	8.427	2.752	48	10.857	2.28	46	4.2%	-0.95 [-1.38, -0.52]
Ciray 2022	16.104	1.42	70	16.534	1.33	64	4.4%	-0.31 [-0.65, 0.03]
Demirci 2016	22.994	3.001	60	27.787	2.811	60	4.3%	-1.64 [-2.05, -1.22]
Demirci, Ozmen 2016	20.665	2.275	40	26.385	1.758	40	3.8%	-2.79 [-3.41, -2.16]
Gumustas 2017	14.13	5.9	65	15.76	4.12	61	4.4%	-0.32 [-0.67, 0.04]
Kaiyoncu 2019	24.586	3.616	151	30.489	3.263	100	4.5%	-1.69 [-1.98, -1.40]
Kilincel 2021	13.195	3.347	42	20.195	1.565	41	3.9%	-2.64 [-3.24, -2.05]
Kuijper 2017	0.735	0.22	34	0.855	0.25	36	4.1%	-0.50 [-0.98, -0.03]
Kuijper 2021	0.715	0.26	36	0.86	0.22	38	4.2%	-0.60 [-1.06, -0.13]
Levy 2023	60.3	13.8	236	67.4	11.5	128	4.6%	-0.54 [-0.76, -0.32]
Maoz 2019	3.83	1.01	24	4.47	0.61	36	4.0%	-0.80 [-1.33, -0.26]
Mohammadzadeh 2020	17.135	5.427	30	22.965	6.87	30	4.0%	-0.93 [-1.46, -0.39]
Parke 2021	27.23	4.66	25	29.97	2.84	25	3.9%	-0.70 [-1.27, -0.13]
Pitzianti 2017	23.935	2.97	23	24.3	2.16	20	3.9%	-0.14 [-0.74, 0.46]
Serrano 2018	70.21	9.3	19	74.01	9.36	26	3.9%	-0.40 [-1.00, 0.20]
Sevincok 2021	7.95	2.18	50	9.13	1.66	40	4.3%	-0.59 [-1.02, -0.17]
Sjöwall 2019	3.52	2.58	52	2.61	1.62	72	4.4%	0.44 [0.07, 0.80]
Staff 2022	-11	6.918	83	-9.97	6.838	30	4.3%	-0.15 [-0.57, 0.27]
Wells 2019	0.858	0.075	35	0.864	0.079	29	4.1%	-0.08 [-0.57, 0.42]
Wells 2021	0.837	0.079	42	0.865	0.064	35	4.2%	-0.38 [-0.83, 0.07]
Özbaran 2018	25.75	3.014	100	29.99	3.465	100	4.5%	-1.30 [-1.61, -1.00]
Total (95% CI)			**1360**			**1159**	**100.0%**	**-0.78 [-1.06, -0.49]**

Heterogeneity: $Tau^2 = 0.44$; $Chi^2 = 248.28$, $df = 23$ ($P < 0.00001$); $I^2 = 91\%$
Test for overall effect: $Z = 5.38$ ($P < 0.00001$)



Appendix C. List of included studies.

Aydın, O., Balıkçı, K., Sönmez, İ., Ünal-Aydın, P., & Spada, M. M. (2022). Examining the roles of cognitive flexibility, emotion recognition, and metacognitions in adult Attention Deficit and Hyperactivity Disorder with predominantly inattentive presentation. Clinical Psychology and Psychotherapy, 29(2), 542–553. https://doi.org/10.1002/cpp.2645

Basile, A., Toplak, M. E., & Andrade, B. F. (2021). Using Metacognitive Methods to Examine Emotion Recognition in Children With ADHD. Journal of Attention Disorders, 25(2), 245 257. https://doi.org/10.1177/1087054718808602

Bednarz, H. M., Kana, R. K., Svancara, A. M., Sherrod, G. M., & Stavrinos, D. (2021). Neuropsychological predictors of driving hazard detection in autism spectrum disorder and ADHD. Child Neuropsychology, 27(7), 857–887. https://doi.org/10.1080/09297049.2021.1908531

Berenguer, C., Roselló, B., Colomer, C., Baixauli, I., & Miranda, A. (2018). Children with autism and attention deficit hyperactivity disorder. Relationships between symptoms and executive function, theory of mind, and behavioral problems. Research in Developmental Disabilities, 83, 260–269. https://doi.org/10.1016/j.ridd.2018.10.001

