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Social functioning and self-perception of social abilities in children and adolescents with Attention Deficit/Hyperactivity Disorder

Coordinator: Prof. Giovanni Galfano

Supervisor: Prof. Irene C. Mammarella

Co-Supervisor: Prof. Paola Sessa

PhD Student: Giulia Crisci

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Abstract

Children and adolescents with ADHD encountered several difficulties during their development, not directly linked to the inattention and hyperactivity traits (Barkley, 2014) and mainly linked to their social functioning (Semrud-Clikeman et al., 2010).

Social functioning, a complex and multifaceted domain, defines the individual's ability to interact with others as peers, adults, and family (Hoza et al., 2002; McQuade et al., 2011). The main components of this domain are the following (Semrud-Clickeman et al., 2010): (a) social perception (i.e., understanding others' emotions, feelings and thoughts during social interaction); social performance (i.e., performing the appropriate social action during social interaction); and social knowledge (i.e., understanding the correct social behavior for a particular social situation). Despite several authors (see for a review Harpin et al., 2016) focused on the social functioning impairment associated to ADHD, few studies have directly assessed these characteristics with lab-based tasks. Furthermore, the role of additional factors (e.g., Theory of Mind, EFs, communication) which could influence the social functioning of children and adolescents with ADHD is still not clear enough (Beauchamp & Anderson, 2010).

Moreover, several studies have suggested that children with ADHD may overestimate their own competences in various areas of functioning (Owens et al., 2007) as academic abilities, social abilities, behavioral symptoms, and physical activities (Helseth et al., 2016; Hoza et al., 2010; Volz-Sidiropoulou et al., 2016) compared to external criteria. On the other hand some contradictory results have been observed (see for a review Owens et al., 2007) and it is still not clear if this overestimation of abilities affects several areas of functioning and whether it is specific for ADHD population, or different in other neurodevelopmental disorders (McQuade et al., 2011, 2017). In

addition, several hypotheses (see for a review Owens et al., 2007) have been proposed to explain this incorrect estimation of abilities, but few studies have empirically tested each hypothesis.

Based on these premises, the main aim of the present PhD dissertation is to improve our knowledge of two main developmental areas of children and adolescents with ADHD: social functioning and self-perception of abilities. Firstly, to better understand the specific characteristics of ADHD in the two areas, a cross-disorder comparisons approach was used. Overall, cross-disorder comparisons have been suggested as the best way to analyze multifaceted abilities in neurodevelopmental disorders (D'Souza, et al., 2016), in order to overcame the limits of previous studies in which children with ADHD had merely been compared with typically developmental children (Crisci et al., 2021; D'Souza, et al., 2016). Specifically, children with ADHD were compared with children with Autism Spectrum Disorder (ASD), because the comorbidity rate between ADHD and ASD is incredibly high (Biederman & Faraone, 2005) and several previous authors (see for a review Antshel & Russo, 2019) underlined as quantitative and qualitative differences exist in the phenotypic presentations of their impairments, despite similar characteristics may also been observed (Ros & Graziano, 2018). Secondly, some aspects of social functioning and self-perception of abilities, which emerged as peculiar of ADHD in the two cross-disorder comparisons studies, have been deeply examined in only in ADHD compared to typically developing children. Moreover, the role of additional factors (e.g., Theory of Mind, EFs, communication) mentioned in literature as crucial for both social functioning (Beauchamp & Anderson, 2010) and self-perception of abilities (Owens et al., 2007) was considered. New tasks and stimuli have been devised in order to assess all the previously mentioned abilities, and four studies have been carried out.

Study I aimed to compare the manifestation of social functioning impairments (on social perception, social performance and social knowledge) that occur in ADHD compared to ASD and typically-developmental –TD- children, with both proxy-report and new lab-based tasks. Two

hundred and twenty-five children (66 with ADHD; 51 with ASD; 108 TD- children) were enrolled and matched for age, gender and Intelligence Quotient (IQ). Social functioning has been investigated in these groups proposing a parent-report questionnaire. Social perception, social performance and social knowledge have been assessed using lab-based tasks created ad hoc for the study. Our findings suggested that according to their parents, children and adolescents with ADHD or ASD have significant social functioning impairments compared to TD individuals, but no differences emerged between the two clinical populations. Conversely, some peculiarities of social functioning impairments were better observed with lab-based tasks. Children with ADHD showed high difficulties in social performance, whereas children with ASD reveal more difficulties in social perception and partially in social knowledge.

Study II (Chapter 3) aimed to investigate social perception ability on semi-naturalistic tasks in children with ADHD, also investigating three higher-order cognitive skills (theory of mind, attention and pragmatic language). The performance of 36 children and adolescents with ADHD were compared with 36 TD controls, matched for age, gender, IQ and language abilities. Participants have been presented with a lab-based task adapted from the Children and Adolescents Social Perception (CASP, Semrud-Clikeman, 2010), which assess social perception abilities, in which the modality of stimuli presentation has been manipulated (i.e., audio, video and multimodal/combined). Moreover, tasks taken from the NEPSY II, (Korkmann et al., 2011) and new paper-and-pencil tests and computerized tasks have been proposed to assess the higher-order cognitive skills. Regarding the social perception tasks (derived from the CASP test), our findings showed that children with ADHD only performed less well than TD children with combined stimuli, which resemble the real-life interactions. As concerns the higher-order cognitive skills, attention explained the largest percentage of variance of the performance on the social perception tasks,

theory of mind also had a contribution, conversely pragmatic abilities were associated with social perception in TD children and adolescents, but not in the ADHD population.

Moving to the second area studied in the present dissertation, Study III (Chapter 4) focuses on the self-perception of ability in ADHD. Particularly, the self-perception of both social abilities and behavioral problems has been taken into account and the role of comorbidities (i.e., internalizing and externalizing disorders) on the self-perception of abilities were considered. Fifty participants with a clinical diagnosis of ADHD, 49 with clinical diagnosis of ASD and 121 TD children were enrolled, matched for age, gender, and IQ. Two parallel forms of the SSIS-RS questionnaire (Gresham & Elliot, 2008) was filled by children and parents, to compare children's and parents' perception. Additionally, a parent-report (CBCL, Achenbach & Rescorla, 2004) assessing clinical impairments has been proposed. Our findings underline as self-perception of social abilities was significantly impaired only in ADHD population compared to both ASD and TD group, confirming as the overestimation of their own abilities vis-à-vis external criteria is a specific phenomenon of children with ADHD (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). Moreover, based on our data, the overestimation of their own characteristics is specific of only some functioning areas in ADHD (e.g., social functioning) and absent in others (e.g., behavioral problems). Finally, clinical impairments did not have a direct impact on the overestimation of abilities in social context.

Finally, considering the unsuccessful role of comorbidities as explanation of the overestimation of abilities in the social context, Study IV (Chapter 5) focuses on two different hypotheses proposed in the literature as possible explanations of this phenomenon: the impact of neuropsychological deficits, as well as communication impairments. Forty-one children with ADHD and 42 TD children matched on age, IQ, and receptive language were enrolled. Similarly to Study III, two parallel versions of the ICS questionnaire (Cairns et al., 1995) have been filled by children and parents, to compare children's and parents' perception. Moreover, measures of neuropsychological

abilities and communication impairments have been administered. The findings revealed as only communications impairments, and not neuropsychological deficits, seem to mediate the association between ADHD and overestimation of abilities in the social context.

General conclusions derived from the main findings of the four studies, limitations as well as clinical implications have been highlighted in the final chapter of this dissertation.

To conclude, investigating the social functioning and self-perception of abilities in children and adolescents with ADHD is a highly complex issue. There is still space for further research on the domains of social functioning, and on the self-perception of abilities as well, specifically comparing ADHD to other developmental disorders. The present dissertation was an effort to raise and clarify some points, but other questions remain open and will require further studies.

Chapter 1

Attention Deficit/Hyperactivity Disorder

1.1 ADHD: definition and main features

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by three categories of symptoms: inattention, impulsivity, and hyperactivity (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition -DSM 5-, American Psychiatric Association -APA-, 2013). Each category is defined by several behavioural manifestations, as reported in the DSM 5 (APA, 2013). The ADHD worldwide-pooled prevalence is 5.29% (see for a review Polanczyk et al., 2007). The symptoms may be severe, and can cause difficulty at school, at home, or with friends (APA, 2013). There are three different ways ADHD presents itself, depending on which types of symptoms are strongest in the individual: *predominantly inattentive presentation; predominantly hyperactive-impulsive presentation; combined presentation:* symptoms of the above two types are equally present in the person (APA, 2013). Although the neuropsychological profile of ADHD is heterogeneous, a huge number of studies has suggested the presence of impairments in executive functions (EF) (Barkley et al., 2014). “Executive functions” is an umbrella term which refer to a set of cognitive processes that are necessary for the cognitive control of behavior, such as inhibition, shifting and updating (Miyake, 2000). Previous findings are hardly conclusive, however, since the mean effect sizes range from small to moderate for EF difficulties, and not all children with ADHD show EF deficits (Willcutt et al., 2005), which can also be seen in typically developing (TD) children (Vaidya et al., 2020), as well as in other neurodevelopmental disorders, suggesting that none of these EF deficits is a necessary or sufficient explanation for the ADHD profile (Willcutt et al., 2005).

1.1.1. Risk factors and etiology

It is well accepted that ADHD is a highly heritable disorder. Molecular genetic researches are emerging rapidly (Thapar, 2018) and genome association studies have identified several genetic loci acting as risk factors for developing ADHD (iPSYCH-Broad Consortium et al., 2019). However, effect sizes of individual loci seem to be too small to be clinically relevant, nor do these findings yet make causal hypotheses (Polanczyck et al., 2007). Other molecular studies suggest the involvement of genetic mutations with potentially larger effects (ADHD Working Group of the Psychiatric Genomics Consortium (PGC) et al., 2019), but some of these involve multiple genes and these will apply to only a small minority of ADHD cases (Thapar, 2018).

Besides, not all of the risk factors are genetic. It is estimated that between 10 and 40% of the variance associated with ADHD is likely to be accounted for environmental factors (Sciberras et al., 2017). Several pre- and post-natal risk factors are well established for ADHD, although none are unique to the disorder. Among the pre-natal risk factors, there are maternal distress (Manzari et al., 2019), maternal substance uses during pregnancy (Langley et al., 2012), pre-term birth (Momany et al., 2018), low birth weight (Serati et al., 2017) and other pregnancy, labour/delivery and neonatal complications (Silva et al., 2014). Among post-natal risk factors, there are social disadvantage and adversity (Björkenstam et al., 2018), and average level lead exposure (Goodlad et al., 2013; Nigg et al., 2016) as well as other environmental toxicants (Myhre et al., 2018; Rivollier et al., 2019).

Overall, Faraone and colleagues (2015) affirmed that there are many risk factors for ADHD, but each one is not necessary and sufficient to cause ADHD.

1.1.2. Developmental changes in ADHD

ADHD is most typically diagnosed during school years, however several core symptoms and related functional impairments may be observed in the early developmental stages (Harpin et al., 2005).

During pre-school age, unusually high activity levels, poor inhibitory control, attention problems, and excessive motor restlessness may be visible. The predominantly hyperactive-impulsive subtype is more common in preschoolers than in older children, as hyperactivity tends to decrease with age (Faraone et al., 2021). In preschool years, the symptoms mainly include high rates of precarious behavior and physical injury, unmanageable conduct across many settings, including home and classroom (Cherkasova et al., 2013).

During school age, ADHD is usually identified, in terms of formal diagnosis, and referred because of classroom disruptiveness and/or academic consequences. During the primary school, the combined subtype seems to be more common, compared to the predominantly inattentive subtype and the hyperactive-impulsive one (Faraone et al., 2021). During school age, the symptoms result in significant impairments not only in terms of academic achievement, but also in family interactions, peer relationships and self-perception (Harpin, 2005). After that period, during the adolescence, a reduction in the overactivity that is often striking in younger children is expected, but inattention, impulsiveness, and inner restlessness remain major difficulties (Harpin, 2005). It is important to underline as childhood and adolescence peer problems and low perceived social acceptance seem predict a wide variety of later negative outcomes in adulthood (Hoza, 2007).

Overall, in terms of symptoms developmental changes, several studies (see for a review Faraone et al., 2021) have suggested that 75% of children with ADHD continue to have either the full syndrome or significant symptoms that fall short of the diagnostic criteria. Specifically, symptoms of inattention show greater persistence and slower decline with age than symptoms of hyperactivity and impulsivity (Faraone et al., 2021). Moreover, functional poorer long-term outcomes in adults with ADHD compared to typical groups are frequently underlined in terms of attainment, occupational rank and job performance, risky sexual practices and early-unwanted

pregnancies, relationship and marital problems, traffic violations and car accidents, and psychiatric comorbidities (Harpin et al., 2005).

1.1.3. Comorbidities

The presence of overlapping psychiatric disorders is more likely to be the rule than the exception in ADHD (Barkley, 2014), in fact, a wide variety of concurrent psychiatric disorders contribute to the psychopathological status of children and adolescents with ADHD. In developmental stages the overall prevalence of psychiatric disorders associated with ADHD ranges from about 40 to 80% (Biederman & Faraone, 2005). The main disorders likely to co-occur with ADHD are: autism spectrum disorders (ASD, 65–80%), oppositional defiant disorder (50–60%), conduct disorder (20–50%), internalizing disorders (as depression 16–26% and anxiety 10–40%), bipolar disorders (11–75%), tic disorders (20%), and obsessive compulsive disorders (6–15%) (Biederman & Faraone, 2005). Moreover, learning difficulties are frequently associated with ADHD, with over 45% having at least one significant impairment in reading, arithmetic or spelling (Barkley, 2014). Furthermore, in different developmental stages children with ADHD experience difficulties in social functioning.

1.2 Social functioning and ADHD

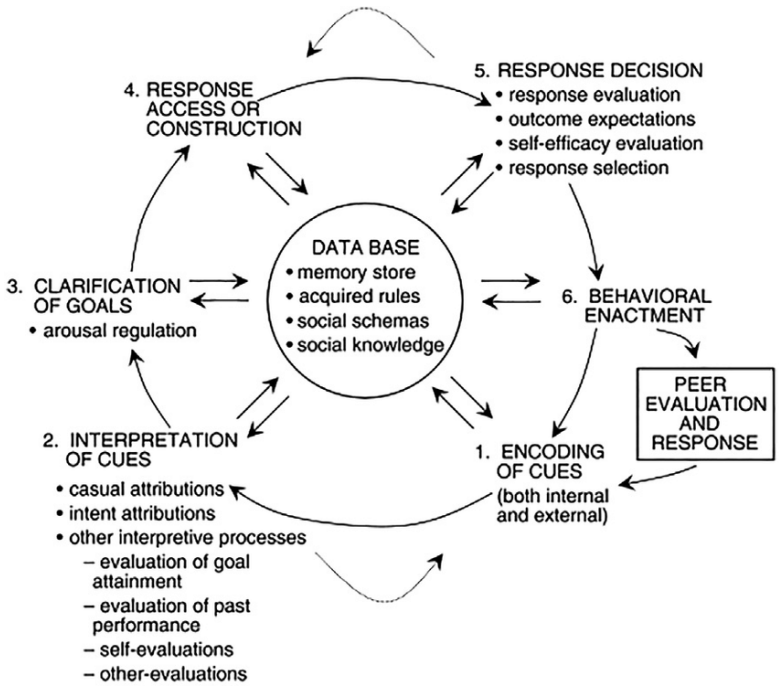
Social functioning defines an individual's interactions with the environment and the ability to fulfill the own role within such environments as school, social activities with peers, and family (Hoza et al., 2002; McQuade et al., 2011). These complex abilities develop from early childhood to adulthood. Infants are sensitive to facial stimuli (i.e., direct gaze, upright faces, straight heads), shows social initiatives, and, around at 9 months of age, reveals joint attention, one of the building blocks of social communication. From childhood to adolescence, thanks to the exposition to a widening range of social contexts and interactions, individuals develop new and more sophisticated cognitive skills as executive functions (i.e., an umbrella term for attentional control, cognitive

flexibility and goal setting), theory of mind (i.e., the ability to attribute mental states to ourselves and others, and to understand that others') and communication (expressive, receptive and pragmatic language), which reflect important milestones in the development of social functioning. Despite these three cognitive skills have direct relevance to the perception and processing of social stimuli, they are considered distinct categories by previous studies (Beuchamp & Anderson, 2010; Yang et al., 2015). Research in neurodevelopmental disoders, indeed, demonstrates that impairments in general cognitive skills do not always explain observed patterns of social deficits, supporting a dissociation between the domains of general cognitive skills and social functioning (Beuchamp & Anderson, 2010; Yang et al., 2015). Moreover, substantial neurostructural changes as the decrease of gray matter volume and the increase of white matter density developed simultaneously with the increase of teenagers' exposure to social situations (Beauchamp & Anderson, 2010).

Three main influential components of this complex and multifaceted domain (Semrud-Clickeman et al., 2010) are: (a) social perception (i.e., the ability to understand emotions and others' feelings and thoughts during social interaction); social performance (i.e., performing the appropriate social action in response to a social stimulus); social knowledge (i.e., understanding the correct social behavior for a particular social situation).

One of the most commonly accredited model of social functioning in childhood and adolescence was proposed by Dodge, 1980 and later reformulated by Crick & Dodge, (1994) and Lemerise & Arsenio (2000). The Social Information Processing (SIP) model (Dodge, 1980; Crick & Dodge, 1994; Lemerise & Arsenio, 2000) asserts that in response to problematic social situations, children and adolescents respond with a sequence of six mental operations (Figure 1.1) within the three main influential components (social perception, social performance and social knowledge).

Figure 1.1 Crick and Dodge's (1994) Social information processing model (SIP).



Based on the model, in every social situation any person starts by encoding of internal and external cues. After that, the individual starts to interpret the intent and emotions of self and others. This involves an analysis of the events and inferences about other people's thoughts or intentions. These first two steps refer to social perception. Based upon these interpretations, the third SIP step contains the clarification of social goals, such as maintaining a good relationship or taking revenge. Then having decided what s/he wants to achieve, in the fourth step the individual generates a first spontaneous response to help him/her achieve it. This response could be prosocial and assertive, but it could also be passive or aggressive. The third and fourth steps of the SIP model refer to social performance. Finally, the fifth SIP step includes the decision process: different response options are evaluated as problem solutions and one response is selected. This last step refers to social knowledge. At the end, the behavioral response chose as the best one is enacted.

Although social functioning impairments are not explicitly required for a diagnosis of ADHD, several behavioral symptoms (as reported above) are commonly reported by both parents and teachers of these children as causing social problems, particularly during childhood and adolescence

(Nijmeijer et al., 2008; Uekermann et al., 2010; Antshel & Russo, 2019). Inattention likely limits the opportunities to acquire social skills through observational learning and to attend to social cues necessary to positive social interaction. Furthermore, hyperactive and impulsive behaviors contribute to generally uncontrolled and over-confident social behavior that makes children with ADHD aversive to peers (Hoza et al., 2010). The Multimodal Treatment Study of Children with ADHD (MTA) found that 52% of children and adolescents with ADHD fell in the rejected category and less than 1% were of popular status (Newcorn, 2000). These data are consistent with subsequent studies indicating that until 80% of children with ADHD have peer rejection scores one standard deviation or more above the mean (Hoza et al., 2002; McQuade et al., 2017).

Most previous studies mainly assessed social functioning with indirect measures (i.e., self- or proxy report, Gresham & Elliot, 2008), which data should be interpreted with caution, considering that questionnaire responses are subjective (Rao et al., 2008), or with sociograms (Hoza et al., 2002), which give a detail picture of the social relations within a specific context, but would not give an exact description of the social functioning of the child. Only few studies directly assessed these abilities with lab-based tasks, presenting for example fictitious episodes about a child, paying attention that the participants would not be able to use racial cues as a way of gaining information about the characters' feelings. Thanks to this type of tasks, difficulties in identifying and labeling emotions (Braaten & Rosen, 2000; Uekermann et al., 2010) and high number of aggressive answers (Abikoff et al., 2004; Erhardt & Hinshaw, 1994), but adequate knowledge of the rules of the social context (Barkley, 2014) emerged in different samples of children and adolescents with ADHD, between 6 to 18 years.

1.3 Self-perception of abilities and ADHD

Competence estimation and self-perceptions have been studied in the field of metacognition, with a main focus on the ability to monitoring the stimuli processed and to assessing how they are

functioning. Competence estimation of a child is generally measured as the discrepancy between a child's self-rated competence and how it is judged by others, such as parents or teachers (Owens et al., 2007): a difference close to zero represents a correct estimation of abilities, whereas positive discrepancy represents an overestimation of abilities. Some previous studies have criticized the use of discrepancy scores from both theoretical and statistical perspective. From the theoretical perspective, some authors have suggested that a positive discrepancy could be associated with negative parental or teacher attributions (Evangelista et al., 2008; Hoza et al., 2010; Owens & Hoza, 2003). Other studies identified the same overestimation of abilities comparing children's self-ratings with their objective performance (Chan & Martinussen, 2016; McQuade et al., 2017; Ohan & Johnston, 2002; Owens & Hoza, 2003). These findings are consistent with the hypothesis that the phenomenon is not just a reflection of negative parental attribution. From the statistical perspective, some authors (Swanson et al., 2012) have judged alternative approaches (e.g., standardized residual or standardized discrepancy scores) more appropriate and informative. Others have claimed that alternative approaches also have statistical limitations, such as a low reliability (Owens et al., 2007), as well as being far from easy to interpret from a clinical standpoint (Martin et al., 2019). Taken these considerations into account, in the present dissertation the discrepancy approach will be used (see Chapter 4 and 5).

In the last few decades, the estimation of competence is an emerging field of interest in developmental phases. The self-perception theory (Harter, 1981) proposed that children who succeed in various domains are able to develop and maintain appropriate beliefs about their own competences. Conversely, children who experience repeated failures are more likely to develop low beliefs. However, this has not always been found to be the case during development. Previous research suggests that typically developmental (TD) children often overestimate their own competence on tasks compared to how it is judged by others, such as parents or teachers (Desoete

et al., 2006; Schneider et al., 2000). This phenomenon, called better-than-average effect (Harter, 1981) or the optimism bias (Weinstein, 1980), is interpreted as an adaptive mechanism, because it can help make children more motivated when they engage in challenging tasks (Owens et al., 2007). Studies have suggested that children and adolescents with ADHD may similarly overestimate their own competence in various areas of functioning (Owens, et al., 2007) as academic abilities, social abilities, behavioural symptoms, and physical activities (Helseth et al., 2016; Hoza et al., 2002; Volz-Sidiropoulou et al., 2016) compared to external criteria.

Some differences emerged between the overestimation of TD children and of children with ADHD. Although some positive self-perceptions seem to have an adaptive quality in TD population, the overestimation in individuals with ADHD has been associated with several negative outcomes, as poorer response to treatment, high rates of aggression, and less prosocial behaviour (Hoza et al., 2010; Linnea & Hoza, 2013). Additionally, in children with ADHD, the overestimation has been shown to be a predictor of maladjustment in new environments (Jia et al., 2016). Moreover, children with ADHD tend more frequently to perform less well and to give up on challenging tasks, despite their overestimation of abilities (Hoza et al., 2010). Finally, the discrepancy between their self-perception and external measures is larger in ADHD than TD children (Owens & Hoza, 2003).

In previous studies, this overestimation has been examined mainly in children with ADHD aged from 7 to 13 years, because it is in this age range that they overestimate their academic, behavioral, and social competence the most (Capodieci et al., 2019; Crisci et al.,2018; Linnea et al.,2012; Martin et al., 2019). It is nonetheless worth noting that the only study (Volz-Sidiropoulou et al., 2016) that included a large sample of children with ADHD over a wide age range (from 6 to 15 years) found that age was not significantly associated with this overestimation. The discrepancy between children's and self and parents' competence ratings tended to decrease with age, but the difference proved insignificant (Volz-Sidiropoulou et al., 2016). Taken these considerations into

account, in the present dissertation the samples included children among 8 to 16 years (see Chapter 4 and 5).

In conclusion, several studies underlined specific characteristics of the overestimation phenomenon in ADHD population, compared to the optimism bias of TD children. This tendency in children with ADHD to overestimate their capabilities vis-à-vis external criteria is called positive illusory bias (PIB) (Capodieci et al., 2019; Hoza et al., 2010; Owens et al., 2007). The presence of PIB in the ADHD population is well established, but the specific features and possible differences with other neurodevelopmental disorders are not clear enough (Owen & Hoza, 2003).