Bolat, N., Eyüboğlu, D., Eyüboğlu, M., Sargin, E., & Eliaçik, K. (2017). Dikkat eksikliği ve hiperaktivite bozukluğu olan çocuk ve ergenlerde zihin kuramı ve duygu tanıma. Anadolu Psikiyatri Dergisi, 18(3), 250–256. https://doi.org/10.5455/apd.237695

Çiray, R. O., Özyurt, G., Turan, S., Karagöz, E., Ermiş, Ç., Öztürk, Y., & Akay, A. (2022). The association between pragmatic language impairment, social cognition and emotion regulation skills in adolescents with ADHD. Nordic Journal of Psychiatry, 76(2), 89–95. https://doi.org/10.1080/08039488.2021.1938211

Dan, O., Haimov, I., Asraf, K., Nachum, K., & Cohen, A. (2020). The Effect of Sleep Deprivation on Recognition of Ambiguous Emotional Facial Expressions in Individuals With ADHD. Journal of Attention Disorders, 24(4), 565–575. https://doi.org/10.1177/1087054718785473

Demirci, E., & Erdogan, A. (2016). Is emotion recognition the only problem in ADHD? effects of pharmacotherapy on face and emotion recognition in children with ADHD. ADHD Attention Deficit and Hyperactivity Disorders, 8(4), 197–204. https://doi.org/10.1007/s12402-016-0201-x

Demirci, E., Ozmen, S., Kilic, E., & Oztop, D. B. (2016). The relationship between aggression, empathy skills and serum oxytocin levels in male children and adolescents with attention deficit and hyperactivity disorder. Behavioural Pharmacology, 27(8), 681–688. https://doi.org/10.1097/FBP.0000000000000234

Gumustas, F., Yilmaz, I., Yulaf, Y., Gokce, S., & Sabuncuoglu, O. (2017). Empathy and facial expression recognition in children with and without attention-deficit/hyperactivity disorder: Effects of stimulant medication on empathic skills in children with attention deficit/hyperactivity disorder. Journal of Child and Adolescent Psychopharmacology, 27(5), 433–439. https://doi.org/10.1089/cap.2016.0052

Helfer, B., Boxhoorn, S., Songa, J., Steel, C., Maltezos, S., & Asherson, P. (2021). Emotion recognition and mind wandering in adults with attention deficit hyperactivity disorder or autism spectrum disorder. Journal of Psychiatric Research, 134, 89–96. https://doi.org/10.1016/j.jpsychires.2020.12.059

Kalyoncu, T., Özbaran, B., Köse, S., & Onay, H. (2019). Variation in the Oxytocin Receptor Gene Is Associated With Social Cognition and ADHD. Journal of Attention Disorders, 23(7), 702 711. https://doi.org/10.1177/1087054717706757

Kilincel, S. (2021). The relationship between the theory of mind skills and disorder severity among adolescents with adhd. Anadolu Psikiyatri Dergisi, 22(1), 7–11. https://doi.org/10.5455/apd.126537

Kis, B., Guberina, N., Kraemer, M., Niklewski, F., Dziobek, I., Wiltfang, J., & Abdel-Hamid, M. (2017). Perception of emotional prosody in adults with attention deficit hyperactivity disorder. Acta Psychiatrica Scandinavica, 135(6), 506–514. https://doi.org/10.1111/acps.12719

Kuijper. (2017). Narrative Production in Children With Autism Spectrum Disorder (ASD) and Children With Attention-Deficit/Hyperactivity Disorder (ADHD): Similarities and Differences. Journal of Abnormal Psychology. https://doi.org/10.1037/abn0000231.supp

Kuijper, S. J. M., Hartman, C. A., & Hendriks, P. (2021). Children's Pronoun Interpretation Problems Are Related to Theory of Mind and Inhibition, But Not Working Memory. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.610401

Levy, T., Dupuis, A., Andrade, B. F., Crosbie, J., Kelley, E., Nicolson, R., & Schachar, R. J. (2023). Facial emotion recognition in children and youth with attention-deficit/hyperactivity disorder and irritability. European Child and Adolescent Psychiatry, 32(11), 2271–2280. https://doi.org/10.1007/s00787-022-02033-3