1.4 ADHD and ASD: similarities and differences

As already reported, the comorbidity rate between ADHD and ASD is incredibly high (65-80%) (Biederman & Faraone, 2005). ASD is characterized by deficits in social communication, social interaction and stereotyped patterns of behavior, interests or activities (APA, 2013).

Several studies compared the neuropsychological profiles of both groups, in an attempt to characterize similarities and differences, specifically between ADHD and ASD without intellectual disabilities (see for a review Antshel et al., 2019). Neuropsychological profiles mainly include Executive functions (EFs), an umbrella term that encompasses multiple domains of function including inhibition, cognitive shifting, planning, working memory (Miyake et al., 2000). EFs has been studied extensively in both ADHD and ASD. While ASD is generally considered a more severe condition, EFs impairments is more severe in ADHD (Bloemen et al., 2018). Moreover, the association between EFs and ADHD symptoms remains after controlling for ASD symptoms (Lukito et al., 2017). Additionally, some differences emerged between the two diagnostic categories: individuals with ADHD struggle most clearly with inhibition and planning, while those with ASD struggle most with cognitive flexibility (Happé et al., 2006).

Other aspects of the psychological profile of children with ADHD or ASD are not so clearly established, instead. Social difficulties are a clear characteristic of ASD, required for the diagnosis (APA, 2013). Although deficits in social functioning are not explicitly required for a diagnosis of ADHD, these abilities are clearly impaired in this population (Semrud-Clickeman et al., 2010). Both children with ADHD and ASD show low levels of reciprocated friendship (Ros & Graziano, 2018). Quantitative and qualitative differences exist, however, in the phenotypic presentations of the impairments which characterize ADHD and ASD (see for a review Antshel & Russo, 2019). For example, ASD seems to show greatest deficits in social perception than ADHD, but when communication abilities are taken into account group differences disappeared (Antshel et al., 2019). Moreover, children with ADHD seem to have intact social knowledge and impaired social interactions, suggestive of a specific performance deficit (Aduen et al., 2018). Conversely, youth with ASD would mainly have knowledge deficits (Pedreño et al., 2017). Finally, the social difficulties of children with ASD appear more due to the absence of positive behaviours (e.g., social approach, eye contact) rather than the presence of aggressive behaviours (e.g., interrupting and intruding on conversations) as for children with ADHD (Gardner & Gerdes, 2015; Locke et al., 2016).

In conclusion, an emerging field of interest is the self-perception of abilities in children with ADHD or ASD. On one hand, as previous reported in this chapter, children with ADHD tend to overestimate their own competences in several domains of their life (McQuade et al., 2017; Owens & Hoza, 2003). On the other hand, empirical and theoretical works suggests that self-perception ability is probably impaired also in individuals with ASD (Furlano et al., 2015). For example, Koning & Magill-Evans (2001) observed that, although a group of adolescents with ASD without intellectual disabilities had some awareness of their social functioning impairments, they assessed themselves as having more social skills compared to parents' report. It is important to underline as no previous

studies directly compared ADHD and ASD, making impossible to estimate the real impact of this overestimation of abilities in each population.

1.5 General aims of the present dissertation

As previous underlined, social functioning impairments and overestimation of abilities are frequently underlined in children and adolescents with ADHD (Barkley, 2014; Owens et al., 2007). Specifically, it has been observed that lab-based tasks which taken into account real social context may be useful to better understand the specific difficulties encountered by children with ADHD (Barkley, 2014). Moreover, the PIB paradigm seems to represent a useful tool for assessing the estimation and self-perception of abilities in ADHD and generally in clinical populations (Toplak et al., 2019).

Based on these premises the main aims of this PhD dissertation are to increase the current understanding of two developmental areas of children and adolescents with ADHD: social functioning and self-perception of abilities. Specifically, the performance of children with ADHD and ASD without intellectual disability will be investigated in both areas and will be compared. Moreover, some aspects of these areas which will emerge as peculiar of ADHD will be deeply examined, considering the role of additional factors (e.g., Theory of Mind, EFs, communication) which could influence the performance of children and adolescents with ADHD.

The series of studies which will be presented in this dissertation could lead to new findings allowing an in-depth analysis of different aspects of both social functioning and self-perception abilities with direct clinical implications. Firstly, our results might help clinicians in the assessment and in the development of specific intervention programs of individuals with ADHD - by identifying strengths and weaknesses of their social profiles. Secondly, our findings may support the differential diagnosis with ASD profile. Finally, confirming the presence of a specific overestimation of ability could shed further light on the prognosis of the diagnosis.

1.6 Overview of the chapters

Two main topics, social functioning and self-perception of abilities, will be analyzed in children with a clinical diagnosis of ADHD, comparing them with children with a clinical diagnosis of Autism Spectrum Disorders (ASD) and typically developmental (TD) children. Table 1.1 summarizes the main characteristics of the groups in the four studies, the main aims and the hypotheses of each study that will be presented in detail in this PhD dissertation.

Chapter 2 will initially define and describe the principal similarities and differences in social functioning between ADHD and ASD, focusing on the state of the art and on the main methodological issues that can be raised. In the second part of this chapter the first study will be presented, with the aim to compare the manifestation of social functioning impairments (specifically on social perception, social performance and social knowledge) that occur in ADHD relative to ASD and TD children, proposing both questionnaires and lab-based tasks. General social functioning will be investigated in these groups proposing a specific parent-report questionnaire. Social perception, social performance and social knowledge will be assessed using a lab-based task created ad hoc for the study.

Chapter 3 will first describe in depth the social perception ability (one of the main influential components of social functioning) of children with ADHD, paying particular attention to the factors which could influence this skill (as nonverbal signals recognition and the modality of the presentation of the stimuli) and the main higher-order cognitive skills (as theory of mind, attention and executive functions and communication), which could be linked to. Secondly, the second study of the present dissertation will be presented, which aimed to investigate social perception ability in children with ADHD. In particular, their performance will be compared with TD controls, matched for age, gender, IQ and language abilities. Participants will be presented a lab-based task adapted from the Children and Adolescents Social Perception (CASP, Semrud-Clikeman, 2010), which assess

social perception abilities with different stimuli. Moreover, several tasks taken from the NEPSY II, (Korkmann et al., 2011) or new computerized tasks will be proposed to assess higher-order cognitive skills (such as theory of mind, attention and executive functions and communication).

After investigating in previous chapters the real social functioning abilities in children with ADHD, **Chapter 4** will focus on the self-perception of this ability involving participants with ADHD, ASD, comparing them with TD controls. Similarities and differences between the two clinical groups will be first highlighted. Secondly, the third Study of the present dissertation will be presented, which aims to investigate the estimation of abilities in children with ADHD, ASD and TD, matched for age, gender, and IQ. Particularly, the self-perception of both social abilities and behavioral problems will be taken into account. Moreover, the role of clinical impairments and comorbidities will be examined.

Chapter 5 will focus on the main hypotheses proposed in literature as explanation of the overestimation of social abilities in children with ADHD. The fourth Study will be presented that aim to analyze the overestimation of social abilities, and to clarify the specific impact of neuropsychological deficits, as well as communication impairments on this overestimation.

In conclusion, **Chapter 6** will summarize the main findings from each study (Chapters 2-5), will describe studies strengths and limits, by also considering open questions and suggestions for further research. Finally, clinical implications of the current studies will be discussed.

Table 1.1 Summary of the essential information concerning each study: number of participants (N), groups involved, the topic examined, the main aims and the hypotheses.

Study	N	Groups	Topic	Aims	Hypotheses
I	225	ADHD ASD TD	Social functioning: a) social perception b) social performance c) social knowledge	1. Examining the general social functioning with proxy report; 2. Analyzing the specific difficulties encountered in three influential components of social functioning (i.e., social perception, social performance and social knowledge) with specific lab-based tasks. 3. Observing the relation between proxy-reports and lab-based tasks	• Greater social functioning impairments are expected in ASD than ADHD using the proxy report (Bora & Pantelis, 2016). • Greater difficulties in social perception are expected in ASD than ADHD (Bora & Pantelis, 2016); in social performance, higher presence of negative social behaviors is expected in ADHD (Channon et al., 2001; Gardner & Gerdes, 2015; Meyer et al., 2006; Ronk, et al., 2011); in social knowledge, ADHD are expected to show intact abilities (Barkley, 2015); ASD are expected to show less knowledge of correct social behavior than ADHD (Matson & Wilkins, 2007; Lerner & Girard, 2021). • Not strong correlations are expected (Saunders et al., 2018; Eisenberg et al., 2019; Joseph & Newman, 2010; Murphy & Lilienfeld, 2019). The information derived by lab-based task will offer a broad picture of of social functioning abilities, compared to proxy report (Mikami et al., 2019).
II	72	ADHD TD	Social perception Higher-order cognitive skills:	1. Examining social perception, investigating the role of nonverbal signals recognition	• A benefit from nonverbal signals recognition (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010) and the simultaneous

			a) ToM b) Attention and executive functions c) Pragmatic language	and of different type of stimuli; 2. Analyzing the different contributions of ToM, attention and executive functions, and pragmatic language skills.	presentation of audio and video stimuli (Cortes et al., 2021; Hunter et al., 2010; Wieck & Kunzmann, 2017) are expected. • ToM, attention and executive functions, and pragmatic language should be related to social perception (Beauchamp & Anderson, 2010; Yang et al., 2015) with different involvement of each ability depending on the task condition (i.e., video, audio and multimodal/combined) (Mitchell & Phillips, 2015; Semrud-Clickeman, 2010; Russell, 2007; Socher et al., 2019).
III	222	ADHD ASD TD	Overestimation of abilities	1. Identifying the overestimation of social abilities in ADHD and ASD; 2. Investigating the estimation of behavioral problems in ADHD, ASD and TD, 3. Examining the role of internalizing and externalizing symptoms in the overestimation of abilities.	• Both ADHD and ASD will overestimate their own social skills (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007), with higher overestimation in ADHD (Wanstall et al., 2019). • The overestimation of ability is expected only in some areas of functioning (Owens et al., 2008; McQuade et al., 2010). • Higher clinical impairments should emerge (both internalizing and externalizing disorders) in both clinical conditions (Jensen et al., 2001; Rosenberg et al., 2011). Both internalizing and externalizing difficulties should have an impact on the overestimation of abilities.
IV	83	ADHD TD	Overestimation of social abilities	1. Identifying the overestimation of social abilities in ADHD;	• An overestimation of social abilities is expected (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007).

	Neuropsychological deficits Communication impairments	2. Investigating the role of neuropsychological deficits and communication impairments.	• Both neuropsychological deficits and communication impairments are expected to mediate the relation between ADHD and the overestimation of social abilities (Owen et al., 2003; Staikova et al., 2013).

Note: ADHD: Attention deficit hyperactivity disorder; ASD: Autism Spectrum Disorders; TD: Typically developmental children; ToM=Theory of mind

Chapter 2

Social functioning in ADHD and ASD population

2.1 Introduction

In the last few years, several authors (see for a review Harpin et al., 2016) focused on the social functioning impairment associated to ADHD. Beside ADHD, also children and adolescents with autism spectrum disorder (ASD) are clearly characterized by social functioning impairments. ASD is described by enduring and impairing social communication and interaction deficits that occur across multiple contexts along with the presence of restricted, repetitive behaviors, interests or activities, or sensory symptoms (DMS-5, APA, 2013). Taking into account these considerations, social functioning is a central domain of impairment in both disorders which significantly affects prognosis, considering that dysfunctional peer relations in childhood are one of the strongest predictors of poor outcomes and adjustment in adolescence and adulthood (Landau et al., 1998; Parker & Asher, 1987). However, the specific aspects impaired of social functioning may have both shared and distinct characteristics between the two disorders. Mikami et al. (2019) in their review have provided some clues to the nature of these impairments by focusing on the mechanisms underlying their expression in ADHD and ASD, but differences and similarities are not clear enough. Moreover, previous research mainly assessed these complex abilities with indirect measures (i.e., self- or proxy report, Gresham & Elliot, 2008), which data should be interpreted with caution, considering that self-report responses are not objective (Rao, et al., 2008). By contrast, reports from multiple observations or lab-based tasks would offer the most comprehensive picture of the child's areas of strengths and deficiencies (Mikami et al., 2019).

The purpose of this study is to compare and contrast the manifestation of social functioning

impairments (specifically on social perception, social performance and social knowledge) that occur in ADHD relative to ASD, comparing them with Typically Developmental (TD) children, proposing both indirect and lab-based tasks.

Social Perception in ADHD and ASD

Social perception involves the ability to interpret emotional signals and to perceive others' mental states correctly. These abilities are involved in the first two steps of the Social Information Processing (SIP) model (i.e., a) encoding of internal and external cues; b) interpretation of the social stimuli) (Crick & Dodge, 1984). Specifically, children with ADHD have difficulties in identifying and labeling emotions (Braaten & Rosén, 2000; Uekermann et al., 2010), independently from the ADHD presentation (combined or inattentive, Dyck et al., 2001; Semrud-Clikeman, et al., 2010). Further, ADHD population seem to be affected by the hostile attribution bias (Sibley et al., 2010) characterized by the inferences that the peer performed the action to be mean, or to intentionally hurt or harm. Children with ASD are also characterized by social perception impairments (Baron-Cohen, 2000), specifically in interpreting facial expressions compared to TD children (Lozier, et al., 2014; Tye et al., 2014). Nonetheless, the severity of social perception impairments is thought to be greater in ASD as compared to ADHD (Semrud-Clikeman et al., 2010; Dyck et al., 2001; Ames & White, 2011), although both groups seem to show more difficulties than controls (Bora & Pantelis, 2016). It is worth noting, however, that previous studies rarely embraced the multifaceted complexity of social perception abilities, or their association with other factors, such as nonverbal signals recognition (see chapter 3 for a detail description of this topic).

Social performance in ADHD and ASD

Social performance is defined as all verbal or nonverbal actions displayed in peer situations. According to the SIP model this ability embraces the clarification of social goals (such as maintaining a good relationship or taking revenge) and the generation of a first spontaneous response. This

response could consist of the presence of positive behaviors (assertive answers), negative behaviors (aggressive answers), or alternatively, the absence of both positive and negative behaviors (passive answers). The negative behaviors among children and youth with ADHD are well-documented (Abikoff et al., 2004; Gardner & Gerdes, 2015; Ronk, et al., 2011), such that ADHD usually show more aggressive answers (Abikoff et al., 2004; Erhardt & Hinshaw, 1994). Conversely, it is not clear enough if children with ADHD are not able to show positive behaviors (i.e., prosocial skills and empathetic responding), compared to TD children (Braaten & Rosén, 2000). Social performance difficulties of children with ASD may instead most pertain to the presence of passive answers (Matson & Wilkins, 2007). These findings show that both children with ADHD and ASD are affected by social performance impairments with some differences. Children and adolescents with ADHD are more likely to demonstrate the presence of aggressive behaviors. By contrast, children and adolescents with ASD tend to show passive answers (Channon et al., 2001). These outcomes manly emerged from proxy report assessments, however; further studies on social performances with direct observations or lab-based tasks are needed (Mikami et al., 2019).

Social knowledge in ADHD and ASD

Social knowledge refers to the knowledge of what to do in a specific social situation (Gresham, 1997). This ability represents the final step of the SIP model (Crick & Dodge, 1984). Previous research underlined as children with ADHD are thought to possess adequate knowledge of the rules of the social context (Barkley, 2014). Specifically, these findings mainly emerged by parents' and teachers' reports, which underlined only performance deficits compared to their peers (Aduen et al., 2019), but few previous studies tested this aspect with lab-based tasks with contradictory findings. By contrast, children with ASD frequently show less knowledge of correct social behaviors compared to TD children, even with adequate intellectual abilities (Matson &

Wilkins, 2007). Therefore, additional research is necessary to directly compare social knowledge abilities in both children with ADHD and with ASD.

2.2 Overview of the current study

As outlined above, previous studies underlined social functioning impairments in both ADHD and ASD population (see for a review Antshel & Russo, 2019 and Mikami et al., 2019). These findings mainly emerged with indirect measures, such as self- or proxy-report (Uekermann et al., 2010; Antshel & Russo, 2019). Few studies, however, have analyzed the characteristics of social functioning impairments with lab-based tasks in these two clinical populations. Furthermore, the shared and distinct specific biases in the steps of the SIP model (Van Rest et al., 2019) are not well understood.

The first aim of the present study was therefore to replicate previous findings using proxy-reports about the general social functioning in children and adolescents with ADHD, compared to ASD and TD individuals. In addition, our second aim was to analyze the specific difficulties encountered in the three main influential components of social functioning (i.e., social perception, social performance and social knowledge) with lab-based tasks created ad hoc for the study. Particularly, each step of the SIP model (i.e., encoding of social cues, interpretation of social cues, spontaneous response access or construction, clarification of goals and response decision) was analyzed in each group. Finally, the third aim was to examine the relation between proxy-reports and lab-based tasks.

As for the first aim, considering previous studies assessing social functioning in children with ADHD and ASD (see for a review Antshel & Russo, 2019 and Mikami et al., 2019), these populations were expected to show significant worst abilities compared to TD children. Specifically, we hypothesize that despite social problems affect both disorders, their severity and consistency would be highlighted in the proxy reports as greater in ASD than ADHD (APA, 2013; Bora & Pantelis, 2016).

Regarding our second aim, we expected that the two clinical populations had significant worst abilities compared to TD children, but with some specificities, when the three main influential components of social functioning (i.e., social perception, social performance and social knowledge) are assessed with lab-based tasks. Regarding social perception, we expect children and adolescents with ASD show greater difficulties than ADHD in the encoding of social cues (see for a review Bora & Pantelis, 2016). About the interpretation of social cues, the hostile attribution bias is expected only in the ADHD population (Sibley et al., 2009), while we do not have specific hypothesis for ASD population, given that no previous studies to our knowledge examined the interpretation of social cues in this group. Concerning social performance, we hypothesize a higher presence of choice of negative goals and negative social behaviors (aggressive answers) among the ADHD sample, while the absence of both negative and positive social behaviors (passive answers) is expected in the ASD group (Channon et al., 2001; Gardner & Gerdes, 2015; Ronk, et al., 2011). Finally, about social knowledge, ADHD are thought to possess intact abilities (Barkley, 2014), by contrast, children with ASD are expected to show less knowledge of correct social behavior (Matson & Wilkins, 2007).

Finally, regarding our final aim, we do not expect strong correlations between proxy report and lab-based tasks. It is in fact well known that lab-based tasks rarely correlate with proxy-report measures, as they assess partially different aspects (Joseph & Newman, 2010; Murphy & Lilienfeld, 2019). However, the information derived by our lab-based task, is expected to offer a broader picture of the complex domain of social functioning abilities than the proxy report frequently used in previous studies (Mikami et al., 2019).

2.3 Method

2.3.1 Participants

Two hundred and twenty-five children (86% M) between 8 and 16 years of age (in months *M*=135.12, *SD*=25.69) were included in the study. Sixty-six participants had a clinical diagnosis of

ADHD (87% M) and 51 participants had a clinical diagnosis of ASD (85% M). Finally, 108 typically-developmental (TD) children (88% M) were enrolled.

Participants with ADHD and ASD had a clinical diagnosis according to the DSM 5 criteria (APA, 2013), previously established by child psychiatrists or psychologists of the hospital or clinical center to which they referred. To confirm the ADHD diagnosis the Conners' Parent Rating Scale (CPRS-R:S, Conners, 1997) were used: only children showing T scores of 65 or higher for inattention and/or hyperactivity and ADHD index were included in this group. To confirm the diagnosis of ASD we used the Autism Diagnostic Interview - Revised (ADI-R; Rutter et al., 2005): only participants who scored above the cut-off on the three modules of the ADI-R, including stereotyped behaviors, were included. All participants were native Italian speakers, and none had visual or hearing impairments. For all participants, the exclusion criteria were: a concurrent diagnosis of other neurodevelopmental disorders; a history of neurological problems; ongoing use of medication; or an intelligence quotient (IQ) below 85.

The three groups were matched on gender, chronological age [$F(2, 222) = .62$, $p = .54$, *Adjusted* $R^2 = .01$], and IQ [$F(2, 222) = 3.76$, $p = .07$, *Adjusted* $R^2 = .02$], as measured using the WISC-IV (Wechsler, 2012).

The ADHD group scored significantly higher than the ASD and the TD group on all CPRS-R:S' indexes: oppositional [$F(2, 222) = 35.1$, $p < .001$, *Adjusted* $R^2 = .23$]; cognitive problems/inattention [$F(2, 222) = 98.56$, $p < .001$, *Adjusted* $R^2 = .47$]; hyperactivity [$F(2, 222) = 77.93$, $p < .001$, *Adjusted* $R^2 = .41$]; and ADHD index [$F(2, 222) = 127.9$, $p < .001$, *Adjusted* $R^2 = .53$]. The ASD group scored significantly higher than the ADHD and the TD group on all ADI-R indexes: reciprocal and social interactions [$F(2, 222) = 156.3$, $p < .001$, *Adjusted* $R^2 = .58$]; language/communication [$F(2, 222) = 125.8$, $p < .001$, *Adjusted* $R^2 = .53$]; repetitive behaviors/interests [$F(2, 222) = 69.86$, $p < .001$, *Adjusted* $R^2 = .38$]. The participants' characteristics are summarized in Table 2.1.

Table 2.1 Characteristics of the ADHD, ASD, and typically-developing (TD) groups: means (M), standard deviations (SD) and results of ANOVAs.

	ADHD (n=66)	ASD (n=51)	TD (n=108)	ANOVAs			
	M (SD)	*M (SD)*	*M (SD)*	*F (2, 222)*	*p*	*Adjusted R^2*	*Post-hoc*
Age (in months)	132.63 (20.44)	137.96 (31.43)	135.30 (25.66)	.62	.54	.01	
IQ	106.45 (11.55)	106.41 (13.41)	110.63 (10.31)	3.76	.07	.02	
CPRS-R:S							
Oppositional	65.67 (15.72)	59.49 (14.88)	48.95 (10.26)	35.1	<.001	.23	ADHD>ASD>TD
Cognitive problems, inattention	73.89 (10.90)	63.67 (14.51)	49.13 (10.24)	98.56	<.001	.47	ADHD>ASD>TD
Hyperactivity	68.53 (14.31)	59.86 (14.54)	46.08 (8.13)	77.93	<.001	.41	ADHD>ASD>TD
ADHD index	73.98 (9.86)	62.20 (13.02)	48.40 (9.20)	127.9	<.001	.53	ADHD>ASD>TD
ADI-R							
Reciprocal and social interactions	6.15 (4.32)	16.88 (6.50)	3.65 (3.12)	156.3	<.001	.58	ASD>ADHD>TD
Language/communication	5.50 (3.80)	11.92 (4.44)	2.51 (2.65)	125.8	<.001	.53	ASD>ADHD>TD
Repetitive behaviors/interests	2.76 (2.44)	5.84 (3.68)	.95 (1.51)	69.86	<.001	.38	ASD>ADHD>TD

Note. ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; IQ= Intelligent Quotient; CPRS-R:S=Conners' Parent Rating Scale- Revised: Short Form; ADI-R=Autism Diagnostic Interview-Revised

2.3.2 Materials

Social Skills Improvement System-Rating Scale (SSIS-RS)

The SSIS-RS (Elliott & Gresham, 2008) is a parent- and a self-report measure assessing two domains of social functioning: social skills and problem behaviors. In the present study, the parent-report of the social skills subscale was considered. The social skills subscale involves 46 items (e.g., "Invites others to join in activities"; "Follows rules when playing games with others"), rated on a four-point scale (from 0 = never to 3 = almost always). Scores on the social skills subscale range from 0 to 138. Higher scores represent higher children's social skills. The raw scores were used in the subsequently analysis (Lyons et al., 2016; Montroy et al., 2014). The overall internal consistency of the measure in our sample was good (Cronbach's $\alpha = .94$).

Social Information Processing test

The Social Information Processing test (adapted from Van Rest, et al., 2017) assessed the following five cognitive steps of the SIP model which allow to select an appropriate social response: (a) encoding of social cues, (b) interpretation of social cues, (c) spontaneous response access or construction, (d) clarification of goals, and (e) response decision. As in the original research (Van Rest, et al., 2017), in our study, participants were presented with three videos representing social problem situations among peers. Differently from Van Rest and colleagues who presented one ambiguous, one hostile, and one accidental social problem, in all our videos, the intent of the perpetrator was designed to be clearly hostile, and the child was asked to empathize with the victim. We choose to present only hostile situations in order to prevent a low reliability of the measure. After each video, participants were asked to respond to both open-ended and multiple-choice questions regarding the five cognitive steps (adapted from Van Rest et al., 2017):

(a) *Encoding of social cues* was assessed by responses to an open-ended question "What happened in this video?". The most essential cues in the social situation were scored from

the verbal answer by the respondent. Zero to two points were attributed per answer, depending on its completeness. The overall internal consistency of the measure was good (Cronbach's $\alpha = .76$). Sum of the scores were calculated across the three videos, higher scores represent better performance.

(b) *Interpretation of social cues* was assessed by administering three multiple-choice questions for each video. The first examined attributions of the perpetrator's intent by asking "Is the intent of [this boy/girl] hostile?". The second item examined purposeful intent with the following question, "Did [this perpetrator] do that on purpose?". The third item examined the emotional impact on the participant using the question "Did you feel reject by [the perpetrator]?". Answers were given on a six-point Likert-type scale from 0 (definitely not) to 5 (definitely yes). Across the three videos of the current study, the overall internal consistency of the measure was good (Cronbach's $\alpha = .77$). Mean scores were calculated across the three videos, higher scores represent higher hostile interpretation.

(c) *Spontaneous response access or construction* is a measure of response generation and was assessed with the open-ended question: "If this happened to you, what would you do?". Answers were coded by two independent reviewers according three categories: aggressive, assertive, or passive (inter-rater agreement 80%).

(d) *Clarification of goals* was assessed after repeating the spontaneous response provided by the participant. "You just mentioned you would do X" followed by five multiple-choice items for each video ("Do you want to take revenge?; Do you want to keep a good relationship?; Do you want to prevent a fight or an argument?; Do you want to show [the perpetrator] who is the boss?; Do you want to earn respect?"). Each multiple-choice question was presented independently from the spontaneous response provided by the participants, as in the original test. Answers were given on a six-point Likert-type scale from 0 (definitely not true)

to 5 (definitely true). Answers given to the following questions: “Do you want to keep a good relationship?; Do you want to prevent a fight or an argument?” were reversed. The overall internal consistency of the measure was good (Cronbach’s $\alpha = .78$). Mean scores were calculated across the three videos, higher scores represent higher choice of negative goals.

(e) *Response decision* was assessed by presenting three different alternatives (one aggressive, one assertive, and one passive) to each situation and asking which was the best choice according to the participant. The order of the three alternatives were presented counterbalanced among the three stories.

2.3.3 Procedure

The study was approved by the Ethics Committee of the University of Padua. Written consent was obtained from children’s parents before they took part in the study. Participants with clinical diagnoses were recruited through local hospitals or clinics, whereas TD children were enrolled through local contacts or schools in Italy. Participants were tested in a quiet room during one individual session lasting approximately 60 minutes each. The three videos of the Social Information Processing test were administered in a counterbalanced order.

2.4 Results

Data analyses

The statistical analyses were conducted using R (R Core Team, 2019). One-way ANOVAs were run for the general index of the SSIS-RS and for three steps of the SIP test (*Encoding of social cues, Interpretation of social cues* and *Clarification of goals*). To analyze the other two steps of the SIP test (*Spontaneous response access or construction* and *Response decision*), considering the categorical definition of the variables (aggressive, assertive, and passive), two mixed-effects multinomial models were used. Groups were treated as fixed effects and participants were included as random effects. The two models were fitted using the “brms” package (Bürkner, 2017), which

uses the Markov chain Monte Carlo (MCMC) Bayesian estimation method. The models were assessed using four chains each with 2,000 iterations. The probability distributions of the fixed effects were examined. Finally, in order to analyze the associations between general social functioning assessed with proxy report and the specific steps of the SIP model tested by lab-based tasks correlation analyses were performed separately for each group. For this purpose, for the categorical variables (i.e., *spontaneous response access or construction* and *response decision*), each answer was dichotomized for the presence or absence (yes/no) of each category (i.e., aggressive, assertive and passive).

Table 2.2. Characteristics of the ADHD, ASD and typically-developing (TD) groups: means (M), standard deviations (SD) and results of ANOVAs.

	ADHD (n=66)	ASD(n=51)	TD (n=108)	ANOVAs			
	M (SD)	*M (SD)*	*M (SD)*	*F (2, 222)*	*p*	*Adjusted R2*	*Post-hoc*
SSIS-RS	83.54 (16.64)	83.24 (18.15)	105.06 (13.04)	55.48	<.001	.33	TD>ADHD,ASD
SIP test							
Encoding of social cues	3.71 (1.16)	3.37 (1.65)	4.58 (1.18)	18.41	<.001	.13	TD>ADHD,ASD
Interpretation of social cues	4.27 (.63)	3.13 (.89)	4.16 (.59)	28.58	<.001	.24	TD,ADHD>ASD
Clarification of goals	3.11 (1.06)	2.69 (.92)	2.24 (.77)	19.65	<.001	.14	ADHD>ASD>TD

Note. ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; SSIS-RS= Social Skills Improvement System-Rating Scale; SIP test=Social Information Processing test

Social Skills Improvement System-Rating Scale

Table 2.2 sums up the descriptive statistics for the three groups (ADHD, ASD and TD) on the Social Skills Improvement System-Rating Scale, for the parents' reports. A main effect of group emerged for the social skills scale (*F[2, 222]*=55.48, *p*<.001, *AdjustedR*^{2}=.33). Parents of children with ADHD or ASD reported a significantly worse social performance than TD children (p_s<.001). No other difference emerged among the groups.

Social Information Processing test

Descriptive statistics for the three groups (ADHD, ASD and TD) on the Social Information Processing test are presented in Table 2.2.

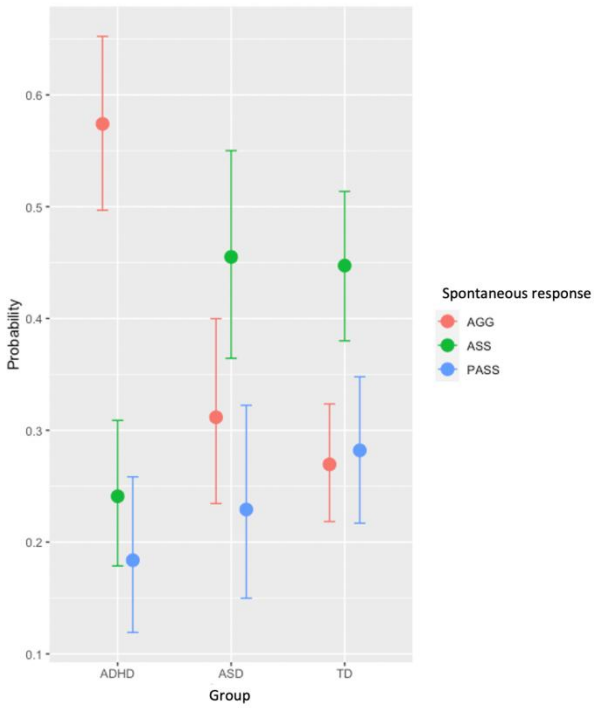
(a) Encoding of social cues. A main effect of group emerged for the *Encoding of social cues* (*F[2, 222]*=18.41, *p*<.001, *AdjustedR*^{2}=.13). Children with ADHD or ASD performed significantly worse than TD children (p_s<.001). No other difference emerged among the groups.

(b) Interpretation of social cues. A main effect of group emerged for the *Interpretation of social cues* (*F[2, 222]*=28.58, *p*<.001, *AdjustedR*^{2}=.24). Children with ASD showed significantly lower hostile interpretation of the social stimuli than children with ADHD and TD children (p_s<.001). No other difference emerged among the groups.

(c) *Spontaneous response access or construction.* Figure 1 shows the effect of the groups on *spontaneous response access or construction*: in ADHD group aggressive answers were more likely than both assertive and passive answers; whereas in both ASD and TD groups assertive answers were more likely than the other two categories, but within each group different patterns emerged. Specifically, within the ADHD group aggressive answers [*B*=.58, *credible interval* (.50, .65)] were more likely than both assertive [*B*=.24, credible interval (.18, .31)] and passive [*B*=.18, *credible interval* (.12, .25)] answers, with no overlaps; moreover, assertive answers were more likely than passive answers, but with high overlap between the two categories. Within the ASD group assertive

answers [*B*=.46, *credible interval* (.37, .55)] were more likely than both aggressive [*B*=.31, *credible interval* (.24, .39)] and passive [*B*=.23, *credible interval* (.15, .32)] answers, with a mild overlap between assertive and aggressive answers; moreover, aggressive answers were more likely than passive answers, but with high overlap between the two categories. Finally, within the TD group assertive answers [*B*=.45, *credible interval* (.38, .51)] were more likely than both passive [*B*=.28, *credible interval* (.21, .35)] and aggressive [*B*=.27, *credible interval* (.22, .39)] answers, with no overlaps; moreover, a quite total overlap between passive and aggressive answers emerged. Model coefficients supported the observations emerging from a visual inspection of the Figure 2.1.

Figure 2.1. Group effect on *spontaneous response access or construction*. Points represents the posterior mean estimate of the probability of ratings in each response category (indicated by different color) for each of the three groups. Error bars indicate 95% credible intervals.

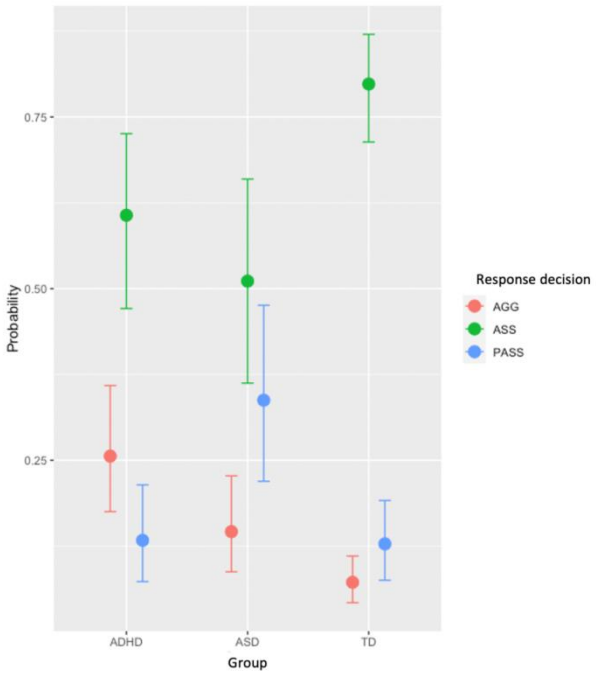


Note. ADHD=Attention deficit/hyperactivity disorder group; ASD=autism spectrum disorder group; TD=typically-developing group; AGG=aggressive; ASS=assertive; PASS=passive

(d) Clarification of goals. A main effect of group emerged for the *Clarification of goals* (*F[2, 222]*=19.65, *p*<.001, *AdjustedR*^{2}=.14). Children with ADHD showed significantly higher choice of negative goals than children with ASD and TD children (ASD: *p*=.01; TD: p<.001). Moreover, children with ASD showed significantly higher choice of negative goals than TD children (*p*=.003).

(e) Response decision. Figure 2.2 shows the Group effect on *response decision*: in each group assertive answers were more likely than both aggressive and passive answers, but different patterns emerged within each group. Specifically, within the ADHD group the choice of assertive answers [*B*=.61, *credible interval* (.48, .73)] were more likely than both aggressive [*B*=.26, *credible interval* (.17, .36)] and passive [*B*=.13, *credible interval* (.07, .21)] answers, with no overlaps; whereas the choice of aggressive answers were more likely than passive answers with mild overlap between them. Within the ASD group the choice of assertive answers [*B*=.52, *credible interval* (.36, .67)] were more likely than both passive [*B*=.34, *credible interval* (.22, .52)] and aggressive [*B*=.14, *credible interval* (.09, .23)] answers, with high overlap between assertive and passive answers; moreover, the choice of passive answers were more likely than aggressive one, with no overlap. Finally, within the TD group the choice of assertive answers [*B*=.52, *credible interval* (.36, .67)] were more likely than both passive [*B*=.13, *credible interval* (.03, .19)] and aggressive [*B*=.14, *credible interval* (.09, .23)] answers, with no overlaps; whereas the choice of passive answers were more likely than aggressive ones, with mild overlap. Model coefficients supported the observations emerging from a visual inspection of the Figure 2.2.

Figure 2.2. Group effect on *response decision*. Points represents the posterior mean estimate of the probability of ratings in each response category (indicated by different color) for each of the three groups. Error bars indicate 95% Credible intervals.



Note. ADHD= Attention deficit/hyperactivity disorder group; ASD=autism spectrum disorder group; TD= typically-developing group; AGG=aggressive; ASS=assertive; PASS=passive

Pearson's correlations between proxy report and lab-based tasks

Pearson's correlations between the SSIS-RS and each step of the SIP test are presented in Table 2.3. As shown in the table, *the encoding of social cues* does not correlate with social functioning assessed by proxy report (SSIS-RS) in any group. A significant medium correlation emerged between interpretation of social cues and SSIS-RS only for ASD group (r=-.40, p<.01); no other significant relations emerged. Additionally, no significant correlations were found between *spontaneous response access or construction* and *clarification of goals* with SSIS-RS, in each group. Finally, about the *response decision* step, a significant medium correlation emerged between aggressive and assertive answers with SSIS-RS only for ADHD group (respectively r=-.24 and r=.21, p<.01); significant low correlations also emerged between assertive and passive answers with SSIS-RS only for TD group (respectively r=.13 and r=.12, p<.01); no other significant relations emerged.

Table 2.3. Correlation Coefficients between SSIS-RS and the five SIP steps (i.e., encoding and interpretation of the social cues; spontaneous response access or construction; clarification of goals; response decision) in each group (ADHD; ASD; TD).

		ADHD (N=66) SSIS-RS	ASD (N=51) SSIS-RS	TD (N=108) SSIS-RS
Encoding of social cues		.04	.01	.08
Interpretation of social cues		.02	**-.40***	-.06
Spontaneous response access or construction	AGG[#]	.04	.01	-.05
	ASS[#]	-.07	-.01	.01
	PASS[#]	.02	-.01	.04
Clarification of goals		.15	-.11	.07
Response decision	AGG[#]	**-.24****	.03	.04
	ASS[#]	**.21****	.02	**.13****
	PASS[#]	-.01	-.05	**.12****

Note: *p<.05; **p<.01; ***p<.001; [#]Point-biserial correlations

ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; SSIS-RS= Social Skills Improvement System-Rating Scale; AGG=aggressive answers; ASS=assertive answers; PASS=passive answers.

2.5 Discussion

Social functioning impairments in both ADHD and ASD population (see for a review Antshel & Russo, 2019 and Mikami et al., 2019) is frequently highlighted using indirect measures, as self- or

proxy-report measures (Uekermann et al., 2010; Antshel & Russo, 2019). Otherwise, very few studies analyzed the characteristics of social functioning impairments with lab-based tasks in ADHD and ASD samples with inconclusive results (Bora & Pantelis, 2016). This study was aimed at shedding light on social functioning in ADHD and ASD, compared with TD children with both indirect measure and lab-based tasks, assessing different domains of social functioning (i.e., social perception, social performance and social knowledge).

Our first goal was to verify the social functioning with proxy report in children and adolescents with ADHD, compared to ASD and TD individuals. Overall, our results confirm that both clinical populations have significant impairments in social functioning compared to TD children (see for a review Mikami et al., 2019). Surprisingly, no differences emerged between the two clinical populations. This outcome is contrary to that of Semrud-Clikeman et al. (2010) and Dyck et al. (2001), who underlined higher impairments in ASD population than ADHD. A possible explanation for this might be that the parent-report used in the present study covers a wide range of social behaviors as cooperation, assertion, responsibility, self-control, communication, empathy and engagement (Gresham & Elliot, 2008). Some behaviors (i.e., responsibility and self-control) might be only impaired in the ADHD population, whereas others only in the ASD one (i.e., communication and engagement). Further studies are needed to examine more in depth these aspects, to replicate our findings and to better investigate groups' differences in social functioning abilities, by using and comparing different parent-report measures.

Our second goal was to analyze the specific difficulties encountered in three main influential components of social functioning (i.e., social perception, social performance and social knowledge) with specific lab-based tasks, in light of the fact that several studies proposed specific impairments associated to each domain in these two clinical populations (Uekermann et al., 2010; Baron-Cohen, 2000; Abikoff et al., 2004; Matson & Wilkins, 2002; Barkley, 2014; Aduen et al., 2019). Each step of

the SIP model (i.e., encoding of social cues, interpretation of social cues, spontaneous response access or construction, clarification of goals and response decision) was analyzed in both clinical groups (i.e., ADHD and ASD), compared with the TD group. Social perception, assessed in this study with the two first steps of the SIP model (encoding and interpretation of social cues), is usually impaired in both children with ADHD and ASD compared to TD children (Uekermann et al., 2010; Baron-Cohen, 2000), with higher difficulties in ASD population (Bora & Pantelis, 2016). As hypothesized, in our sample both children with ADHD and ASD revealed worst abilities in social perception, compared to TD children. Some differences emerged between the two clinical populations, related to the specific steps taken into account. Specifically, both ADHD and ASD showed encoding impairments compared to TD children. This is unsurprisingly considered that several previous studies (see for a review Bora & Pantelis, 2016) underlined significant difficulties in encoding social stimuli from both clinical populations. Contrary to previous studies (Semrud-Clikeman et al., 2010; Dyck et al., 2001; Ames & White, 2011), no differences emerged between the two clinical populations in the encoding of social cues. This is probably due to the complexity of the request ("What happened in this video?"), which could be influenced not only from poor social perception abilities but also from attention problems. About the interpretation of social stimuli, the hostile attribution bias (Sibley et al., 2009) was not confirmed in our ADHD sample. Children with ADHD estimate the same level of aggressiveness of children with TD. This is probably due to the specific social stimuli shown, clearly hostile. Further studies may deep this estimation of aggressiveness with more ambiguous stimuli. Differently, children with ASD underestimate the level of aggressiveness, compared both to ADHD and TD children. This result may be explained by the emotion recognition difficulties of children with ASD. Previous studies underlined that these children show difficulties with both low and high intensity emotion recognition (Uekermann et al., 2010; Baron-Cohen, 2000). Overall, as expected (see for a review Bora & Pantelis, 2016), we found

that both clinical populations had significant difficulties in social perception compared to TD, with children and adolescents with ASD showing greater difficulties than ADHD.

Concerning social performance assessed with clarification of goals and spontaneous answers generation in our SIP test, our hypotheses were partially confirmed. Children with ADHD were characterized by higher presence of negative goals and aggressive answers, compared to both ASD and TD sample (Channon et al., 2001). Contrary to previous findings (Gardner & Gerdes, 2015; Ronk, et al., 2011), despite their choices of higher negative goals compared to TD, children with ASD show similar probability to generate assertive answers. A possible explanation may be that interventions for ASD, frequently focused on assertiveness, improved these specific aspects of social performance in our group of participants.

About social knowledge our hypotheses were totally confirmed. Children with ADHD possess intact abilities (Barkley, 2014), choosing with highest probability the assertive answers as the best one in social context. By contrast, children with ASD show less knowledge of correct social behavior (Matson & Wilkins, 2007), showing with higher probability the choice of both assertive and passive answers.

Finally, our third goal was to examine the correlation between the parent-report measure and our Social Information Processing test. As expected (Joseph & Newman, 2010; Murphy & Lilienfeld, 2019), different correlations emerged between the variables in each group. Social perception abilities correlate with parents' estimation of social functioning, in children with ASD. Considering few peer interactions of children with ASD, it is possible their parents based the estimation of social abilities only on children's ability to interpret emotional signals and to perceive others' mental states correctly. On the other hand, social knowledge and not social performance correlates with parent's estimation of social functioning, in both children with ADHD and TD. It is possible that these parents estimate their children's social abilities on the story telling of social

interactions rather than on direct observations of children's interactions. Further studies are necessary to expand these hypotheses. Generally, our lab-based task, using videos which provided an optimal way to facilitate the identification process of children in some real social contexts, offers a broader and clearer picture of the complex domain of social functioning abilities than the proxy report frequently used in previous studies (Mikami et al., 2019). This finding highlight one more time the importance to empirically assess social functioning in clinical evaluation. Evaluating these peculiar characteristics may be useful to develop treatments with higher efficacy and specificity for each clinical population.

While this study provides new insights into the specific domains of social functioning that may be impaired in ADHD or ASD, it also reveals some limits. First of all, SIP steps were assessed based upon responses to questions about only three videos in which only hostile interactions among peers were shown. The decision for using a small number of videos was made to produce feasible test durations and valid outcomes for youth with clinical diagnosis, who would not tolerate lengthier test administrations. However, we cannot exclude that the use of hostile interactions may have increased the differences between ADHD and ASD, despite the presence of the hostile attribution bias was not confirmed in our sample of ADHD. Future research may include other interactions (i.e., ambiguous or positive) to obtain a wider overview of social functioning of children with ADHD and ASD. Second, the perception of social functioning abilities was only recorded with parent-report measures, the child's perception of their own social skills was not considered. This choice was made to limit the presence of underestimation of their own problems from children with ADHD or ASD, called Positive Illusory Bias (Hoza et al., 2005) that will be examined in the next chapters. Finally, males were disproportionately represented in our sample. This is not surprising, as sex differences in the incidence of both ADHD and ASD have been well documented in the literature. Nonetheless,

further studies should try to replicate our findings in samples of children with a similar proportion of male and female participants.

Overall, our findings partially confirm previous results in the literature. Children with ADHD or ASD shown significant impairments in social functioning compared to TD children as emerged from the results of the parent-report measure. However, some peculiarities of social impairments were better observed in the Social Information Processing test. Children with ADHD showed high difficulties in social performance, whereas children with ASD revealed more difficulties in social perception and only partially in social knowledge.

Chapter 3

Social perception in ADHD:

the role of higher-order cognitive skills

3.1 Introduction[1]

Previous studies showed social perception impairment in ADHD (Bora & Pantelis, 2016; Uekermann et al., 2010). However, the specific factors that influence social perception difficulties in ADHD are still to be understood.

Social perception involves several skills, such as: recognizing emotions; processing nonverbal signal recognition, as facial expressions and body gestures; attributing to others' opinion and thoughts; paying attention to several stimuli; understanding pragmatic language. Most of previous studies have investigated social perception focusing primarily on children's ability to accurately identify emotional states by presenting facial expressions (often static pictures) or vocal expressions in isolation (see Bora & Pantelis, 2016 for a review). Those studies revealed a worst performance in emotional recognition tasks in children with ADHD than their typically developmental (TD) peers, reinforcing the hypothesis of the existence of social perception deficits in this clinical group (Tehrani-Doost et al., 2017). However, findings have not been consistent in all studies. For example, Wells et al. (2019) found evidence against deficit in emotional recognition in children with ADHD. According to the authors, between-group differences underlined in previous studies were related to the type of measures used, as well as the task's demands. Similarly in our Study I, significant social

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perception impairments emerged compared to TD children, but it was not clear if it depends on the tasks demands or represent a real impairment. Moreover, in real social situations, emotions are expressed by a combination of dynamic facial, vocal, and bodily expressions, and contextual information is believed to play a significant role in how emotion and nonverbal cues are interpreted (Magill-Evans et al., 1995). Thus, the multifaceted complexity of social perception was not embraced in previous emotional recognition tasks and the role of crucial additional factors was poorly considered. For example, nonverbal signals recognition (i.e., including eye contact, facial expressions, gestures, posture, and body language, the use of social cues, distance between people, physical environments/appearance, voice and touch) is essential in ambiguous situations to infer emotional information from context rather than from direct evidence or facial expressions.

Little research has included these aspects or addressed social perception as the synthesis of information from different channels. To the best of our knowledge, only three studies assessed social perception ability within a semi-naturalistic context, taking also nonverbal signals into account. These studies used the Children and Adolescents Social Perception (CASP) measure, in which video recordings of social interactions between two or more child actors were shown with voice prosody intact, but lexical content obscured by distortion. The CASP was developed as a clinical tool for evaluating social perception in children and adolescents, indeed to perform the task correctly, children have to watch each social scene, understand what happened in the interaction between the actors, and describe what each of the people was feeling, and how they could tell the person was feeling that way, inferring emotional states from nonverbal cues (MagilI-Evans, et al., 1995). The CASP thus assesses a more extended ability than simple emotion recognition (Semrud-Clikeman et al., 2010; Fine et al., 2008). Using this task, Fine et al. (2008) underlined that ADHD children performed more poorly than controls on measures of social perception. Similarly, Semrud-Clikeman (2010; Semrud-Clikeman et al., 2010), in two different studies with the CASP, highlighted

that social perception difficulties were independent from different subtypes of ADHD (combined or predominately inattentive). All children with ADHD performed significantly worse than controls on social perception. The results of these studies suggest that children and adolescents with ADHD have significant social perception impairments within a semi-naturalistic context.