Maoz, H., Gvirts, H. Z., Sheffer, M., & Bloch, Y. (2019). Theory of Mind and Empathy in Children With ADHD. Journal of Attention Disorders, 23(11), 1331–1338. https://doi.org/10.1177/1087054717710766

Mohammadzadeh, A., Khorrami Banaraki, A., Tehrani Doost, M., & Castelli, F. (2020). A new semi nonverbal task glance, moderate role of cognitive flexibility in ADHD children's theory of mind. Cognitive Neuropsychiatry, 25(1), 28–44. https://doi.org/10.1080/13546805.2019.1681951

Noordermeer, S. D. S., Luman, M., Buitelaar, J. K., Hartman, C. A., Hoekstra, P. J., Franke, B., Faraone, S. v., Heslenfeld, D. J., & Oosterlaan, J. (2020). Neurocognitive Deficits in Attention-Deficit/Hyperactivity Disorder With and Without Comorbid Oppositional Defiant Disorder. Journal of Attention Disorders, 24(9). https://doi.org/10.1177/1087054715606216

Özbaran, B., Kalyoncu, T., & Köse, S. (2018). Theory of mind and emotion regulation difficulties in children with ADHD. Psychiatry Research, 270, 117–122. https://doi.org/10.1016/j.psychres.2018.09.034

Parke, E. M., Becker, M. L., Graves, S. J., Baily, A. R., Paul, M. G., Freeman, A. J., & Allen, D. N. (2021). Social Cognition in Children With ADHD. Journal of Attention Disorders, 25(4), 519 529. https://doi.org/10.1177/1087054718816157

Pitzianti, M., Grelloni, C., Casarelli, L., D'Agati, E., Spiridigliozzi, S., Curatolo, P., & Pasini, A. (2017). Neurological soft signs, but not theory of mind and emotion recognition deficit distinguished children with ADHD from healthy control. Psychiatry Research, 256. https://doi.org/10.1016/j.psychres.2017.06.029

Quintero, J., Vera, R., Morales, I., Zuluaga, P., & Fernández, A. (2020). Emotional Intelligence as an Evolutive Factor on Adult With ADHD. Journal of Attention Disorders, 24(10), 1462–1470. https://doi.org/10.1177/1087054716688251

Serrano, V. J., Owens, J. S., & Hallowell, B. (2018). Where Children With ADHD Direct Visual Attention During Emotion Knowledge Tasks: Relationships to Accuracy, Response Time, and ADHD Symptoms. Journal of Attention Disorders, 22(8), 752–763. https://doi.org/10.1177/1087054715593632

Sevincok, D., Avcil, S., & Ozbek, M. M. (2021). The relationship between theory of mind and sluggish cognitive tempo in school-age children with attention deficit and hyperactivity disorder. Clinical Child Psychology and Psychiatry, 26(4), 1137–1152. https://doi.org/10.1177/13591045211030665

Sjöwall, D., & Thorell, L. B. (2019). A critical appraisal of the role of neuropsychological deficits in preschool ADHD. Child Neuropsychology, 25(1), 60–80. https://doi.org/10.1080/09297049.2018.1447096

Staff, A. I., Luman, M., van der Oord, S., Bergwerff, C. E., van den Hoofdakker, B. J., & Oosterlaan, J. (2022). Facial emotion recognition impairment predicts social and emotional problems in children with (subthreshold) ADHD. European Child and Adolescent Psychiatry, 31(5), 715 727. https://doi.org/10.1007/s00787-020-01709-y

Tatar, Z. B., & Cansız, A. (2022). Executive function deficits contribute to poor theory of mind abilities in adults with ADHD. Applied Neuropsychology: Adult, 29(2). https://doi.org/10.1080/23279095.2020.1736074

Thoma, P., Sonnenburg, S., Marcinkowski, N., Juckel, G., Edel, M. A., & Suchan, B. (2020). Social problem solving in adult patients with attention deficit hyperactivity disorder. Psychiatry Research, 285. https://doi.org/10.1016/j.psychres.2019.112721

Wells. (2019). Supplemental Material for Are Emotion Recognition Abilities Intact in Pediatric ADHD? Emotion. https://doi.org/10.1037/emo0000520.supp

Wells. (2021). Supplemental Material for Evidence Against Emotion Inference Deficits in Children With ADHD. Emotion. https://doi.org/10.1037/emo0000732.supp