Despite the interesting results, which seemed to confirm social perception impairment in children with ADHD, also when assessed within a semi-naturalistic context, previous studies never explored whether stimuli visually or orally presented may affect this ability. Previous research in typical population involving either young or older adults (Cortes et al., 2021; Hunter et al., 2010; Wieck & Kunzmann, 2017) have shown differences in the participants performance according to different types of stimuli. Specifically, Hunter et al. (2010), comparing three conditions (i.e., video, audio, and combined/multimodal), found that participants, independently from their age, may benefit from the multimodal condition and perform worse in the unimodal one. Similarly, Cortes et al. (2021) and Wieck & Kunzmann (2017) highlighted that emotional recognition impairments may become less evident when dynamic emotional stimuli were used.

Overall, these findings emphasize social perception impairments in children with ADHD, but it is not clear if these difficulties are related to the type of tasks used or represent a real deficit. The use of semi-naturalistic tasks appears to be of particular interest in order to gain a better understanding of this complex domain and highlight possible differences related to the type of stimuli used. Despite this, little is known about the possible role of these factors in ADHD impairments. Moreover, previous studies did not focus on several higher-order cognitive skills that could influence social perception difficulties in this population.

Higher-order cognitive skills and social perception

Given its complex nature, some studies have recommended the role of various higher-order cognitive skills in order to examine the possible contribution of different abilities to social

perception difficulties experienced by children with ADHD (Imanipour et al., 2021). Specifically, theory of mind (ToM), attention and executive functions, and pragmatic language skills appear to be fundamentally important in this complex domain (Beauchamp & Anderson, 2010).

ToM represents the ability to attribute mental states (beliefs, intentions, desires, pretending, knowledge) to ourselves and others and to understand that others' mental states may differ from their own (Frith & Frith, 2006). This ability, as illustrated by theoretical models (Beauchamp & Anderson, 2010; Yang et al., 2015) and research evidence (Imanipour et al., 2021), may be considered different, although closely related with social perception skills. Indeed, social perception is a broader construct that include awareness of social cues and norms that dictate social interactions (Yang et al., 2015). Despite ToM is for sure crucial for developing social perception skills, however, the two abilities showed partially independent neural systems: the first one implicates posterior superior temporal sulcus, medial prefrontal cortex, temporal parietal junction and the posterior cingulate cortex/precuneus; the second one involves posterior superior temporal sulcus, the amygdala, the orbital frontal cortex and the fusiform gyrus (Yang et al., 2015). ToM has been found significantly impaired in individuals with ADHD (see Bora & Pantelis, 2016 for a review), but it did not reveal significant correlations with social perception impairments, unlike the TD controls (Charman et al., 2001).

Other processes underlying social perception concern attentional control (i.e., selective attention and sustained attention, self-regulation, response inhibition), cognitive flexibility (i.e., working memory, attentional shift) and goal setting (i.e., initiating, planning, problem solving), which all come under the umbrella term of executive functions. Although the neuropsychological profile of ADHD is heterogeneous, a huge number of studies revealed executive function impairments (see Sergeant et al., 2002 for a review). Executive functions and specifically attentional difficulties can affect the ability of children with ADHD to process social information (Semrud-

Clikeman et al., 2010). In particular, symptoms of inattention were found to be significant associated to poor social perception (Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010).

Communication is another skill strongly associated with social perception (Bruce et al., 2006). Expressive and receptive language skills have clear implications for social interactions, impacting both the expression and the comprehension of the messages exchanged between individuals. Subtle aspects of language processing are also essential (Beauchamp & Anderson, 2010). Specifically, pragmatics language can be defined as the ability to use language effectively (Cardillo et al., 2020), conveying meaning beyond words used and without ambiguity. Impairments in this area are strongly related to social perception abilities (Adams, 2002). Specifically, several previous research highlighted as drawing inferences and indirect requests, disambiguating meanings of polysemous words automatically in context have a key role in social perception (Brock, et al., 2008; MacKay & Shaw, 2004). Previous studies (Leonard et al., 2011; Staikova et al., 2013) found pragmatics language difficulties in children with ADHD, especially in prosody, turn taking and inferences. These deficits affected academic functioning (Troia, 2011), peer relationships (Leonard et al., 2011), and general adjustment (Landa, 2005) in children and adolescents with ADHD.

In summary, children and adolescents with ADHD have revealed difficulties in at least three high-order cognitive skills, such as ToM, attention and executive functions and pragmatic language, which have been found closely related to social perception (Bora & Pantelis, 2016; Charman et al., 2001; Crisci et al., 2021; Semrud-Clikeman et al., 2010; Staikova et al., 2013), but no research has examined all these skills together to better explain the social perception difficulties associated with ADHD.

3.2 Overview of the current study

Previous research highlighted social perception difficulties in children and adolescents with ADHD (Bora & Pantelis, 2016; Fine et al., 2008; Semrud-Clikeman et al., 2010; Uekermann et al.,

2010), but few studies analyzed it in a semi-naturalistic context (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010), and no one focused on different types of presentation of social stimuli. Furthermore, no study investigated together the relation between social perception and ToM, attention, executive functions, and communication, skills strongly linked to this ability (Beauchamp & Anderson, 2010; Bruce et al., 2006; Fine et al., 2008; Yang et al., 2015; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010).

The first aim of the present study was therefore to examine social perception in children and adolescents with ADHD, compared to typically-developing (TD) sample, investigating whether social perception was differently related to nonverbal signals recognition and different type of stimuli (i.e., video, audio, and combined/multimodal), within the two samples. Our second aim was to analyze the different contributions of three different higher-order cognitive skills involved for each type of social stimulus (i.e., video, audio, and combined/multimodal). Specifically, the role of ToM, attention and executive functions, and pragmatic language skills was considered in both groups. We included verbal and figurative stimuli to measure ToM, a measure of the ability to pay attention and inhibit automated responses for the attentional and executive functioning problems, as well as a measure of pragmatics language, testing the ability to infer information not explicitly stated, to assess communication skills.

Based on the results of the previous studies which examined the topic with a semi-naturalistic task (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010), we hypothesized that children and adolescents with ADHD would had a general worst performance in social perception abilities within semi-naturalistic tasks, compared to TD children.

As regard the aspects related to social perception, based on previous research (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010), we expected a significant positive association with nonverbal signals recognition in both groups. About the type of stimuli, we

hypothesized that TD participants may benefit from the presentation of different type of stimuli together (i.e., combined/multimodal condition) and will perform worse in the unimodal one, as for young and older typical adults (Cortes et al., 2021; Hunter et al., 2010; Wieck & Kunzmann, 2017). As no previous studies examined the impact of different type of stimuli in children and adolescents with ADHD, we could not make any a priori hypothesis, but differences may emerge considered the specific symptoms of the ADHD group.

Regarding the underlying role of the three higher-order cognitive skills (i.e., ToM, attention and inhibition, and pragmatic language) considered, we expected them to be related to social perception, in agreement with previous theoretical models (Beauchamp & Anderson, 2010; Yang et al., 2015) and evidence from research (Imanipour et al., 2021; Leonard et al., 2011; Semrud-Clikeman et al., 2010). No previous study examined the role of higher-order cognitive skills according to the type of presentation conditions of social stimuli (video, audio, and combined/multimodal), but we could hypothesize a different involvement of each ability depending on the task condition, regardless of the group the participants belonged to. Specifically, ToM could have a main part in the video and combined condition, considering the importance of face perception and eye gaze detection in its decoding (Mitchell & Phillips, 2015). The number of inattentive symptoms could relate to poor performance, whereas inhibition problems could show a less robust relation in all conditions, as already reported by Semrud-Clickeman (2010). Finally, pragmatic language may affect to all the three types of stimulus, but particularly the video and audio ones, in which some relevant information (respectively lexical content and face expressions) was not intelligible (Russell, 2007; Socher et al., 2019).

3.3 Method

3.3.1 Participants

72 children (66 males) between 8 and 15 years of age (in months M=128.75, SD=18.01), were included in the study. The sample consisted of two groups: 36 children had a clinical diagnosis of ADHD (33 males, age range from 95 to 170 months) and 36 were TD children (33 males, age range from 88 to 174 months). The two groups were matched on chronological age [$F(1, 70)$ = .02, p = .90, *Adjusted* R^2 = .01], and IQ [$F(1, 70)$ = 3.40, p = .07, *Adjusted* R^2 = .03], measured using the WISC-IV (Wechsler, 2003).

Children with ADHD had a clinical diagnosis according to the criteria of the DSM 5 (APA, 2013), previously established either by private practitioners (child psychiatrists or psychologists) or at the child neuropsychiatry department of the hospital to which they referred. The inclusion criteria for the present study required the confirmation of their diagnosis through T-scores of 65 or higher for inattention and/or hyperactivity on the Conners' Parent Rating Scale (CPRS-R:S, Conners, 1997), as well as meeting the DSM 5 (APA, 2013) criteria. The ADHD group scored significantly higher than the TD group on all the Conners' indexes: oppositional [$F(1, 70)$ = 27.11, p < .001, *Adjusted* R^2 = .27]; cognitive problems/inattention [$F(1, 70)$ = 80.99, p < .001, *Adjusted* R^2 = .53]; hyperactivity [$F(1, 70)$ = 88.69, p < .001, *Adjusted* R^2 = .55]; and ADHD index [$F(1, 70)$ = 138.1, p < .001, *Adjusted* R^2 = .66].

Children with ADHD were enrolled at specialized centers for neurodevelopmental disorders, hospitals, or clinics. The TD children were recruited through local community contacts or at local schools in Italy. All participants were native Italian speakers, and none had any visual or hearing impairments, or any other diagnosed neurological conditions. For all participants, exclusion criteria were: concurrent diagnosis of other neurodevelopmental disorders, a history of neurological problems, ongoing use of medication, or an intelligence quotient (IQ) below 85. The participants' characteristics are summarized in Table 3.1.

Table 3.1. Characteristics of the ADHD and typically-developing (TD) groups: means (M), standard deviations (SD) and results of ANOVAs.

	ADHD (n=36)	TD (n=36)	ANOVAs		
	M (SD)	*M (SD)*	*F (1, 70)*	*P*	*Adjusted R^2*
Age (in months)	129.03 (17.73)	128.47 (18.54)	.02	.90	.01
IQ	108.42 (9.45)	112.17 (7.74)	3.40	.07	.03
CPRS-R:S					
Oppositional	60.17 (12.65)	46.50 (9.39)	27.11	<.001	.27
Cognitive problems, Inattention	70.58 (6.00)	49.28 (12.88)	80.99	<.001	.53
Hyperactivity	66.42 (12.13)	44.00 (7.53)	88.69	<.001	.55
ADHD	72.03 (6.54)	48.61 (10.01)	138.10	<.001	.66

Note. ADHD= group with attention deficit/hyperactivity disorder; TD= typically-developing group; IQ= intelligence quotient; CPRS-R:S=Conners' Parent Rating Scales-Revised: Short form.

3.3.2 Materials

Social Perception

Child and Adolescent Social Perception Measure

Three modified versions of the Child and Adolescent Social Perception Measure (CASP, Magill-Evans et al., 1995) were developed for the present study to evaluate social perception abilities. The first, as in the original one, includes 10 videos (each video lasting approximately 40 seconds) where voice prosody could be heard, but the lexical content of the dialogs was obscured by distortion (video condition); the second one includes 10 audios where both prosody and lexical content could be heard (audio condition); the last one includes 10 videos of children interacting

with both audio (prosody and lexical content) and video (combined condition). Among the three conditions (video, audio and combined) for each story the characters' emotion was the same, only the context changed. For example, the first story in the three conditions includes 2 guys and one girl in three different contexts (i.e., a splatter film; the telling of a disgusting joke; a play with a Slime, a squishy and oozy green material). In each condition, the two guys are amused, whereas the girl was disgusted. In the 10 vignettes, the emotions portrayed are basic emotions of happy, sad, anger, disgust or fear, as in the original test. The stories were presented in a counterbalanced order. After each story presentation, the child was asked in an open question format to tell what each of the characters was feeling (emotive score). One point was given for each emotion correctly attributed, for a maximum of 46 points for each condition. Moreover, to understand what children used to recognize the stated emotions, it was asked to indicate how they could tell what the characters felt. Common examples of responses include, for example, ''by the smile'' or ''voice went up''. This type of answers is codified as a correct identification (1 point) of nonverbal cues (nonverbal signals score), instead if child underlined other contextual aspects not directly related to the emotion of the characters, zero point was attributed to the nonverbal signals score. The scoring procedure considered: (a) the accuracy for both emotion and nonverbal signals score; (b) the total proportion scores of the emotions correctly identified.

Higher-order cognitive skills

Theory of Mind task

Theory of Mind (TOM), a specific task from Nepsy II battery (Korkman et al., 2007) standardized for child and adolescents from 5 to 16 years old, was used to measure the ability to attribute others' emotions, desires, beliefs, and knowledge. This task includes two parts: verbal and contextual ones.

The *verbal TOM task,* composed by 15 items, is mainly a measure of the ability to understand beliefs, intentions, thoughts, and feelings considering another individual's point of view. All questions are based on verbal scenarios with or without pictorial support.

The *contextual TOM task*, structured in 8 items, measures the child's ability to relate emotion to the social context. In these items children in several social contexts are shown. In each picture there is a target girl whose face is not shown. The child needs to infer the girl's emotion based on the context and on the specific situation. The child is asked to select one of four photographs of the same girl's face with different emotions based on the social context.

The raw scores (maximum raw score for verbal TOM task = 17 points; for contextual TOM task = 8 points) were compared with normative data, and z scores were computed.

Continuous Performance Task

This Continuous Performance Task (CPT), adapted from Conners' Continuous Performance Task-2 (CPT-2, Conners, 2000), is a neuropsychological task assessing attention problem and the ability to inhibit automated responses. The test was administered using a laptop computer with a 15-inch LCD screen, programmed with the Opensesame software (Mathôt, Schreij & Theeuwes, 2012). 360 stimuli (different letters) were presented one at time, on the center of the computer screen with various interstimulus interval (1, 2 or 4 seconds). The interstimulus interval was counterbalanced within the test. The duration of the task is lasting approximately 14 minutes. Children were instructed to press the spacebar when each letter appears on the screen, except for the letter "X" (it appears 10% of times in a randomized order). Two variables were considered: (a) the proportion of omission errors (i.e. the failure to respond to a target letter) and (b) the proportion of commission errors (i.e. the failure to inhibit the answer when letter "X" appears).

Pragmatic language

The inference task adapted from Cardillo et al. (2020), is a paper-and-pencil task assessing the ability to infer information about inner or physical states not explicitly stated from contextual cues or previous knowledge. It consists of two different subtests: verbal and pictorial inferences, each one composed by 20 items. In the *verbal inferences*, participants were asked to listen to short stories, while in the *pictorial inferences,* children were instructed to look at figures of some scenes. Then it was asked to answer questions about information not directly explicated that can be drawn from contextual cues or previous knowledge. Participants are awarded one points for each correct answer (maximum raw score = 20 points in each subtest).

3.3.3 Procedure

The study was approved by the ethics committee at the University of Padua. Written consent was obtained from children's parents before they took part in the study. Participants were tested in a quiet room during two individual sessions lasting about 40 minutes. Tasks were administered in a counterbalanced order. Instructions were given for each task, and participants practiced with each task before starting the experiment. For the computer-based task, the children sat in front of the computer screen and the experimenter sat on the child's side to present the task.

3.4 Results

Data analyses

The statistical analyses were conducted using R (R Core Team, 2019). The analyses were run in two stages.

First, the social perception accuracy data obtained from the CASP were analyzed with a logistic mixed-effects model (Baayen, 2008; Jaeger, 2008), using the "lme4" package (Bates et al., 2015). The fixed effects were group (ADHD and TD), nonverbal signals and CASP condition (video, audio or combined), while participants were treated as random effects.

Second, to answer the question of what the main factors associated to social perception abilities are, Pearson's correction analyses, and linear regression analyses for each condition (video, audio, or combined) were run. This, in order to investigate the association between the dependent variable (social perception) and hypothesized associated factors: Group (ADHD and TD), verbal ToM, contextual TOM, omission and commission from CPT, verbal and pictorial inferences. The main effects and the interaction between Group and each other independent variables were tested for the three CASP condition (video, audio and combined).

The significance of fixed effects (in the first part) and of main effects (in the second part) and their interactions was examined by likelihood ratio tests for nested models. The Akaike information criterion (AIC; Akaike, 1974) was also recorded for each model, the *AIC* provided the best description of the relationships between variables (Bentler, 1990; Schermelleh-Engel, Moosbrugger, Müller, 2003). Graphical effects were obtained using the "effects" package (Fox, 2003).

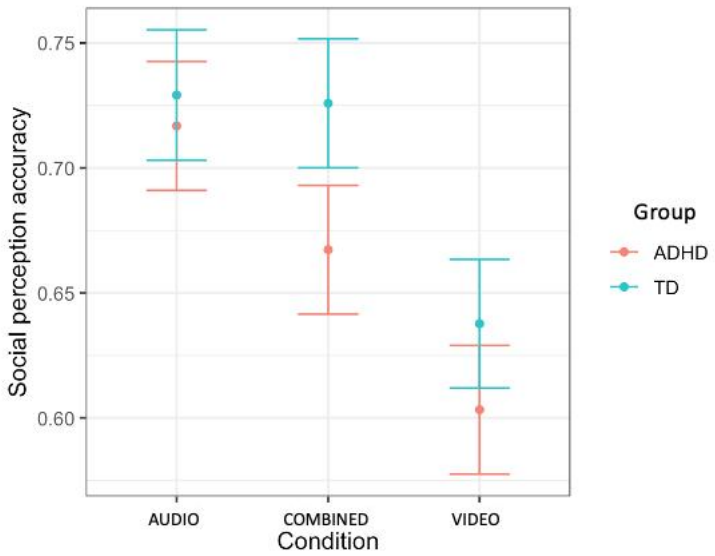
Social Perception accuracy

No main effect of Group emerged ($\chi 2(1)$ = 1.60, p = .21, full model: *AIC* = 11603, model without Group: *AIC* = 11603). The main effect of the condition was significant ($\chi 2(2)$ = 120.71, p < .001, model without condition: *AIC* = 11720), showing a better performance in the audio condition than the combined (p = .006) and the video (p < .001) ones (Figure 1). In addition, the social perception accuracy in the combined condition was significantly higher than that in the video condition (p <.001).

The main effect of nonverbal signals was significant ($\chi 2(1)$ = 33.63, p < .001, model without nonverbal signals: *AIC* = 11635), higher nonverbal signals was significantly associated with higher social perception accuracy. In addition, no significant interactions emerged between group and nonverbal signals ($\chi 2(1)$ = .62, p = .43, model with interaction: *AIC* = 11605) and between condition and nonverbal signals ($\chi 2(2)$ = 1.30, p = .52, model with interaction: *AIC* = 11606), while significant

interactions emerged between group and condition ($\chi 2(2)$ = 4.68, p = .05, model with interaction: *AIC* = 11503) (Figure 3.1). Multiple comparisons revealed differences statistically significant between groups in the combined condition, in which TD group performed better than ADHD group (p = .05). No other significant differences emerged between groups in the remaining conditions. Looking within group differences, the TD group registers a significant better performance in the audio and combined conditions than in the video condition (p_s < .001). While, the ADHD group registered significant differences between each condition (p_s < .001), showing a performance more accurate in the audio condition than in the combined and in the video ones. In addition, a better performance in the combined condition than the video ones emerged for this clinical group.

Figure 3.1. Interaction between group (ADHD and TD) and type of social stimulus condition associating to social perception accuracy in the CASP. Error bars represent 95% confidence intervals.



Note. ADHD= Attention deficit/hyperactivity disorder group; TD= typically-developing group

Pearson's Correlations

Table 3.2 sums up Descriptive Statistics and Pearson's correlations between social perception in each condition of the CASP (i.e., video, audio, combined), Theory of Mind (both verbal and

contextual), attention and inhibition (omission and commission from the CPT) and pragmatic language (verbal and pictorial inferences) in the two different groups. As represented in the table, ToM shows medium correlations (r=.35 to r=.41, p=.05) with video and combined stimuli of the CASP, only in the TD group. The severity of inattention problems (i.e., omission errors) showed significant medium-high correlations (r=-.39 to r=-.69, p=.05 to p<.001) with the CASP, independently from the type of stimuli and the group. Moreover, inhibition problems (i.e., commission errors) revealed significant high correlations (r=-.61 to r=-.69, p<.001) with the CASP, independently from the type of stimuli, only in the TD group. Finally, significant medium correlations (r=.36 to r=.37, p=.05) emerged between the CASP and pragmatic language skills for both groups. Specifically, verbal inferences were correlated with the CASP in the ADHD group, whereas pictorial ones in the TD group.

Table 3.2. Descriptive statistics and Pearson correlation coefficients between SP in the three different conditions (video, audio, combined), and the three higher order cognitive skills (verbal and contextual TOM; omission and commission errors from CPT; verbal and pictorial inferences) in ADHD *(lower diagonal)* and TD *(upper diagonal)*

	Child and Adolescent social perception measure (CASP) *accuracy*			**Theory of Mind (ToM)** *z score*		**Continuous Performance Task (CPT)** *accuracy*		**Pragmatic language** *raw score*	
	SP video	**SP audio**	**SP combined**	**Verbal TOM**	**Contextual TOM**	**Omission**	**Commission**	**Verbal inferences**	**Pictorial inferences**
SP video		.56***	.82***	.20	.36*	-.50*	-.004	.37*	.27
SP audio	.72***		.64***	.12	.18	-.39*	-.07	.37*	.07
SP combined	.62***	.66***		.35*	.41*	-.58*	-.07	.36*	.26
Verbal TOM	.06	.07	.18		.28	-.02	.09	.09	.24
Contextual TOM	.33	.17	.29	.36*		-.17	.14	.02	.38*
Omission CPT	-.57***	-.58***	-.59***	-.12	-.18		-.04	-.40*	-.52**
Commission CPT	-.69***	-.63***	-.61***	.16	.46*	-.78***		-.49**	.07

Verbal inferences	.01	.03	.05	.09	.17	-.40*	.32		.32
Pictorial inferences	.37*	.31	.36*	.32	.28	-.47**	.58***	.51**	
ADHD (N=36) M(DS)	.60 (.14)	.72 (.14)	.67 (.16)	.18 (.94)	-.68 (1.37)	.21 (.18)	.51 (.24)	16.06 (2.63)	16.67 (2.60)
TD (N=36) M(DS)	.67 (.15)	.77 (.14)	.75 (.16)	.38 (.77)	.34 (1.09)	.13 (.11)	.35 (.15)	17.72 (1.30)	17.39 (1.64)

Note: *p=.05; **p=.01;***p<.001

SP_video=Social perception_video condition; SP_audio=Social perception_audio condition; SP_combined=Social perception_combined condition;

Verbal TOM=Verbal theory of mind; Contextual TOM=Contextual theory of mind; CPT=Continuous Performance Task.

Regression analyses

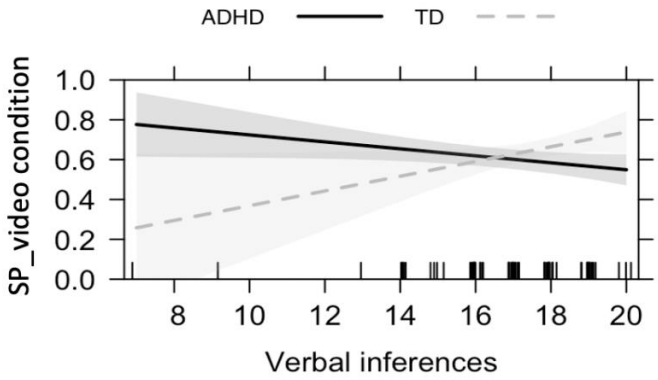
Video condition. Social perception in the video condition was significantly associated with Contextual TOM task [*F(1, 65)* = 4.56, *p* = .04, full model *AIC* = 185.66, model without Contextual TOM task *AIC* = 188.62] and CPT omission errors [*F(1, 65)* = 13.27, *p* < .001, full model *AIC* = 185.66, model without CPT omission errors *AIC* = 197.23]). Moreover, a significant interaction emerged between group and verbal inferences [*F(1, 64)* = 8.27, *p* =.005, full model *AIC* = 185.66, model with interaction *AIC* = 178.78]. Contextual TOM task was positively associated, CPT omission errors negatively, finally a better performance in the social perception was associated to the verbal inferences task, only for the TD group (Figure 3.2A). See Table 3.3A for a summary of all the statistical information about the models.

Table 3.3A. Results of the linear models for the video social stimulus in the CASP with Group, verbal ToM, contextual ToM, omission and commission errors from the CPT, and verbal and pictorial inferences.

Condition	*Effects*	*F*	*df*	*p*	ΔR^2	*AIC*
Video	Group (ADHD vs TD)	.19	1, 65	.66	.003	183.88
	Verbal ToM task	.01	1, 65	.93	.001	183.67
	Contextual ToM task	**4.56**	**1, 65**	**.04**	**.07**	**188.62**
	CPT omission errors	**13.27**	**1, 65**	**<.001**	**.17**	**197.23**
	CPT commission errors	.05	1, 65	.82	.001	183.72
	Verbal inferences	1.27	1, 65	.26	.01	185.07
	Pictorial inferences	.20	1, 65	.65	.003	183.89

Group*Verbal ToM task	1.59	1, 64	.21	.02	185.87
Group*Contextual ToM task	.43	1, 64	.51	.006	187.17
Group*CPT omission errors	1.13	1, 64	.29	.02	186.39
Group*CPT commission errors	1.23	1, 64	.27	.02	186.28
Group*Verbal inferences	**8.27**	**1, 64**	**.005**	**.12**	**178.78**
Group*Pictorial inferences	.02	1, 64	.89	.001	187.64

Figure 3.2A. Interaction between group (ADHD and TD) and verbal inferences for the video condition for social perception (SP) accuracy in the video condition of the CASP.



Note. ADHD= Attention deficit/hyperactivity disorder group; TD= typically-developing group; SP=social perception

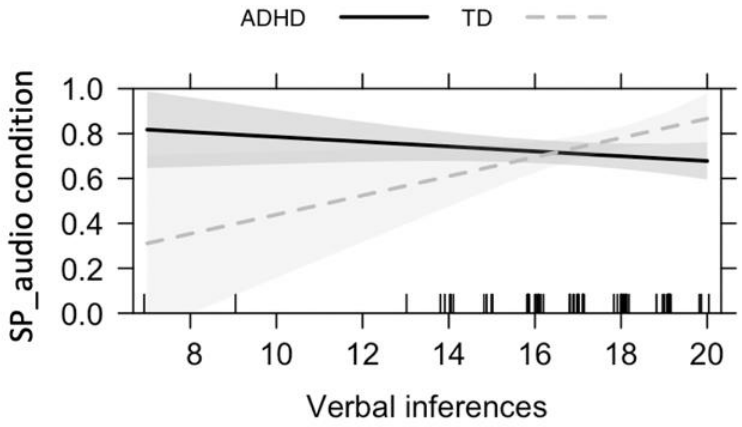
Audio Condition. Social perception in the audio condition was significantly associated with CPT omission errors [*F(1, 65)* = 10.99, *p* = .002, full model *AIC* = 197.85, model without CPT omission errors *AIC* = 207.26] (Table 3). Moreover, a significant interaction emerged between group and verbal inferences [*F(1, 64)* = 7.12, *p* = .01, full model *AIC* =197.85, model with interaction *AIC* = 192.14]. CPT omission errors were negatively associated with emotions recognition and a better

performance in the emotion recognition was associated to the verbal inferences task, only for the TD group (Figure 3.2B). See Table 3.3B for a summary of all the statistical information about the models.

Table 3.3B. Results of the linear models for the audio social stimulus in the CASP with Group, verbal ToM, contextual ToM, omission and commission errors from the CPT, and verbal and pictorial inferences from the pragmatic language as independent variables.

Condition	*Effects*	*F*	*df*	*p*	ΔR^2	*AIC*
Audio	Group (ADHD vs TD)	.22	1, 65	.64	.003	196.10
	Verbal ToM task	.13	1, 65	.72	.002	195.99
	Contextual ToM task	.42	1, 65	.52	.007	196.32
	CPT omission errors	**10.99**	**1, 65**	**.002**	**.15**	**207.26**
	CPT commission errors	.22	1, 65	.64	.003	196.09
	Verbal inferences	.10	1, 65	.76	.001	195.96
	Pictorial inferences	.29	1, 65	.59	.005	196.18
	Group*Verbal ToM task	.38	1, 64	.54	.006	199.42
	Group*Contextual ToM task	.31	1, 64	.58	.005	199.50
	Group*CPT omission errors	.29	1, 64	.59	.005	199.52
	Group*CPT commission errors	2.10	1, 64	.15	.03	197.50
	Group*Verbal inferences	**7.12**	**1, 64**	**.01**	**.10**	**192.14**
	Group*Pictorial inferences	.51	1, 64	.48	.008	199.27

Figure 3.2B. Interaction between group (ADHD and TD) and verbal inferences for the audio condition with social perception (SP) accuracy in the audio condition of the CASP.



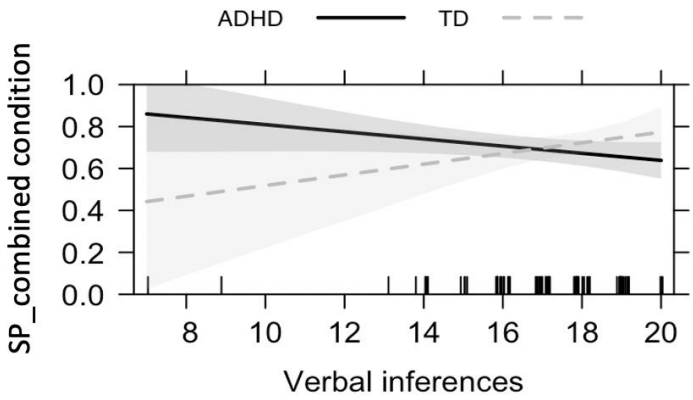
Note. ADHD= Attention deficit/hyperactivity disorder group; TD= typically-developing group; SP=social perception

Combined Condition. Social perception in the combined condition was significantly associated with Contextual TOM task [*F(1, 65)* = 4.86, *p* = .03, full model *AIC* = 177.03, model without Contextual TOM task *AIC* = 180.29] and CPT omission errors [*F(1, 65)* = 23.52, *p* <.001, full model *AIC* = 177.03, model without CPT omission errors *AIC* = 197.56] (Table 3). Moreover, a significant interaction emerged between group and verbal inferences (model with interaction *F(1, 64)* = 4.04, *p* = .05, *AIC* = 174.55). Contextual TOM task was positively associated, CPT omission errors negatively, finally a better performance in the emotion recognition was associated to the verbal inferences task, only for the TD group (Figure 3.2C). See Table 3.3C for a summary of all the statistical information about the models.

Table 3.3C. Results of the linear models for the audio social stimulus in the CASP with Group, verbal ToM, contextual ToM, omission and commission errors from the CPT, and verbal and pictorial inferences for pragmatic language as independent variables.

Condition	*Effects*	*F*	*df*	*p*	ΔR^2	*AIC*
Combined	Group (ADHD vs TD)	.001	1, 65	.99	.001	175.03
	Verbal ToM task	2.12	1, 65	.15	.03	177.37
	Contextual ToM task	**4.86**	**1, 65**	**.03**	**.07**	**180.29**
	CPT omission errors	**23.52**	**1, 65**	**<.001**	**.27**	**197.56**
	CPT commission errors	.69	1, 65	.41	.006	175.80
	Verbal inferences	1.42	1, 65	.24	.02	176.60
	Pictorial inferences	.001	1, 65	.99	.001	175.03
	Group*Verbal ToM task	2.53	1, 64	.12	.04	176.19
	Group*Contextual ToM task	.88	1, 64	.35	.01	178.03
	Group*CPT omission errors	1.13	1, 64	.29	.02	177.75
	Group*CPT commission errors	.87	1, 64	.35	.01	178.03
	Group*Verbal inferences	**4.04**	**1, 64**	**.05**	**.06**	**174.55**
	Group*Pictorial inferences	.32	1, 64	.57	.005	178.66

Figure 3.2C. Interaction between group (ADHD and TD) and verbal inferences for the audio condition with social perception (SP) accuracy in the audio condition of the CASP.



Note. ADHD= Attention deficit/hyperactivity disorder group; TD= typically-developing group; SP=social perception

3.5 Discussion

To the best of our knowledge, only three studies (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010) assessed social perception abilities, using semi-naturalistic tasks in children and adolescents with ADHD, also taking the type of stimulus presented (video, audio or combined/multimodal) into account. Moreover, the association between higher-order cognitive skills (i.e., ToM, attention and inhibition, and pragmatic language skills) and social perception abilities were under-investigated in this population.

Thus, the main goals of the present study were to investigate a) social perception within a semi-naturalistic context in children and adolescents with ADHD, compared to TD sample, taking nonverbal signals recognition and different types of stimuli into account and b) the role of ToM, attention and inhibition, and pragmatic language abilities in association with social perception abilities, distinguishing between different presentation modality of the social stimuli.

About our first goal, the present findings showed that social perception of both children with ADHD and TD benefited from nonverbal signals recognition. This result confirmed that nonverbal signals recognition is significantly associated to higher social perception (Fine et al., 2008; Semrud-

Clikeman, 2010; Semrud-Clikeman et al., 2010), indipendetly from the clinical diagnosis. Interestingly, the social perception accuracy differed between the two populations, depending on the type of social stimuli presented: the performance of children with ADHD was significantly worse, but only for combined (video and audio) stimuli, while no such differences emerged for audio or video stimuli alone. It is worth noting that the combined stimuli more closely resembled to real-life interactions, showing simultaneously several stimuli (i.e., audio and video). Our results seem to confirm that ADHD is associated with social perception impairments in every-day life interactions (Bora & Pantelis, 2016; Uekermann et al., 2010). That said, these impairments seem to be associated with the number of stimuli that should be processed. Several previous research underlined that, for ADHD population especially, dividing attention between different stimuli could result in a decrement in performance, relative to when each stimulus was performed alone (Huizenga et al., 2009; Fuermaier et al., 2018). Finally, our two groups showed within group differences relating to which type of social stimuli (video, audio, combined) was presented. The TD children and adolescents performed better with the combined or the audio stimuli than with the videos. This result is partially consistent with Hunter et al. (2010), who found that typical younger and older adults benefited from the multimodal compared to the unimodal condition, independently from their age, probably because the first one more closely resembled real everyday life interactions. Our TD sample also registered a better performance in the audio condition compared to the videos, however (and just as well with the audio and the combined stimuli). A possible explanation for this result might be that attention is a more limited resource in children than adults (Cowan et al., 2006), and the unimodal audio presentation alone may allow our young participants to focus on fewer details, making them easier to understand (Plummer & Eskes, 2015). Similarly, our children and adolescents with ADHD also registered a significant better performance with the audio alone than with the video or combined stimuli, supporting the idea that even if with attention problems the

audio presentation alone would be easier compared to the others, which had many stimuli. As already reported, dividing attention between several stimuli affected ADHD population's performances in several tasks (Huizenga et al., 2009; Fuermaier et al., 2018).

Regarding our second aim, Pearson's correlations underlined the main role of inattention problems in social perception difficulties, independently from the stimuli shown and the specific group. Whereas the other variables (ToM, inhibition and pragmatic language) assumed a specific role in each group, better explained in the regression analyses. When separate linear regressions were run for each type of social stimulus (video, audio, or combined), our results showed a specific contribution of ToM for the video and combined condition, and attention had the main role in each condition. In addition, the significant interaction between pragmatic language and group suggested that communication skills were differently involved in ADHD and TD groups' social perception abilities. As expected, ToM revealed a significant contribution to social perception, especially for the video and combined conditions, in which face perception and eye gaze detection could make decoding simplifier (Mitchell & Phillips, 2015). It is worth nothing that only contextual ToM was significantly related to social perception abilities, in our study. A possible explanation for this might be related, at least partly, to the differences in the sensitivities of tests used (Mary et al., 2015; Pineda-Alhucema et al., 2015). Moreover, contextual ToM measures the ability to relate an emotion to a specific context (Korkmann et al., 2007), and is strongly linked to social perception skills. Generally speaking, our finding is consistent with studies highlighting that ToM has profound implications for complex social behaviors and contribute to the development of prosocial behaviors (Knafo, et al., 2008; Walker, 2005), independently from ADHD condition. Our finding contrast, however, with previous studies suggesting that ToM does not correlate with social functioning in ADHD population (Charman et al., 2001). A possible explanation for this discrepancy might relate to the use of parent's questionnaire to evaluate social perception, and the lack of adequate behavioral

measure in previous studies. In addition, our results revealed that attention and not inhibition was the variable most strongly associated with our groups' social perception abilities in each condition. Attention assumed the most important role in the combined condition, as there were more different stimuli demanding attention, than the audio or video material alone. These findings diverge from previous studies suggesting that social deficits in ADHD are mainly due to behavioral inhibition problems (Barkley, 1997; Rapport, et al., 2002; Uekermann et al., 2010). On the other hand, our findings are consistent with those of Semrud-Clickeman (2010) who also found that attention (and not inhibition) problems were related to social perception abilities. Finally, as expected, pragmatic language affected particularly the conditions in which relevant information, such as lexical content or face expressions, was intelligible (Socher et al., 2019). Pragmatic language abilities are necessary to make inference from the social context (Russell, 2007), indeed. Surprisingly, in our study, pragmatic language had different role in the two populations. The TD children and adolescents' better performance on pragmatic tasks was related to higher social perception abilities. In contrast, no significant associations emerged for the children and adolescents with ADHD. These results support the findings of Staikova and colleagues (2013) of a different relation between pragmatics and social skills depending on the area of pragmatics language considered. It is worth noting that, pragmatics is a heterogeneous construct that includes several skills, and it can be divided into separate areas: discourse management (i.e., skills to initiate, maintain, and end a conversation), presupposition (i.e., assumptions and inferences about the conversational partner and the specific social context) and narrative discourse (i.e., ability to generate a successful narrative) (Adams, 2002, Landa, 2005). Staikova et al. (2013) underlined that only discourse management, not presupposition or narrative discourse, is related to social functioning in children with ADHD. These findings suggest that the three pragmatic language areas refer to distinct abilities, which may have specific implications for social perception and social functioning. For example, interrupting others in a

conversation may have a more direct adverse effect on popularity among peers than difficulty understanding social context. It is worth noting that according to this classification, our pragmatics language measures mainly focused on presupposition than in discourse management.

Despite our interesting results, further studies are needed to confirm and extend our findings, and to overcome the limitations of the present study. First, we relied on cross-sectional data rather than investigating the three high-order skills during the development of social perception abilities. It may be that better social perception abilities promote greater ToM abilities. Attention, and communication abilities may also influence each other in some way. Secondly, we only focused on a limited set of measures for each cognitive skill taken into account. Further studies could include different measures of ToM, attention and executive functions, and communication skills, as well as include other significant higher-order cognitive skills. Finally, our sample showed a large disproportion between males and females. In the literature sex differences in the ADHD rate is well documented, with a male to female ratio of about 3:1 (Willcutt, 2012), moreover previous findings underlined as males likewise show more severe symptoms among diagnosed individuals. However, further studies should try to replicate our findings by assessing samples of children with a similar proportion of both male and female participants.

In conclusion, our findings partially confirmed previous results (Beauchamp & Anderson, 2010; Fine, et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010) showing that higher-order cognitive skills (i.e., ToM, attention and inhibition, and pragmatic language) are essential to social perception in both TD and ADHD. Our results extend previous findings in that our children and adolescents with ADHD performed significantly worse than TD controls in social perception, in tasks more similar to real every-day life interactions. Nonverbal signals recognition and the type of social stimulus influenced social perception accuracy of both children with ADHD and TD controls. Attention appeared the factor explaining the largest percentage of variance of the performance on

the social perception tasks, independently from the type of stimulus presented. ToM also had a contribution, especially in the case of stimuli where face expressions were included. Finally, pragmatic abilities were associated with social perception only in TD children and adolescents, but not in ADHD population.

Chapter 4

Self-Perception of abilities in ADHD and ASD

4.1 Introduction

Examining the self-perception of abilities in clinical conditions has been an emerging field of interest (Dimaggio & Lysaker, 2010). The self-perception theory (Harter, 1981) suggests that individuals with neurodevelopmental conditions, who face with several difficulties in different areas, may develop negative beliefs about their own competences (Owens & Hoza, 2003). However, previous studies have suggested that individuals with ADHD or ASD overestimate their own competence in various areas of functioning (Owens, et al., 2007; Fritz, et al., 2010). Despite several difficulties are frequently emphasized by parents, teachers, and even classmates, they seem to overestimate their own abilities. This tendency to overestimate their capabilities in respect of external criteria is called positive illusory bias (PIB) (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007).

As widely discussed in the first chapter, PIB has been studied extensively in children with ADHD (Weyandt & Gudmundsdottir, 2015), rising most evident in cognitive and academic aspects (Volz-Sidiropoulou et al., 2016), probably because these are the domains in which they encounter the most difficulties (Hoza et al., 2004). PIB in ADHD is associated with negative long-term outcomes, as poorer response to treatment, high rates of aggression, and less prosocial behaviour (Hoza et al., 2010; Hoza, et al., 2002; Linnea, et al., 2012) and maladjustment in new environments (Jia, et al., 2016). However, some studies have failed to identify PIB in ADHD population (Hoza et al., 2002; Jiang & Johnston, 2017). On the other hand, only few research studied PIB in children or adolescents with ASD, and almost exclusively focused on social functioning (Wanstall et al., 2019).

Children with ASD seem to estimate their social abilities as better than their teachers and parents do (Koning & Magill-Evans, 2001; Knott, et al., 2006; Vickerstaff, et al., 2007), for what concerns empathy (Johnson, et al., 2009) and prosocial behaviors (Lerner, et al., 2012). Overall, despite some contradictory results, evidence suggest that children and adolescents with ADHD and ASD have difficulty reporting their self-perceptions in various domains when compared to an external perception, but further studies are necessary to better understand why some specific areas are overestimated, comparing directly ADHD and ASD (Wanstall et al., 2019).

A phenomenon conceptually similar to PIB, sometimes encountered in the typically developmental (TD) population, is the Negative Illusory Bias (NIB, Harter, 1983). This phenomenon has been initially studied in highly competent children, who exhibit an unrealistically low self-perception (Gresham et al., 2000). This overestimation of negative characteristics has been observed regarding behavioral problems in children with typical development (McQuade et al., 2010). It is worth noting that, to the best of our knowledge, no previous studies assessed this specific phenomenon in neurodevelopmental disorders.

Coming back to the PIB, several hypotheses have been applied for explaining the underlying factors of this incorrect perception of abilities. Owens and colleagues (2007) have argued that clinical impairments and comorbidities with internalizing (i.e., depression and anxiety) and externalizing (i.e., aggression, rule braking behavior) disorders may have a decisive role. It would be possible that internalizing symptoms may be related to lower PIB acting as protective factors, whereas externalizing symptoms may be related to higher PIB, because aggressiveness could make children unable to understand the other's feedback (see for a review Owens et al., 2007).These comorbidities are frequently reported in both children with ADHD and ASD (Jensen et al., 2001; Rosenberg et al., 2011), but previous studies have not been adequately assessed them when examining overestimation of abilities in these clinical populations.

In summary, some previous studies underlined an overestimation of their own abilities (PIB) in children and adolescents with ADHD or ASD, compared to TD sample. However, to the best of our knowledge, there are not previous research carrying out a direct comparison between the two clinical populations. Moreover, previous studies focused rather exclusively on the self-perception of the academic and cognitive fields for children with ADHD (Owens et al., 2007; Prevatt et al., 2012) and of the social sphere for children with ASD (Koning & Magill-Evans, 2001; Knott, et al., 2006; Vickerstaff, et al., 2007). The social sphere deserves more attention in ADHD, however, because of its possible implications in terms of a less prosocial behavior (Linnea et al., 2012), or weaker response to interventions (Hoza et al., 2010). Secondly, it is not clear enough, if this overestimation affects other functioning areas as behavioral problems, similarly to the NIB of TD children (Gresham et al., 2000). Finally, as suggested in previous studies (Owens et al., 2007) comorbidities in other clinical areas such as externalizing and internalizing disorders which are common in neurodevelopmental conditions, should be adequately considered for examining overestimation of abilities.

4.2 Overview of the current study

PIB has been observed in different contexts (as academic and social area) in children and adolescents with ADHD or ASD, but it has generated some contradictory results and it is not clear if it affects several areas of functioning (McQuade et al., 2011; McQuade et al., 2017). Moreover, no previous studies have considered the NIB (i.e., the overestimation of behavioral problems) in neurodevelopmental conditions (Graham et al., 2000). Finally, clinical comorbidities, frequently shown in ADHD and ASD, should be assessed to understand their impact on the overestimation of abilities (Owens et al., 2007). The present study was designed to look for empirical evidence of PIB in social context (social PIB), as well as to clarify the presence of NIB in behavioral problems and the role of clinical impairments in two different populations with neurodevelopmental disorders (ADHD

and ASD), compared to TD children. Specific questionnaires measuring social skills, behavioral problems and clinical impairments were used to compare the self-perception of the three groups. We tested a sample of children with a clinical diagnosis of ADHD and one of children with a clinical diagnosis of ASD, matched for sex, chronological age and intelligence, with a sample of TD children. All the children were between 8 and 15 years old. Our four main goals were: (a) to identify social skills impairments in children with ADHD or ASD, and confirm the presence of social PIB in these groups; (b) to investigate the estimation of behavioral problems in the three groups, confirming the presence of NIB in the TD group; (c) to confirm higher internalizing and externalizing symptoms in children with ADHD or ASD and to clarify the role of this clinical impairment in PIB.

We expected both samples of children with ADHD and ASD to be weak in social functioning (Carpenter et al., 2009; Hoza et al., 2010), and to overestimate their own social skills (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007), compared to TD children. Particularly, based on their metacognitive well studied difficulties (Wanstall et al., 2019), we hypothesized children with ADHD show a higher PIB, compared to ASD. We also expected the overestimation of ability is a specific phenomenon which affected only some areas of functioning (Owens et al., 2008) and we only expected an overestimation of behavioral problems – NIB, in TD children (McQuade et al., 2010). We assumed higher clinical impairments (both internalizing and externalizing symptoms) in both clinical conditions (Jensen et al., 2001; Rosenberg et al., 2011) than TD children. Moreover, making a comparison between the two clinical populations, we hypothesized higher externalizing disorders in ADHD group, whereas higher internalizing disorders in children with ASD (Mayes et al., 2022). Finally, considering the hypothesis of internalizing and externalizing symptoms (Owens et al, 2007) into PIB development, we might suppose both internalizing and externalizing difficulties have an impact on PIB, although no previous studies taken these aspects into account.

4.3 Method

4.3.1 Participants

Two hundred and twenty children (87% M) between 8 and 16 years of age (in months *M*=138.05, *SD*=27.3) were included in the study. 50 participants had a clinical diagnosis of ADHD (92% M) and 49 participants had a clinical diagnosis of ASD (89% M). Finally, 121 typically-developmental (TD) children (90% M) were enrolled.

Participants with ADHD and ASD had a clinical diagnosis according to the DSM 5 criteria (APA, 2013), previously established by child psychiatrists or psychologists of the hospital or clinical center to which they referred. The Conners' Parent Rating Scale (CPRS-R:S, Conners, 1997) were used to confirm the ADHD diagnosis: only children on T scores of 65 or higher for inattention and/or hyperactivity and ADHD index were included in this group. The ADHD group scored significantly higher than the ASD and the TD group on all CPRS-R:S' indexes: oppositional [$F(2, 217) = 60.92$, $p < .001$, *Adjusted* $R^2 = .35$]; cognitive problems/inattention [$F(2, 217) = 237.7$, $p < .001$, *Adjusted* $R^2 = .68$]; hyperactivity [$F(2, 217) = 135.01$, $p < .001$, *Adjusted* $R^2 = .55$]; and ADHD index [$F(2, 217) = 293.4$, $p < .001$, *Adjusted* $R^2 = .73$].

To confirm the diagnosis of ASD we used the Autism Diagnostic Interview - Revised (ADI-R; Rutter et al., 2005): only participants who scored above the cut-off on the three modules of the ADI-R, including stereotyped behaviors, were included. The ASD group scored significantly higher than the ADHD and the TD group on all ADI-R indexes: reciprocal and social interactions [$F(2, 217) = 258.6$, $p < .001$, *Adjusted* $R^2 = .70$]; language/communication [$F(2, 217) = 213.44$, $p < .001$, *Adjusted* $R^2 = .66$]; repetitive behaviors/interests [$F(2, 217) = 117.7$, $p < .001$, *Adjusted* $R^2 = .52$].

All participants were native Italian speakers, and none had visual or hearing impairments. For all participants, the exclusion criteria were: a concurrent diagnosis of other neurodevelopmental disorders; a history of neurological problems; ongoing use of medication; or an intelligence quotient

(IQ) below 85. The three groups were matched on gender, chronological age [$F(2, 217) = .05$, $p = .95$, *Adjusted* $R^2 = .01$], and IQ [$F(2, 217) = 4.85$, $p = .08$, *Adjusted* $R^2 = .03$], as measured using the WISC-IV (Wechsler, 2012).

The participants' characteristics are summarized in Table 4.1.

Table 4.1. Characteristics of the ADHD, ASD, and typically-developing (TD) groups: means (M), standard deviations (SD) and results of ANOVAs.

	ADHD (n=50)	ASD (n=49)	TD (n=121)	ANOVAs			
	M (SD)	*M (SD)*	*M (SD)*	*F (2, 217)*	*p*	*Adjusted R^2*	*Post-hoc*
Age (in months)	137.80 (23.29)	138.90 (31.48)	137.46 (27.13)	.05	.95	.01	
IQ	105.88 (12.60)	106.57 (13.19)	108.17 (10.80)	4.85	.08	.03	
CPRS-R:S							
Oppositional	68.74 (15.03)	59.25 (15.03)	47-10 (9.08)	60.92	<.001	.35	ADHD>ASD>TD
Cognitive problems, inattention	77.70 (7.79)	63.37 (14.73)	46.03 (15.64)	237.7	<.001	.68	ADHD>ASD>TD
Hyperactivity	70.98 (11.46)	59.63 (14.77)	44.34 (6.45)	135.1	<.001	.55	ADHD>ASD>TD
ADHD index	78.08 (6.58)	61.71 (12.93)	45.60 (12.96)	293.4	<.001	.73	ADHD>ASD>TD
ADI-R							
Reciprocal and social interactions	5.18 (2.27)	16.73 (6.46)	2.93 (2.17)	258.6	<.001	.70	ASD>ADHD>TD
Language/communication	4.22 (2.99)	11.88 (4.41)	1.96 (1.75)	213.4	<.001	.66	ASD>ADHD>TD
Repetitive behaviors/interests	2.60 (2.27)	5.88 (3.67)	.46 (.68)	117.7	<.001	.52	ASD>ADHD>TD

Note. ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; IQ= Intelligent Quotient; CPRS-R:S=Conners' Parent Rating Scale- Revised: Short Form; ADI-R=Autism Diagnostic Interview-Revised

4.3.2 Materials

Perception of social abilities and behavioral problems

The Social Skills Improvement System-Rating Scale (SSIS-RS) (Elliott & Gresham, 2008), already described in chapter 2, is a parent- and a self-report measure assessing both social abilities and behavioral problems. The social abilities subscale involves 46 items, whereas the behavioral problems subscale involves 30 items, each one rated on a four-point scale (from 0 = never to 3 = almost always). Scores range from 0 to 138 on the social abilities' subscale and from 0 to 90 on the behavioral problems subscale, higher scores represent respectively higher social abilities and higher behavioral problems. The raw scores were used in the subsequently analysis (Lyons et al., 2016; Montroy et al., 2014). The overall internal consistency of the measure is excellent (Cronbach's $\alpha = .97$) (Gresham et al., 2011).

Clinical impairments

The Child Behavior Checklist (CBCL, Achenbach & Rescorla, 2000) is a widely used caregiver report form identifying clinical impairments in children. It exists in two different versions, depending on the age of the child being referred to. The CBCL is composed by two different sections: the first ratings of positive behaviors, academic functioning, and social competence; the second section lists common behavior problems. This latter (addressed to 6-18 years) was used in the present study. Responses are recorded on a Likert scale (from 0=not true to 2=very often or true). Eight empirically based syndrome scales are scored: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior and aggressive behavior. There are two scales that combine several of the syndrome scales: internalizing problems combines the anxious/depressed, withdrawn-depressed, and somatic complaints scores; externalizing problems combines rule-breaking and aggressive behavior. There is also a total problems score, which is the sum of the scores of all the items. The raw score was scaled on standard

score so that 50 is average, with a standard deviation of 10 points. Higher scores indicate greater problems. The overall internal consistency of the measure is excellent (from Cronbach's α = .78 to .97) (Achenbach & Rescorla, 2001).

4.3.3 Procedure

The study was approved by the ethics committee at the University of Padua. Written consent was obtained from children's parents before they took part in the study. Participants were tested in a quiet room during one individual session lasting about 40 minutes. Tasks were administered in a counterbalanced order. Instructions were given for each task. For the questionnaires, the children sat in front of the experimenter, who could help him/her if items were considered unclear.

4.4 Results

Data analyses

The statistical analyses were conducted using R (R Core Team, 2019). First, two different estimation indices were computed as the discrepancy between the child's perception and the adult's report of the social abilities and behavioral problems subscale of the SSIS-RS. Differences close to zero represent a correct estimation of abilities/problems, positive scores indicate an overestimation of social abilities (called Positive Illusory Bias - PIB) or an overestimation of behavioral problems (called Negative Illusory Bias - NIB) according to the child compared to their parent's perception (McQuade et al., 2017). Second, one-way ANOVAs were run for both estimations and clinical impairments indices to examine differences among the three groups. Finally, to answer the questions if clinical impairments and which specific clinical index impact on PIB, firstly Pearson correlation analysis, then linear regression analysis were run. The significance of main effects and their interactions was examined by likelihood ratio tests for nested models. We assumed that a model with a smaller Akaike information criterion (AIC) better describes the

relationship between the variables (Bentler, 1990; Schermelleh-Engel et al., 2003). Graphical effects were obtained using the "ggplot2" package.

Perception of social abilities and behavioral problems

Table 4.2 sums up the descriptive statistics and one-way Anovas for the three groups (ADHD, ASD and TD) on the social skills subscale and the behavioral problems subscale for both the children's self-reports and the parents' reports, and on the estimation indices (PIB and NIB). A main effect of group emerged for the social skills subscale for both the children's ($F[2, 217]$=23.26, p<.001, $AdjustedR^2$=.17) and parents' report ($F[2, 217]$=72.46, p<.001, $AdjustedR^2$=.39). Children with ADHD or ASD reported significantly worse social skills than TD children (p_s<.001). Moreover, children with ASD reported worse social skills than ADHD group (p<.001). Similarly, parents of children with ADHD or ASD highlighted worse social abilities of their children (p_s<.001), than TD group. No other differences emerged among the groups. Figure 4.1 shows the effect of the groups on the PIB index ($F[2, 217]$=6.79, p<.001, $AdjustedR^2$=.15): children with ADHD overestimate their own social skills compared to both ASD (p=.02) and TD group (p<.001). No other differences arose among the groups. A main effect of group emerged for the behavioral problems subscale for both the children's ($F[2, 217]$=29.84, p<.001, $AdjustedR^2$=.21) and parents' report ($F[2, 217]$=135.1, p<.001, $AdjustedR^2$=.55). Children with ADHD or ASD reported significantly higher behavioral problems than TD children (p_s<.001). Moreover, children with ADHD reported higher behavioral problems than TD group (p=.01). Similarly, parents of children with ADHD or ASD highlighted higher behavioral problems of their children (p_s<.001), than TD group. No other differences emerged among the groups. Figure 4.2 shows the effect of the groups on NIB index ($F[2, 217]$=8.39, p<.001, $AdjustedR^2$=.06): TD children overestimate their own behavioral problems compared to both ADHD (p=.04) and ASD group (p<.001), with a low effect. No other differences arose among the groups.

Table 4.2. Mean scores *(M)*, standard deviations *(SD)* and results of ANOVAs for social functioning, behavioral problems, PIB and NIB indices and clinical impairments for ADHD, ASD and TD groups.

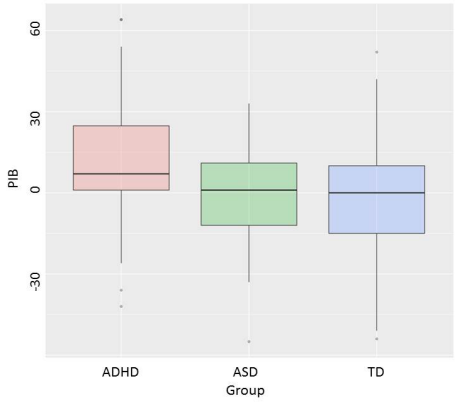
	ADHD (n=50)	ASD (n=49)	TD (n=121)	ANOVAs			
	M (SD)	*M (SD)*	*M (SD)*	*F (2, 217)*	*P*	*Adjusted R^2*	*Post-hoc*
SSIS-RS (raw score)							
SS_children	91.02 (21.02)	83.69 (20.73)	104.52 (17.89)	23.26	<.001	.17	TD>ADHD>ASD
SS_parents	80.54 (16.09)	84.39 (17.44)	106.78 (13.40)	72.46	<.001	.39	TD>ADHD, ASD
PIB_index[1]	10.48 (23.43)	-.69 (17.76)	-2.26 (20.71)	6.79	.001	.15	ADHD>ASD,TD
BP_children	38.54 (13.82)	30.37 (13.29)	21.32 (13.70)	29.84	<.001	.21	ADHD>ASD>TD
BP_parents	34.16 (15.91)	29.51 (11.86)	10.78 (8.96)	135.1	<.001	.55	ADHD>ASD>TD
NIB_index[1]	4.38 (18.49)	.86 (13.35)	10.54 (13.86)	8.39	<.001	.06	TD>ADHD,ASD
CBCL indices (T score)							
anxious/depressed	63.92 (9.46)	62.69 (11.26)	54.08 (6.30)	33.33	<.001	.23	ADHD,ASD>TD
withdrawn/depressed	60.04 (8.99)	64.98 (11.16)	54.08 (4.36)	39.44	<.001	.26	ASD>ADHD>TD

somatic complaints	60.32 (6.91)	59.12 (9.31)	53.71 (5.69)	20.96	<.001	.15	ADHD,ASD>TD
social problems	64.16 (9.43)	62.69 (8.22)	52.62 (4.30)	70.89	<.001	.39	ADHD,ASD>TD
thought problems	60.80 (8.36)	61.04 (9.17)	51.72 (2.91)	59.01	<.001	.35	ADHD,ASD>TD
attention problems	68.24 (8.49)	60.57 (7.47)	52.43 (3.74)	128.3	<.001	.54	ADHD>ASD>TD
rule-breaking behavior	57.84 (6.39)	54.25 (4.55)	51.60 (3.43)	34.51	<.001	.23	ADHD>ASD,TD
aggressive behavior	63.26 (10.32)	56.63 (8.02)	51.86 (3.42)	52.25	<.001	.32	ADHD>ASD>TD
Internalizing problems	62.34 (9.23)	62.90 (11.52)	49.82 (9.62)	44.75	<.001	.29	ADHD,ASD>TD
Externalizing problems	61.50 (9.96)	52.82 (8.94)	45.64 (7.95)	62.53	<.001	.36	ADHD>ASD>TD
Total problems	64.38 (8.87)	60.86 (9.09)	45.66 (9.70)	90.83	<.001	.45	ADHD,ASD>TD

Note. ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; SSIS-RS=Social Skills Improvement System-Rating Scale; SS_children= Social skills according to children; SS_parents=Social skills according to parents; PIB index= Positive Illusory Bias index; BP_children= behavioral problems according to children; BP_parents=behavioral problems according to parents; NIB index= Negative Illusory Bias index; CBCL indices=Child Behavioral Checklist indices.

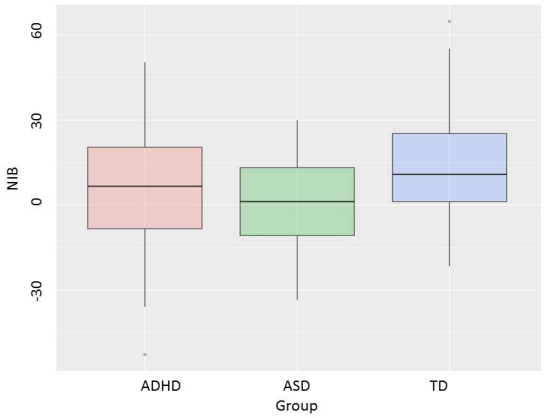
[1] The analyses were controlled for age, and the significance of the age effects was examined using likelihood ratio tests for nested models. The age had no significant effect.

Figure 4.1. Boxplot representing PIB index by Group (ADHD; ASD; TD). The central mark is the median. The edges of the box are the 25th and the 75th percentiles.



Note. A difference close to zero represents a correct estimation of abilities; ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; PIB= Positive Illusory Bias index.

Figure 4.2. Boxplot representing NIB index by Group (ADHD; ASD; TD). The central mark is the median. The edges of the box are the 25th and the 75th percentiles.



Note. A difference close to zero represents a correct estimation of abilities; ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; NIB= Negative Illusory Bias index.

Clinical impairments

Table 4.2 sums up the descriptive statistics and one-way Anovas for the three groups (ADHD, ASD and TD) on each clinical impairments index. About the eight empirically based syndrome scales of the CBCL, a main effect of group emerged for the anxious/depressed subscale (*F[2, 217]*=33.33, *p*<.001, *AdjustedR*^{2}=.23), the somatic complaints (*F[2, 217]*=20.96, *p*<.001, *AdjustedR*^{2}=.15), the social problems (*F[2, 217]*=70.89, *p*<.001, *AdjustedR*^{2}=.39) and thoughts problems (*F[2, 217]*=59.01, *p*<.001, *AdjustedR*^{2}=.35); in each subscale, parents of children with ADHD and ASD reported significantly worse impairments than TD children (p_s<.001). A main effect of group also emerged for the withdrawn/depressed subscale (*F[2, 217]*=39.44, *p*<.001, *AdjustedR*^{2}=.26), attention behavior (*F[2, 217]*=128.3, *p*<.001, *AdjustedR*^{2}=.54), rule breaking behaviors (*F[2, 217]*=34.51, *p*<.001, *AdjustedR*^{2}=.23) and aggressive behaviors (*F[2, 217]*=52.25, *p*<.001, *AdjustedR*^{2}=.32). In each subscale, parents of children with ADHD and ASD reported significantly worse impairments than TD children (p_s<.001); but also children with ADHD showed significantly higher difficulties than ASD group (p_s<.001). Finally, a main effect of group emerged for the internalizing (*F[2, 217]*=44.75, *p*<.001, *AdjustedR*^{2}=.29), externalizing (*F[2, 217]*=62.53, *p*<.001, *AdjustedR*^{2}=.36) and total problems subscale (*F[2, 217]*=90.83, *p*<.001, *AdjustedR*^{2}=.45). Children with ADHD and ASD obtained a significantly higher scores in each index, compared to TD sample (p_s<.001). Parents of children with ADHD reported also significantly higher externalizing problems than the ASD group (p<.001).

Pearson's correlation analysis

Table 4.3 sumps up the Pearson correlations among PIB and clinical impairments based on the CBCL indices in the three different groups. As represented in the table, low correlations emerged in each group. PIB correlates with social problems (*r*=.16, *p*<.05), attentional problems (*r*=22, p<.01) and aggressive behaviors (*r*=.19, *p*<.05), only in the ADHD group. Whereas higher thought problems

show a low negative correlation (*r*=-.19, *p*<.05) with PIB in the TD group. No other significant relations emerged.

Table 4.3. Pearson's correlation coefficients between the two estimation indices (PIB and NIB) and the clinical impairments indices in each group.

	PIB index		
	ADHD	**ASD**	**TD**
Anxious/depressed	.11	-.12	-.11
Withdrown/depressed	.07	-.11	-.12
Somatic complaints	.02	-.10	-.14
Social problems	**.16***	-.01	-.12
Thought problems	.05	-.13	**-.19***
Attentional problems	**.22****	-.02	-.01
Rule braking behaviors	.09	.05	-.17
Aggressive behaviors	**.19***	-.14	-.05
Internalizing problems	.06	-.10	-.16
Externalizing problems	.14	-.13	-.09
Total Problems	.13	-.12	-.14

Note. *p<.05; **p<.01; ***p<.001

ADHD= group with attention deficit/hyperactivity disorder; ASD= group with autism spectrum disorder; TD= typically-developing group; PIB index=Positive Illusory Bias index.

Regression analysis

PIB was significantly associated with Group [*F(2, 209)* = 3.14, *p* = .05, full model *AIC* = 1972.75, model without Group *AIC* = 1975.26]. Moreover, PIB was significantly associated with thought problems [*F(1, 209)* = 4.97, *p* = .03, full model *AIC* = 1972.75, model without thought problems *AIC* = 1975.93] (Table 4.4). Thought problems were positively associated with PIB. No significant interaction emerged between group and clinical impairments indices. See Table 4.4 for a summary of all the statistical information about the models. Based on AIC values, the model with Group may be considered better than the model with thought problems.

Table 4.4. Results of the linear models for PIB index with Group and clinical impairment indices (e.g. anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attentional problems, rule braking behaviors and aggressive behaviors from the CBCL) as independent variables.

Effects	*F*	*df*	*p*	ΔR^2	*AIC*
Group	**3.14**	**2, 209**	**.05**	**.13**	**1975.26**
Anxious/depressed	.02	1, 209	.88	<.001	1970.78
Withdrawn/depressed	.28	1, 209	.59	.001	1971.05
Somatic complaints	1.33	1, 209	.25	.01	1972.15
Social problems	.66	1, 209	.41	.003	1971.45
Thought problems	**4.97**	**1, 209**	**.03**	**.02**	**1975.93**
Attentional problems	.48	1, 209	.49	.002	1971.26
Rule braking behaviors	1.36	1, 209	.25	.01	1972. 18
Aggressive behaviors	1.21	1, 209	.27	.01	1972.02

Group*Anxious/depressed	1.34	2, 207	.26	.01	1973.93
Group*Withdrown/depressed	.79	2, 207	.45	.01	1975.08
Group*Somatic complaints	1.07	2, 207	.35	.01	1974.5
Group*Social problems	1.52	2, 207	.22	.01	1973.55
Group*Thought problems	1.38	2, 207	.25	.01	1973.84
Group*Attentional problems	.14	2, 207	.87	.001	1976.46
Group*Rule braking behaviors	2.63	2, 207	.07	.02	1971.23
Group*Aggressive behaviors	.84	2, 207	.43	.01	1974.97

4.5 Discussion

Studying self-perception of abilities in population with neurodevelopmental disorders is an emerging field of interest (Dimaggio & Lysaker, 2010). Two main phenomena came to light from literature: positive illusory bias (PIB) and negative illusory bias (NIB). Some previous studies failed in the attempt to confirm PIB (i.e., the overestimation of abilities vis-à-vis external criteria) in ADHD (McQuade et al., 2017) and only few research studied in deep PIB in ASD population (Wanstall et al., 2019). Importantly, no previous studies directly compared these two clinical populations to understand if PIB has a greater impact on ADHD than ASD. Moreover, to the best of our knowledge, no previous studies have considered NIB (i.e., the overestimation of behavioral problems) in neurodevelopmental conditions (Graham et al., 2000). Finally, the impact of internalizing and externalizing symptoms on PIB is still not clear (Owens et al., 2007). The present study was designed to look for empirical evidence of PIB in social context and NIB in behavioral problems in two different populations with neurodevelopmental disorders (ADHD and ASD), compared to TD children. The role of internalizing and externalizing symptoms was also taken into account on PIB development.

Our first goal was to identify social skills impairments in children with ADHD and ASD, and to analyze the presence of PIB in social context in these two groups. Overall, our results showed that both clinical populations have significant impairments in social functioning compared to TD children (see for a review Mikami et al., 2019): in our sample both parents and children with ADHD and ASD underlined social difficulties. More interesting, whereas parents of children with ADHD underlined similar social difficulties of children with ASD, children with ADHD reported higher abilities compared to ASD group. Thus, PIB was totally confirmed in children with ADHD (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). It is possible that metacognitive difficulties and neuropsychological impairments, frequently underlined in ADHD population (Wanstall et al., 2019; Owens et al., 2008) take a role in this peculiar phenomenon, further studies may deep this hypothesis. Surprisingly, contrary to previous findings (Koning & Magill-Evans, 2001; Knott, et al., 2006; Vickerstaff, et al., 2007) our children with ASD showed correct estimation of their own social abilities. This incongruence with previous evidence, may be explained considering that previous studies rarely matched the ASD group with the TD sample in terms of IQ, thus further studies should consider the role of IQ in studies measuring PIB. It is possible that difficulties of children with ASD in estimation their own social abilities underlying in previous studies represent a consequence of general cognitive impairments rather than a specific metacognitive phenomenon. It is in fact well established as younger children or children with intellectual disabilities have important difficulties in the estimation of their own abilities (see for a review Owens et al., 2007)

Our second goal was to investigate if the overestimation of their own characteristics is specific of some functioning areas in the three groups, and confirming the presence of NIB only in the TD group. Our results totally confirm this hypothesis: the overestimation of their own behavioral competences do not affect all areas of functioning in children and adolescents with ADHD or ASD (Owens et al., 2008). In addition, behavioral problems were overestimated only by TD children,

showing NIB (McQuade et al., 2010). On one hand it is possible that children with clinical conditions are able to correctly estimate their own behavioral problems because of the frequent parents' and teachers' negative feedback about them. However, further studies should consider the role of feedback in self-perception abilities in neurodevelopmental disorders. On the other hand, social desirability may make TD children unable to estimate their own behavioral problems, showing overestimation of their own difficulties (Gresham et al., 2000). Additional studies should consider also this aspect, introducing social desirability scale when behavioral problems are assessed.

Our third goal takes into account clinical impairments, such as internalizing and externalizing symptoms. As expected (Jensen et al., 2001; Rosenberg et al., 2011), in our study, generally higher clinical impairments emerged in both clinical conditions than TD children. However, making a comparison between the two clinical populations, our hypotheses were partially confirmed. As hypothesized, children with ADHD showed higher externalizing symptoms (Mayes et al., 2022), than children with ASD. Unpredictably, internalizing symptoms emerged in both clinical conditions. Specifically, high anxious traits, somatic complains and thought problems were reported for both children with ADHD and ASD. Only higher depressive symptoms emerged in the ASD group. Previous studies (South et al., 2017) underlined as several questionnaires could have low discriminant validity between internalizing symptoms, attention/hyperactivity problems and autistic traits. This aspect is probably due to the fact that some behavioral manifestations are closely related to each one of these problems. For example, the description "confused or seems to be in a fog" (CBCL, Achenbach & Rescorla, 2004) represents anxiety traits in the CBCL scale, but it could be commonly considered a description of attention impairments of children with ADHD (Cholemkery et al., 2014). Similarly, "impulsive or act without thinking" (CBCL, Achenbach & Rescorla, 2004) clearly described hyperactivity traits, but anxiety may cause restlessness that can be interpreted as hyperactivity (see for a review Jarrett & Ollendick, 2008).

Finally, considering the hypothesis of the role of clinical impairments (Owens et al, 2007) into PIB development in social context, we run correlations and regression analyses to clarify the role of each clinical index in the overestimation of children and adolescents with ADHD and ASD. Surprisingly, neither externalizing and internalizing problems have a direct impact on social PIB. Alternative hypotheses better considered in the next chapter, may be taken into account in the explanation of social PIB. For example, previous authors (Owens et al., 2007) hypothesized as neuropsychological deficits could make children with ADHD unable to self-estimate their abilities, similarly to patients with anosognosia (e.g., Duke et al. 2002; Kaszniak & Christensen, 1995).

Despite this research offers new findings on the self-perception of abilities in two different clinical populations, some limitations may be drawn. First of all, we considered only some children's abilities, as social and behavioural problems. Additional studies may include other life's areas to understand if the overestimation of abilities affects other domains. Second, we only considered clinical impairments, such as internalizing and externalizing symptoms, as potential predictor of the self-perception overestimation, but other studies should tested alternative hypotheses to understand if other factors influence social PIB. Finally, despite age has no impact on the overestimation of abilities in our sample as well as in previous studies (Martin et al., 2019; Volz-Sidiropoulou et al., 2016), future studies may recruit more children to analyze more in depth possible age group differences. Moreover, the cross-sectional design of our study prevents us the possibility to test if the self-perception of abilities changes during development. Future studies may try to understand the different trajectories of PIB in each clinical population by carrying out longitudinal studies.

In conclusion, our results partially confirm previous findings. The parents of children with ADHD esteem their children as impaired in social functioning as well as children with ASD, while children with ADHD underline better social performance, confirming the PIB in social context. Both

children with ADHD and ASD correctly estimate their own behavioral problems, underling as PIB is specific of some functioning area. Finally, despite the higher clinical impairments of children with ADHD and ASD compared to TD sample, internalizing and externalizing symptoms seem not having a specific role on the overestimation of social abilities.

Chapter 5

Positive illusory Bias and individual factors

5.1 Introduction[2]

Despite the important social difficulties, children and adolescents with ADHD underestimate their social functioning impairment compared to parents', teachers' and peers' opinions (Hoza et al., 2002; Hoza et al., 2003; McQuade et al., 2017). As previously mentioned (Chapter 4) this phenomenon is called positive illusory bias (PIB, Capodieci, et al., 2019; Hoza et al., 2002; Owens et al., 2007). Although it is still unclear the explanation of the PIB in ADHD population, at least three main hypotheses have been proposed.

According to the hypothesis of cognitive immaturity (Milich, 1994), some authors highlighted that typical younger children normally overestimate their own abilities and their performance, and these positive beliefs help them to persist with challenging tasks (Owens et al., 2007). Children with ADHD are described as behaviorally and cognitively immature, and that is why cognitive immaturity has been hypothesized as a possible explanation for their PIB (Milich, 1994). However, this first hypothesis collected limited empirical support (Milich, 1994). Children with ADHD are not constant in performing challenging tasks, even though their PIB seems to resemble the optimism of young children (Hoza et al., 2001). This evidence reduces the validity of cognitive immaturity as the best explanation for PIB (Owens et al., 2007).

[2] The present study has been published: Crisci, G., Cardillo, R., & Mammarella, I. C. (2022). The Processes Underlying Positive Illusory Bias in ADHD: The Role of Executive Functions and Pragmatic Language Skills. *Journal of Attention Disorders*, *26*(9), 1245–1256. doi: https://doi.org/10.1177/10870547211063646.

The second hypothesis is known as ignorance of incompetence (Hoza et al., 2002). According to this hypothesis, incompetence in a specific domain can make people poor judges of their own and others' competence (Dunning et al., 2003). In other words, the ignorance of incompetence hypothesis refers to children with ADHD are not able to evaluate their own abilities, because they are incompetent in social functioning. Evangelista et al. (2007) discredited this hypothesis, however, when they found that children with ADHD were accurate in assessing other children's competence, even though their own performance was deficient.

Based on the last hypothesis, PIB is considered the consequence of neuropsychological deficits (Owens & Hoza, 2003). Several studies have shown that executive functions (EFs) are needed to assess and judge one's own and other people's competence and behavior (Bivona et al., 2008). EF impairments could therefore be associated with a lesser awareness of competence, and with PIB, as observed in several other clinical populations (Owens et al., 2002; Shad et al., 2006). EFs are higher-order cognitive processes that enable us to focus attention, plan, organize, and carry out multiple tasks. According to Miyake et al. (2000), EFs can be divided into three distinct, but interacting domains: inhibition refers to the ability to deliberately inhibit automatic responses; shifting refers to an attention-switching process, needed to disengage from an irrelevant task and then actively engage in a relevant task; updating refers to the monitoring and replacing older or irrelevant information with newer or more relevant information in the working memory system. EF impairments have been extensively highlighted in children with ADHD (Barkley, 1997; Barkley, 2011; Sergeant et al., 2002), but the little research conducted on the relation between EFs and PIB has produced mixed findings. McQuade et al. (2011) found that EFs partially mediated the relation between ADHD symptoms and PIB in social domain (social PIB). The same authors (McQuade et al., 2017) underscored that children in the PIB group (including both children with ADHD and TD children) were significantly more impaired on EFs tasks than children in the no-bias group. Chan and

Martinussen (2016) identified EFs as predictors of PIB only in the academic domain, however. Similarly, Golden (2009) found that EFs were not predictors of PIB in the social domain, but only in the academic domain.

Another important cognitive domain that has rarely been considered is the role of language in PIB (Graham et al., 2018). PIB is relatively close to perspective taking, the ability to understand and process a situation from another person's point of view (Selman, 1971). Perspective taking is needed to accurately assess a situation, and others' opinions, thoughts and perspective; it is essential to children's proper social development (Selman, 2003). Several studies support the existence of a close link between language and perspective taking (Farrant et al., 2006), leading to hypothesizing that language impairments - particularly in pragmatic aspects - could have a role in social PIB. We specifically refer to pragmatic language abilities because they concern the aspect of language that controls how phonology and syntax are used in social contexts (Russell, 2007). Pragmatic language abilities consist of both verbal and non-verbal aspects (i.e., initiating and ending a conversation, assumptions about the context, facial expressions, and tone of voice, Adams, 2002). These aspects have been investigated in children and adolescents with ADHD in relation to their social functioning impairments. Previous studies (Leonard et al., 2011; Staikova et al., 2013) found that children with ADHD have pragmatic language impairments, especially in prosody, turn taking and semantic aspects. Moreover, these pragmatic language deficits seem to affect academic functioning and performance (Troia, 2011), peer relationships (Leonard et al., 2011), and general adjustment (Landa, 2005). Despite the clear link between language impairments and social functioning problems in ADHD, only one study to our knowledge (Graham et al., 2018) has investigated how language impairments influences PIB in children with behavioral problems. This study showed that children with behavioral problems differ significantly in both expressive and receptive language compared with TD children, but no evidence of PIB emerged. Considering this

theoretical background, the relationship between pragmatic language and social PIB is worth to be further investigated (Graham et al., 2018). This gave rise us to include pragmatic language among the factors to consider in our efforts to clarify the predictors of social PIB.

5.2 Overview of the current study

The PIB has been observed in different contexts (i.e., academic and social life) in children and adolescents with ADHD and several hypotheses have been developed, as previously mentioned. Specifically, the role of neuropsychological deficits – EFs, in particular- is one of the most accredited on the PIB development, but it has generated contradictory results (Chan & Martinussen, 2016; Golden, 2009; McQuade et al., 2011; McQuade et al., 2017). Moreover, despite the fundamental role of pragmatic language abilities in perspective taking and understanding other people's opinions and thoughts, no studies have considered pragmatic language impairments in relation to social PIB (Graham et al., 2018).

The present study was designed to look for empirical evidence of social PIB, and to clarify the specific impact of EFs and pragmatic language. For this purpose, specific tests measuring social skills and tapping EFs and pragmatic language were used to compare the performance of two groups, one of children and adolescents with ADHD, the other of TD participants. We tested a sample of children and adolescents with a clinical diagnosis of ADHD, matched for chronological age, intelligence level and receptive language with a sample of TD children. All the children were between 8 and 15 years old. Our three main goals were: (a) to identify social skills impairments in children with ADHD, and confirm the presence of social PIB in this group; (b) to investigate specific EF and pragmatic language deficits in children with ADHD; and (c) to run mediation analyses to clarify the role of EF impairments and pragmatic language deficits in social PIB.

Based on previous studies, we expected the children with ADHD to be weak in social functioning (Carpenter et al., 2009; Hoza et al., 2010), and to overestimate their own social skills

(Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). We also expected these children to be impaired in EFs (Barkley, 2011; Sergeant et al., 2002) and pragmatic language (Staikova et al., 2013). Finally, based on the neuropsychological hypothesis (Bivona et al., 2008), we might expect EFs impairment to mediate the relation between ADHD and social PIB. On the other hand, because of previous research identifying pragmatic language deficits in children with ADHD (Staikova et al., 2013), and a link between pragmatic aspects and social perspective taking (Selman, 2003), we might also expect pragmatic language abilities to mediate this same relation between ADHD and PIB.

5.3 Method

5.3.1 Participants

Eighty-three children and adolescents, 64 males and 19 females, between 8 and 15 years of age (M=10.53, SD=2.23) were enrolled. Children with a clinical diagnosis of ADHD (N=41) were recruited at specialized centres for neurodevelopmental disorders, hospitals or clinics. The TD children (N=42) were contacted through local schools in north-eastern Italy. All participants were native Italian speakers, and none had any visual or hearing impairments, or any other diagnosed neurological conditions.

Children with ADHD had a diagnosis of ADHD according to the criteria of the DSM 5 (American Psychiatric Association, APA, 2013), previously established either by private practitioners (child psychiatrists or psychologists) or at the child neuropsychiatry department of the hospital to which they referred. Confirmation of the diagnosis of ADHD required T-scores of 65 or higher for inattention and/or hyperactivity on the Conners' Parent Rating Scale (CPRS-R:S, Conners, 1997), as well as meeting the DSM 5 (APA, 2013) criteria. For all participants, our exclusion criteria were: a history or concurrent diagnosis of autism spectrum disorder, a history of neurological problems, ongoing use of medication, or a certified intelligence quotient (IQ) below 85. The two groups were matched on gender, chronological age [$F(1, 81)$=.01, p=.91, *Adjusted* R^2=.01], and IQ [$F(1, 81)$=.10,

p =.75, *Adjusted* R^2=.01]. Participants' level of intelligence was confirmed by administering the block design and vocabulary subtests from the WISC-IV (Wechsler, 2003). The TROG-2 (Test for Reception of Grammar-Version 2, Bishop, 2009) revealed no differences in receptive language between the two groups [*F(1, 81)*=.27, *p*=.61, *Adjusted* R^2=.001]. The ADHD group scored significantly higher on all the Conners' indexes: oppositional [*F(1, 81)*= 47.18, *p* <.001, *Adjusted* R^2=.36]; cognitive problems/inattention [*F(1, 81)*=94.56, *p*<.001, *Adjusted* R^2=.53]; hyperactivity [*F(1, 81)*=48.95, *p*<.001, *Adjusted* R^2=.37]; and ADHD index [*F(1, 81)*=111.9, *p* <.001, *Adjusted* R^2=.57]. The participants' characteristics are summarized in Table 5.1.

Table 5.1. Characteristics of the ADHD and typical development (TD) groups: means (M), standard deviations (SD) and results of ANOVAs.

	ADHD (n=41)	TD (n=42)	ANOVAs		
	M (SD)	*M (SD)*	*F (1, 81)*	*p*	*Adjusted* R^2
Age	130.78 (26.67)	131.45 (26.28)	.013	.91	.01
IQ	107.56 (11.4)	108.38 (11.97)	.10	.75	.01
TROG-2	101.54 (9.62)	102.67 (10.30)	.27	.61	.001
CPRS-R:S					
Oppositional	65.63 (11.38)	49.17 (10.45)	47.18	<.001	.36
Cognitive Problems/Inattention	73.10 (11.55)	50.90 (9.13)	94.56	<.001	.53
Hyperactivity	65.78 (13.10)	48.83 (8.55)	48.95	<.001	.37
ADHD	75.75 (10.03)	51.95 (10.46)	111.9	<.001	.57

Note. ADHD= group with attention deficit and hyperactivity disorder; TD= control group with typical development; IQ= intelligence quotient; TROG-2= Test of Reception of Grammar-2; CPRS-R:S=Conners' Parent Rating Scales-Revised: Short form.

5.3.2 Materials

Social functioning

Interpersonal competence scale (ICS, Cairns et al., 1995)

Interpersonal and social skills (see also Crisci et al., 2018) were assessed with the ICS, administered to both the parents and the children to identify any discrepancies between their impressions of the child's social skills. The scale consists of 18 items covering: three main factors, aggressiveness, popularity, and academic skills; and three secondary factors, friendliness, appearance, and internalizing difficulties. Each item is rated from 1 to 7 on a continuum between two polarities, one positive and the other negative (e.g. from never aggressive to always aggressive), expressing the child's usual behavior. The total interpersonal competence score is derived from the mean of the five subscale scores (aggressiveness, popularity, and academic skills, friendliness, appearance), reversing the score for aggressiveness. Total interpersonal competence score and social PIB index, computed as the discrepancy between the children's self-reports and the adults' reports of the children's social functioning, were considered. (Cronbach alpha: aggressiveness factor =.82, popularity factor = 81, academic skills factor=.71, friendliness factor=.71, appearance factor=.67, and overall scale score=.84).

Executive functions

Inhibition (NEPSY II, Korkman et al., 2007)

A series of black and white shapes or arrows were shown, and the subtest included two tasks: a) inhibition, in which participants had to name the opposite shapes (or arrow directions) as rapidly and accurately as possible; and b) shifting, in which they had to label either the correct or opposite shapes (or arrow directions) depending on their color. Test-retest reliability for different age groups ranges from .79 to .82 for the inhibition condition, and from .75 to .93 for the switching condition (Brooks et al., 2009).

Verbal and visuospatial updating

Verbal and visuospatial updating tasks were designed using different types of stimuli, verbal in one and visuospatial in the other (see Crisci et al., 2021). Both tests, programmed with the E-Prime software (Schneider et al., 2007), asked the children to recall the last verbal stimulus or the last positions of a visual stimulus belonging to *target categories* previously shown on the screen. Each test was characterized by four levels of difficulty depending on the increased number of target categories. Each level consisted of two items in which the memory span required stayed the same.

The verbal updating task consists of 8-word lists, containing from 6 to 12 words. After listening to a word list, participants had to remember the last word they had heard that belonged to a given semantic category shown on the screen. Every list included: “target”, words belonging to one of the semantic categories; and “distractors”, or words belonging to another category. At the beginning of each list, the target semantic categories appeared on the computer screen, and remained visible until a new list was presented. Immediately (1000 ms) after the categories appeared, the words were presented verbally, one at a time with an interval of 1000 ms.

The visuospatial updating task was much the same, but consisted of visuo-spatial stimuli. The task involved 8 sets of shapes, each containing 6 to 12 shapes. Participants were asked to recall the last position of a target shape seen on the computer screen. Each set included these “targets” (the position of the shape to be remembered) and “distractors” (the positions of the other figures shown). The target shapes were initially presented in the center of the screen (for 600 ms), then they appeared for 1000 ms below a 4x4 grid in which each shape in a given set (targets and distractors) was presented in a randomized position in the 4x4 grid, with an interval of 1000 ms between one shape and the next. After a set of shapes had been presented, participants used the mouse to indicate the positions of the target shapes. The proportion of correct responses was considered for both tasks. (Cronbach alpha: .71 verbal updating and .76 visuospatial updating).

Pragmatic language abilities

Children's Communication Checklist, second edition (CCC-2; Bishop, 2003)

The CCC-2 is a 70-item questionnaire designed to assess children's skills in various areas of language, including pragmatics. The CCC-2 provides standard scores for 10 scales: speech, syntax, semantics, coherence, inappropriate initiation, stereotyped language, use of context, non-verbal communication, social relations, and interests. For the present study we used four of these scales (inappropriate initiation, stereotyped language, use of context, and non-verbal communication) to compute a pragmatic language (PL) index (see also, Bignell & Cain, 2007; Leonard et al., 2011; Staikova et al., 2013), focusing on verbal and nonverbal pragmatic language skills. Internal consistency, or Cronbach's reliability coefficients ranged from .94 to .96 across age groups (Bishop, 2003).

5.3.3 Procedure

The study was approved by the ethics committee at the University of Padua. Written consent was obtained from children's parents before they took part in the study. Participants were tested in a quiet room during two individual sessions lasting about 40 minutes. Tasks were administered in a counterbalanced order. Instructions were given for each task, and participants practiced with each task before starting the experiment. At the same time, parents completed a rating scale to assess their children's communication abilities.

5.4 Results

Data analyses

The statistical analyses were conducted using R (R Core Team, 2019). First, PIB index was computed as the discrepancy between the child's perception of their own social functioning and the adult's report on the ICS. Positive scores indicate an overestimation of abilities according to the child compared to their parent's perception (McQuade et al., 2017). Second, one-way ANOVAs were run

for each test to examine differences between the groups. Third, latent variables (EF index and pragmatic language –PL- index) were computed using the *psych* statistical package (Revelle, 2019). Finally, the correlations were explored in the two groups (Table 5.2). Then mediation analyses were run with *lavaan* (Rosseel, 2012) to examine the mediation effect of the EF and PL indexes on the relation between groups and the social PIB index. We assumed that a model with a smaller Akaike information criterion (AIC) better describes the relationship between the variables (Bentler, 1990; Schermelleh-Engel et al., 2003).

Social functioning

Table 5.2 sums up the descriptive statistics for the two groups (ADHD and TD) on the general scale of the ICS, for both the children's self-reports and the parents' reports. Compared with TD children, those with ADHD showed no significant differences in self-reported aggressiveness [*F(1, 81)*=2.57, *p*=.11, *Adjusted* R^2=.02], popularity [*F(1, 81)*=.28, *p*=.60, *Adjusted* R^2<.001], academic skills [*F(1, 81)*=2.91, *p*=.09, *Adjusted* R^2=.02], friendliness [*F(1, 81)*=.007, *p*=.93, *Adjusted* R^2=.01], appeareance [*F(1, 81)*=.46, *p*=.50, *Adjusted* R^2=.006], or internalizing difficulties [*F(1, 81)*=2.26, *p*=.14, *Adjusted* R^2=.02]. No main effect of group emerged for the overall score on the ICS [*F(1, 81)*=3.37, *p*=.07, *Adjusted* R^2=.03]. Concerning the parents' reports, a main effect of group emerged for the aggressiveness scale [*F(1, 81)*=12.81, *p*<.001, *Adjusted* R^2=.13], the popularity scale [*F(1, 81)*=6.13, *p*=.015, *Adjusted* R^2=.06], the academic skills scale [*F(1, 81)*=30.59, *p*<.001, *Adjusted* R^2=.27], and the appearance scale [*F(1, 81)*=3.84, *p*=.05, *Adjusted* R^2=.03]. To sum up, when compared with TD children, those with ADHD were described by their parents as more aggressive, less popular, with weaker academic skills, and less general competence. No significant effect of group emerged for the two secondary factors: friendliness [*F(1, 81)*=2.26, *p*=.14, *Adjusted* R^2=.02] or internalizing difficulties [*F(1, 81)*=.16, *p*=.69, *Adjusted* R^2=.01]. According to parents, significant differences between the two groups also emerged for overall scores on the ICS [*F(1, 81)*=41.68, *p*<.001, *Adjusted*

R^2=.33], again indicating that the group with ADHD was weaker than the TD group in terms of interpersonal competence.

Positive illusory bias (PIB)

Table 5.2 summarizes the descriptive statistics for the two groups on the PIB index, computed as the discrepancy between the children's self-reports and the adults' reports of the children's social functioning on the ICS (Cairns et al., 1995). A main effect of group emerged [*F(1, 81)*= 9.47, *p*=.003, *Adjusted* R^2=.09]: the children with ADHD showed higher PIB, higher PIB representing an overestimation of their own abilities from children relative to external criteria, while the TD children did not.

Table 5.2. Mean scores (M), standard deviations (SD) and results of ANOVAs for social functioning and the PIB index for the ADHD and TD groups

	ADHD (n=41)	TD (n=42)	ANOVAs		
	M (SD)	*M (SD)*	*F (1, 81)*	*p*	*Adjusted* R^2
Children					
ICS_SC	4.47 (.63)	4.72 (.6)	3.39	.07	.03
Aggressiveness	3.84 (1.14)	3.42 (1.27)	2.57	.11	.02
Popularity	4.38 (1.06)	4.48 (.76)	.28	.60	<.001
Academic skills	3.63 (1.39)	4.16 (1.43)	2.91	.09	.02
Friendliness	5.48 (1.28)	5.50 (1.38)	.007	.93	.01
Appearance	4.69 (1.56)	4.88 (.91)	.46	.50	.006
Internalizing difficulties	3.17 (1.07)	3.48 (.81)	2.26	.14	.02
Parents					

ICS_SC P	4.34 (.51)	5.06 (.5)	41.67	<.001	.33
Aggressiveness	3.94 (1.09)	3.06 (1.18)	12.81	<.001	.13
Popularity	4.04 (.91)	4.47 (.74)	6.13	.02	.06
Academic skills	3.39 (1.13)	4.86 (1.28)	30.59	<.001	.27
Friendliness	5.49 (1.18)	5.85 (.98)	2.26	.14	.02
Appearance	4.74 (.91)	5.09 (.73)	3.84	.05	.03
Internalizing difficulties	3.44 (1.09)	3.53 (1.02)	.16	.69	.01
PIB index	.13 (.80)	-.34 (.56)	9.47	.003	.09

Note: PIB index=positive illusory bias index.

Executive functions

Table 5.3 shows descriptive statistics for the performance of the two groups (ADHD and TD) in the EF tasks. In the inhibition task, there was a main effect of group for both the conditions investigated, inhibition [*F(1, 81)*=10.33, *p*=.002, *Adjusted* R^2=.10] and shifting [*F(1, 81)*=17.17, *p*<.001, *Adjusted* R^2=.17], in which the children with ADHD performed significantly worse than the TD children. There was also a main effect of group in the verbal updating task [*F(1, 81)*=15.09, *p*<.001, *Adjusted* R^2=.15], again with the ADHD group performing worse than the TD group, while no significant differences came to light between the groups in the visuospatial updating task [*F(1, 81)*=.66, *p*=.42, *Adjusted* R^2=.004]. A main effect of group emerged for the EF index [*F(1, 81)*=21.92, *p*<.001, *Adjusted* R^2=.21], the children with ADHD again performing significantly worse than the TD children.

Pragmatic language abilities

Table 5.3 shows the descriptive statistics for the two groups (ADHD and TD) on the pragmatic language subscales used to compute the PL index. There was a main effect of group for

inappropriate initiation [*F(1, 81)*=34.66, *p*<.001, *Adjusted* R^2=.29], and use of context [*F(1, 81)*=18.05, *p*<.001, *Adjusted* R^2=.17]. Children in the ADHD group were more often described by their parents as impaired in appropriate initiation and use of context than children in the TD group. No significant effect of group emerged for stereotyped language [F(1, 81)=2.89, p=.09, *Adjusted* R^2=.02] or non-verbal communication skills [*F(1, 81)*=3.52, *p*=.06, *Adjusted* R^2=.03]. The main effect of group [*F(1, 81)*=16.46, *p*<.001, *Adjusted* R^2=.16] emerged for the PL index, in which the ADHD performed significantly worse than the TD group.

Table 5.3. Mean scores (M), standard deviations (SD) and results of ANOVAs for Executive functions and Pragmatic language abilities the ADHD and TD groups

	ADHD (n=41)	TD (n=42)	ANOVAs		
	M (SD)	*M (SD)*	*F (1, 81)*	*p*	*Adjusted* R^2
Executive functions					
Inhib	6.85 (2.49)	8.60 (2.45)	10.33	.002	.10
Shift	6.55 (2.57)	8.83 (2.42)	17.17	<.001	.17
UPv	.60 (.12)	.70 (.12)	15.09	<.001	.15
UPvs	.65 (.29)	.69 (.17)	.66	.42	.004
EF index	-.44 (.88)	.46 (.86)	21.92	<.001	.21
Pragmatic language abilities					
Inappropriate initiation	6.22 (1.89)	9.43 (2.95)	34.66	<.001	.29
Stereotyped language	8. 07 (3.06)	9.17 (2.79)	2.89	.09	.02
Use of context	6.20 (3.03)	9.17 (3.33)	18.05	<.001	.17

Non-verbal communication	7.51 (3.35)	8.90 (3.41)	3.52	.06	.03
PL index	-.41 (.84)	.40 (.98)	16.46	<.001	.16

Note: Inhib=inhibition (NEPSY II); Shift=shifting (NEPSY II); UPv=verbal updating; UPvs=visuospatial updating; EF index=executive functioning index; PL index=pragmatic language index.

Pearson's correlation analysis

Results of correlation analyses between PIB, EFs, and PL abilities by group are summarized in Table 5.4. As represented in the table, the severity of ADHD symptoms does not correlate with PIB, EF and PL index neither in ADHD nor in TD participants. Significant medium correlations emerged between PIB index and PL index for ADHD participants (r = .32, p< .05), but no for TD group. No significant correlations between EF and PL index emerged neither in ASD nor in TD participants. Similarly, no significant correlations emerged between EF index and PL index.

Table 5.4. Pearson Correlation Coefficients between PIB, EF and PL measures in ADHD *(lower diagonal)* and TD *(upper diagonal)*

	ADHD symptoms	*PIB Index*	*EF index*	*PL index*
ADHD symptoms	-	-.10	-.20	-.28
PIB index	-.13	-	-.10	.17
EF index	.02	-.10	-	-.03
PL index	-.19	.32*	-.03	-

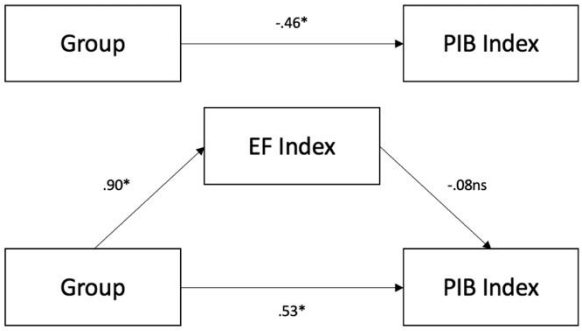
*Note: *p<.05, **p<01, ***p<.001*

ADHD symptoms=Attention Deficit/Hyperactivity Disorder symptoms; PIB index=positive illusory bias index; EF index=Executive Functions index; PL index=Pragmatic Language index

Mediation analyses

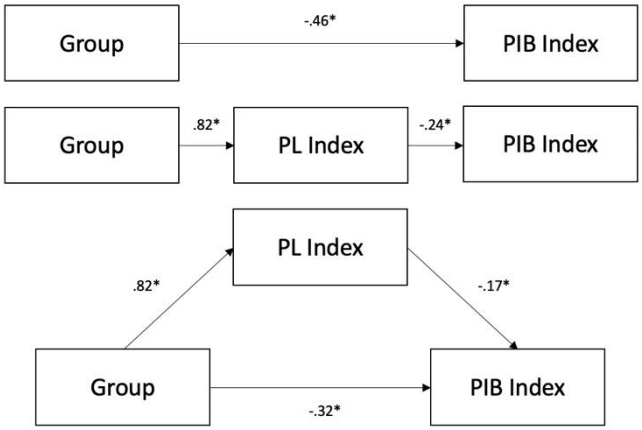
The results of our correlation analyses showed that only PL index was significantly related to the PIB index, while EFs were not in ADHD group. Although the path between EFs to the PIB was not statistically significant, it may be that EFs play a part in the relationship between ADHD status and the PIB index. So, to check the last research question, we tested the hypothesis that EF index and PL index might mediate the relation between ADHD status and the PIB index. Two mediation analyses were performed to examine the hypothesis that EF and PL abilities mediated the relationship between ADHD and PIB, with group as the independent variable, while the EF and PL indexes (computed as latent variables) were considered as mediators. Figure 5.1A shows that group was a significant predictor of PIB (β=-.46, *SE*=.15, *p*=.002). It was also a significant predictor of the EF index (β=.90, *SE*=.19, *p*<.001), whereas the EF index did not predict PIB (β=-.08, *SE*=.09, *p*=.38). The indirect effect (ab) was not statistically significant (β=-.07, p=.53, 95%CI[-.22;.09]). These paths do not support the first mediation hypothesis (Fig 1A). On the other hand, group was also a significant predictor of the PL index (β=.82, *SE*=.20, *p*<.001, Fig 1B). When we compared a fully-mediated with and a partially-mediated model (Fig 5.1B), the better model with the lower AIC was the partially-mediated one (AIC[fully-mediated] =398.07, AIC[partially-mediated] =396.03). In this last model, the PL index emerged as significant predictors of PIB (β=-.17. *SE*=.16, *p*=.04). The indirect effect (ab) was statistically significant (β=-.14, p=.04, 95%CI[-.29; .004]).

Fig 5.1A Mediation model between group and PIB index using the EF index as a partial mediator.



Note: Group: 0=ADHD; 1=TD; PIB index=positive illusory bias index; EF index=executive function index

Fig 5.1B. Mediation model between group (0=ADHD; 1=TD) and PIB index using the PL index as a full and partial mediator.



Note: Group: 0=ADHD; 1=TD; PIB index=positive illusory bias index; PL index=pragmatic language index

5.5 Discussion

The present study aimed to throw light on the effect of EF and pragmatic language impairments on PIB (Hoza et al., 2002) in children and adolescents with ADHD. For this purpose, first

of all children with ADHD were compared with TD children on their self-perception of social functioning. Secondly, EFs and pragmatic language abilities were assessed. Finally, to better understand whether specific neuropsychological characteristics or pragmatic language abilities affect children's self-perception, we tested the association between impairments in EF and/or pragmatic language and PIB regarding social functioning.

Concerning our first goal, our findings generally confirm, one more time, that children and adolescents with ADHD show an overestimation of their own social abilities (i.e., social PIB). The children with ADHD showed no difference in their perception of their own social abilities, compared with TD children. By contrast, parents described children with ADHD as more aggressive, less popular, with weaker academic abilities, and a lower degree of interpersonal competence than the TD group. These results are consistent with previous studies showing a significant PIB in children with ADHD, regarding not only their academic and cognitive abilities, but also their social functioning (Hoza et al., 2002; Linnea et al., 2012; Owens & Hoza, 2003).

The second goal of our study was to assess our two groups' EFs and pragmatic language abilities. Such EFs as inhibition, shifting and verbal or visuospatial updating (Miyake et al., 2000) are commonly impaired in ADHD population (Barkley, 2011; Sergeant et al., 2002). Similarly in our sample, the ADHD group performed less well than the TD children in terms of inhibition, shifting and verbal updating. Somewhat surprisingly, however, we found no differences between the ADHD and TD groups for the visuospatial updating tasks. Nevertheless, variability across tasks is one of the most common outcomes in children with ADHD (Castellanos & Tannock, 2002) and a core factor in this variability seems to be motivation (Sonuga-Barke et al., 2010). Children with ADHD may perform better when a task is cognitively challenging, but not excessively difficult (Silvetti et al., 2013). This may have been the case of our visuospatial updating task, and would explain why our ADHD group performed better than we expected. About pragmatic language abilities, previous studies also

suggested that children with ADHD show significant impairments (Staikova et al., 2013). Our results showed that parents of children and adolescents with ADHD described their pragmatic language abilities as weak, specifically as concerns understanding when to start a conversation, and adapting their language to a given context. Notable, in our study, the pragmatic language difficulties described by the parents of children with ADHD emerged, although the ADHD and TD groups were matched on their receptive language abilities (i.e., TROG-2 test).

Finally, the third aim of our study was to identify possible predictors of social PIB by performing mediation analyses. Based on explanations pointed out earlier for the PIB, we examined neuropsychological impairments, and specifically EF deficits, in our sample. EFs seem to be necessary to judge one's own and others' competence, so neuropsychological difficulties could be responsible for PIB (Shad et al., 2006). We also considered an alternative hypothesis concerning the role of pragmatic language abilities, considered crucial to the social use of language (Russell, 2007). Previous findings underlined that pragmatic language is needed for social perspective taking (Selman, 1971; Russell, 2007), which demands an accurate assessment of one's own abilities and of others' opinions and thoughts. We thus hypothesized that both EFs and pragmatic language abilities might be involved in social PIB. Although specific EF impairments emerged in our group with ADHD, EFs did not mediate the relation between ADHD and social PIB. As concluded in previous studies, EFs probably mediates PIB only in the academic and achievement domains (Chan & Martinussen, 2016; Golden, 2009). We found evidence instead to support pragmatic language abilities partially mediating the presence of social PIB: although the association between the groups and PIB was limited in absolute terms, based on the pragmatic language index, it nonetheless differed from zero when the mediator was introduced.

To our knowledge, this is the first study to test the specific relation between ADHD, pragmatic language and social PIB, after accounting for receptive language skills (which did not differ

between our ADHD and TD groups). Our findings suggest the importance of pragmatic language when it comes to paying attention to other peoples' perspectives, and understanding them (Selman, 2003). This hypothesis is also supported by previous studies in children with other types of neurodevelopmental disorders, which underlined a relation between pragmatic language and social perspective taking (Cardillo et al., 2020; Farrant et al., 2006). Our study confirms that pragmatic language could be seen as the social part of language, the ability to take the other party's perspective into account, and to provide the right amount of information to understand feedbacks from other people. Pragmatic language could thus contribute to explaining differences between children with ADHD and TD children in terms of social PIB.

While this study provides new insight on the factors relevant to the development of social PIB, it some limitations may be drawn. First of all, we only administered a limited set of EF tasks. The tasks we used were chosen because they reflect our theoretical background (Miyake et al., 2000), but other measures and EFs could be considered in further studies. Moreover, we used both paper-pencil test and computerized ones, probably more sensitive in detecting individual differences, further studies may take into account this aspect. Second, our measure of pragmatic language was based on parental reporting scales, while no objective measures were administered to our children. The literature shows that children with ADHD reveal important pragmatic language problems, whatever the assessment method used (Staikova et al., 2013), but further studies should compare the mediating role of pragmatic language measured in different ways (i.e., parental reports vs objective measures) and its effect on PIB. Third, our experimental design prevented us from testing for age or gender effects in the mediation model, given the limited power, once all the variables had been taken into account. Although previous studies found that both children and adolescents with ADHD overestimate their abilities (Volz-Sidiropoulou et al., 2016), further research should include a sample of children with ADHD over a wider age range to empirically test the relation

with EF and PL impairments, also considering both age and gender effects. Finally, alternative hypotheses could be tested to ascertain whether other factors influence social PIB. In the present study we considered two possibilities, (i.e., the role of EFs and pragmatic language abilities), future research could consider the self-protection hypothesis (Hoza et al., 2010). For example, the effect of PIB on loneliness may be considered, as some studies suggested that PIB could have a protective role (Hoza et al., 2010).

Even with these limitations, overall, our findings partially confirm previous results. The parents of children with ADHD esteem their children as impaired in social functioning, while their children saw no differences with TD children, confirming their social PIB. EFs and pragmatic language impairments, especially as regards turn taking and adapting their language to a given context were also confirmed in children and adolescents with ADHD. Interestingly, in our study only pragmatic language abilities partially mediate the relation between our ADHD and TD groups and social PIB.

Chapter 6

General discussion and clinical implications

In the last few years due to their strong impact on general adjustment, two developmental areas have aroused more interest in the literature on ADHD (see for reviews Harpin et al., 2016 and Wanstall et al., 2019): social functioning and self-perception of abilities.

Social functioning includes all the abilities and behaviors necessary to successfully interact with other people and peers (McQuade et al., 2010; Hoza et al., 2010). Social perception (i.e., the ability to understand emotions and others' feelings and thoughts during social interaction), social performance (i.e., performing the appropriate social action in response to a social stimulus) and social knowledge (i.e., understanding the correct social behavior for a particular social situation) are the three main influential components of the social functioning (Semrud-Clickeman et al., 2010). Within these three main influential components (i.e., social perception, social performance and social knowledge), the Social Information Processing (SIP) model (Dodge, 1980; Crick & Dodge, 1994; Lemerise & Arsenio, 2000) asserts that in response to problematic social situations, children and adolescents respond with a sequence of six mental operations: encoding of internal and external cues; interpretation the intent and emotions of self and others; clarification of social goals, such as maintaining a good relationship or taking revenge; generation of a first spontaneous response (assertive, aggressive or passive) to help the individual to achieve the social goals; evaluation of different response options and selection of the best one; behavioral enactment. Despite the abundance of research on social functioning impairments in ADHD (see for review Harpin et al., 2016) to date, few studies have analyzed the characteristics of social functioning impairments with both questionnaires and lab-based tasks in this clinical population, outlining similarities and

differences with another developmental disorder mainly characterized by social functioning impairment: the autism spectrum disorder (ASD). Furthermore, the shared and distinct specific biases that may generate in the different steps of the SIP model (Van Rest et al., 2017) in ADHD are still not well understood.

Moving to the second area, several studies underlined as both children with TD and ADHD tend to overestimate their own abilities vis-à-vis external criteria (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). This overestimation, however, assumed specific characteristics in ADHD population, compared to TD group. First of all, the overestimation in ADHD is associated with several negative outcomes (Hoza et al., 2010; Hoza, et al., 2002; Linnea, et al., 2012). Secondly, it has been shown to be a predictor of maladjustment in new environments (Jia, Jiang, & Mikami, 2016). Thirdly, it is not useful to perform well on challenging tasks, contrary to TD children (Hoza et al., 2001). Finally, it has been documented that the discrepancy between the self-perception and external measures is larger in ADHD than TD children (Owens & Hoza, 2003). The overestimation phenomenon in ADHD population has been called positive illusory bias (PIB) (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). The presence of PIB in the ADHD population is well established, but the specific features and possible differences with other neurodevelopmental disorders (e.g., ASD) are not clear enough (Owen & Hoza, 2004). Moreover, several hypotheses (see for a review Owens et al., 2007) have been suggested for explaining the underlying factors of this incorrect perception of abilities. It would be possible that clinical impairments and comorbidities with internalizing (i.e., depression and anxiety) and externalizing (i.e., aggression, rule braking behavior) disorders may have a decisive role (see chapter 4 for a detailed description). Another hypothesis is that neuropsychological deficits could make children with ADHD unable to self-estimate their abilities (see chapter 5 for a detailed description). Finally, several other factors as

communication impairments could be related to this overestimation of abilities (see chapter 5 for a detailed description).

The present PhD dissertation aimed to improve our understanding of social functioning and self-perception of abilities in children and adolescents with ADHD, using cross-disorder comparisons. Cross-disorder comparisons, indeed, are suggested as the best way to analyse multifaceted abilities in neurodevelopmental disorders (D'Souza, et al., 2016), considering that a general impairment frequently emerged when children with ADHD had merely been compared with typically developmental children (Crisci et al., 2021; D'Souza, et al., 2016). Specifically, first of all the performance of children with ADHD in the two areas was compared to the performance of children with ASD without intellectual disability. This specific comparison was chosen because the comorbidity rate between ADHD and ASD is incredibly high (65-80%) (Biederman & Faraone, 2005) and shared and distinct features on both social functioning and self-perception have not been fully understood (see for a detailed description chapter 1). Moreover, some aspects of these areas which emerged as peculiar of ADHD have been deeply examined, considering the role of additional factors (Theory of Mind, neuropsychological impairments, or communication) which could influence the performance of children and adolescents with ADHD. Specifically, in this dissertation, social functioning and its main components (i.e., social perception, social performance and social knowledge) were studied with both questionnaire and new lab tasks based on the SIP model in ADHD and ASD (Study I, Chapter 2), in an effort to identify strengths and weaknesses in their social functioning profiles. A second study involved only participants with ADHD, focusing on social perception and on additional factors (Theory of Mind, neuropsychological impairments, and communication) which could influence their social perception (Study II, Chapter 3). In the second part of the dissertation, a third study (Chapter 4) applied the same cross-disorder comparison between children with ADHD and ASD to seek similarities and differences in their self-perception

abilities, in different areas (i.e., social abilities and behavioural problems) and taken into account the role of comorbidities. Finally, the specific factors which could influence the overestimation of social abilities in children and adolescents with ADHD were considered in the last study (Study IV, Chapter 5).

In the following sections the main findings of each study will be summarized. The strengths and limitations of the studies will also be mentioned, as well as the questions that remain open and the suggestions for further research. Finally, the clinical and educational implications of the study findings will be discussed.

6.1 Research findings overview

In Study I, ADHD and ASD groups were compared on social functioning with both proxy-reports and new lab-based tasks, composed by three videos representing social problem situations among peers. Specifically, parents filled a questionnaire about their children's social functioning; whereas using the lab-based task, children were presented with questions regarding videos assessing the three main influential components of social functioning: social perception (i.e., the ability to understand others' feeling, thoughts and emotions); social performance (i.e., all verbal or nonverbal actions displayed in peer situations); social knowledge (i.e., the knowledge of what to do in specific social contexts). The findings confirmed that both ADHD and ASD have significant impairments in social functioning compared to TD children (see for a review Mikami et al., 2019). On one hand, contrary to the hypotheses (Semrud-Clikeman et al., 2010; Dyck et al., 2001), according to their parents no differences emerged between the two clinical populations' social abilities. On the other hand, deepening the specific difficulties encountered in the three main influential components of social functioning (i.e., social perception, social performance and social knowledge) with the new lab-based task, resembling real life interactions, particular features emerged in each population. In social perception, both children with ADHD and ASD revealed worst

abilities, compared to TD children (Uekermann et al., 2010; Baron-Cohen, 2000), with higher difficulties in the ASD group (Bora & Pantelis, 2016). Concerning social performance, our sample of children with ADHD were characterized by higher presence of negative goals and aggressive answers, compared to both ASD and TD sample (Channon et al., 2001; Meyer et al., 2006). Contrary to previous findings (Gardner & Gerdes, 2015; Ronk, et al., 2011), children with ASD generate the same amount of assertive answers as TD children. It is worth noting that most of the ASD participants of our study had been involved in specific interventions which frequently focused on assertiveness, thus probably these previous experiences allowed to improve these specific aspects of social performance in our group of participants. Moreover, our results revealed that in social knowledge children with ADHD possessed intact abilities (Barkley, 2015), whereas children with ASD showed less knowledge of correct social behavior (Matson & Wilkins, 2007; Lerner & Girard, 2021). Finally, as expected (Saunders et al., 2018; Eisenberg et al., 2019; Joseph & Newman, 2010; Murphy & Lilienfeld, 2019), the parent-report measure and our lab based tasks do not show strong correlations. Our lab-based task, resembling the real life interactions, give us a broader picture of social functioning impairments of children with ADHD rather than proxy report.

In the light of the results that emerged from the Study I, in which social perception was examined for both ADHD and ASD outline differences that were not clear if depended on the specific task used, in the Study II this aspect was deepened in ADHD population, trying to understand specific factors that could have an impact on their performance. Specifically, using semi-naturalistic tasks the role of nonverbal signals recognition, the type of stimulus presented (video, audio or combined/multimodal) and the association between higher-order cognitive skills (i.e., ToM, attention and inhibition, and pragmatic language skills) and social perception abilities were investigated. First of all, our findings confirmed that social perception of both children with ADHD and TD benefited from nonverbal signals recognition (Fine et al., 2008; Semrud-Clikeman, 2010;

Semrud-Clikeman et al., 2010). Second, we also find differences according to the type of social stimuli manipulated. Specifically, the performance of children with ADHD was significantly worse than TD, only for combined (video and audio) stimuli, probably because this modality of stimuli presentation more closely resembled to real-life interactions, showing simultaneously several stimuli (i.e., audio and video). Finally, about the higher-order cognitive skills, attention had the main role in each condition (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010), whereas theory of mind assumed more importance for the video and combined conditions, in which face perception and eye gaze detection could make easier to decode information (Mitchell & Phillips, 2015). In addition, communication affected particularly the conditions (i.e., audio and video) in which relevant information, such as lexical content or face expressions, was intelligible (Socher et al., 2019), but only in the TD group. Several previous studies underlined, indeed, a different relation between communication and social functioning in ADHD, depending on the area of communication considered (Staikova et al., 2013; Adams, 2002, Landa, 2005).

Moving on the second area examined in the present PhD dissertation, the Study III focused on self-perception of abilities in two populations with neurodevelopmental disorders (ADHD and ASD), compared with TD children. Two different areas were examined: social functioning and behavioural problems, with the SSIS-RS (Gresham & Elliot, 2008). Two parallel forms of the questionnaire were filled by children and parents, making possible to compare children's and parents' perception. Additionally, using a parent-report measure (CBCL, Achenbach & Rescorla, 2004) the role of comorbidities (i.e., internalizing and externalizing disorders) on the self-perception of abilities was considered. Overall, our findings underlined as self-perception of social abilities is significantly impaired only in ADHD population compared to both ASD and TD group, confirming as the overestimation of their own abilities vis-à-vis external criteria is a specific phenomenon of children with ADHD, called Positive Illusory Bias (PIB, Capodieci et al., 2019; Hoza et al., 2002; Owens

et al., 2007). Contrary to previous findings (Koning & Magill-Evans, 2001; Knott, Dunlop, & Mackay, 2006; Vickerstaff, Heriot, Wong, Lopes, & Dossetor, 2007), indeed, our children with ASD showed a correct estimation of their own social abilities. Moreover, based on our data, the overestimation of their own characteristics is specific of some functioning areas in ADHD (e.g., social functioning) and absent in others (e.g., behavioural problems): children with ADHD correctly estimate their own behavioural problems. Conversely, TD children overestimate their own behavioural incompetence, confirming the presence of the Negative Illusory Bias (NIB) only in the TD group, probably because of the social desirability (Gresham et al., 2000). Finally, as expected (Jensen et al., 2001; Rosenberg et al., 2011), higher clinical impairments emerged in both clinical conditions (i.e., ADHD and ASD) than TD children, but neither externalizing and internalizing problems have a direct impact on PIB in social context (social PIB).

Taken into account the unsuccessful role of comorbidities as explanation of the social PIB in children with ADHD, in the last study (Study IV) additionally hypotheses were tested. First of all, consistently with previous studies (Hoza et al., 2002; Linnea et al., 2012; Owens & Hoza, 2003) our findings confirmed, one more time, that children and adolescents with ADHD show an overestimation of their own social abilities (i.e., social PIB). Secondly, the role of neuropsychological deficits (i.e., Executive function – EFs - deficits) and communication impairments (i.e., pragmatic language) were taken into account. From a theoretical point of view, indeed, both EFs, necessary to judge one's own and others' competence (Shad et al., 2006), as well as pragmatic language abilities, crucial to the social use of language (Russell, 2007) and social perspective taking (Selman, 1971; Russell, 2007), might be involved in social PIB. Both EFs deficits and pragmatic language impairments, frequently highlighted in ADHD population (Barkley, 2016; Staikova et al., 2013), were significantly impaired in our sample. However, we found evidence to support that only pragmatic language abilities and not EFs deficits partially mediated the presence of social PIB, suggesting the

importance of pragmatic language when it comes to paying attention to other peoples' perspectives, and understanding them (Selman, 2003).

Table 6.1 summarizes the main findings of the four studies carried out for the present PhD dissertation.

Table 6.1 Summary of the essential information concerning each study: number of participants (N), groups involved, the topic examined, main aims and findings.

Study	N	Groups	Topic	Aims	Main findings
I	225	ADHD ASD TD	Social functioning: d) social perception e) social performance f) social knowledge	4. Examining the general social functioning with proxy report; 5. Analyzing the specific difficulties encountered in three influential components of social functioning (i.e., social perception, social performance and social knowledge) with specific lab-based tasks. 6. Observing the relation between proxy-reports and lab-based tasks	• No differences in social functioning impairments between ADHD and ASD using the proxy report (Bora & Pantelis, 2016). • Using lab-based tasks emerged: greater difficulties in ASD than ADHD in social perception (Bora & Pantelis, 2016); higher presence of negative social behaviors in ADHD than ASD and TD in social performance (Channon et al., 2001; Gardner & Gerdes, 2015; Meyer et al., 2006; Ronk, et al., 2011); in social knowledge intact abilities in ADHD (Barkley, 2015), whereas less knowledge of correct social behavior in ASD than ADHD (Matson & Wilkins, 2007). • Weak correlations appeared between proxy-reports and lab-based tasks (Saunders et al., 2018; Eisenberg et al., 2019; Joseph & Newman, 2010; Murphy & Lilienfeld, 2019). The information derived by lab-based task offered a broad picture of social functioning abilities, than the proxy report (Mikami et al., 2019).
II	72	ADHD TD	Social perception Higher-order cognitive skills:	3. Examining social perception, investigating the role of nonverbal signals recognition	• Nonverbal signals recognition are essential to social perception (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010); in ADHD social perception was impaired when simultaneous

			d) ToM e) Attention and executive functions f) Pragmatic language	and of different type of stimuli; 4. Analyzing the different contributions of ToM, attention and executive functions, and pragmatic language skills.	presentation of audio and video stimuli were used (Cortes et al., 2021; Hunter et al., 2010; Wieck & Kunzmann, 2017). • ToM, attention, and pragmatic language were related to social perception (Beauchamp & Anderson, 2010; Yang et al., 2015) with different involvement of each ability depending on the task condition (i.e., video, audio and multimodal/combined) (Mitchell & Phillips, 2015; Semrud-Clickeman, 2010; Russell, 2007; Socher et al., 2019): attention had the main role in each condition (Fine et al., 2008; Semrud-Clikeman, 2010; Semrud-Clikeman et al., 2010); ToM in the video and combined condition (Mitchell & Phillips, 2015); pragmatic language in the audio and video and video conditions (Socher et al., 2019), but only in the TD group.
III	222	ADHD ASD TD	Overestimation of abilities	4. Identifying the overestimation of social abilities in ADHD and ASD; 5. Investigating the estimation of behavioral problems in ADHD, ASD and TD, 6. Examining the role of internalizing and externalizing symptoms in the overestimation of abilities.	• Only ADHD overestimated their own social skills (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007; Wanstall et al., 2019). • The overestimation of ability emerged only in some areas of functioning (Owens et al., 2008; McQuade et al., 2010). • Higher clinical impairment was oberved (both internalizing and externalizing disorders) in both clinical conditions (Jensen et al., 2001; Rosenberg et al., 2011), but it had no impact on the overestimation of abilities.

IV	83	ADHD TD	Overestimation of social abilities Neuropsychological deficits Communication impairments	3. Identifying the overestimation of social abilities in ADHD; 4. Investigating the role of neuropsychological deficits and communication impairments.	• An overestimation of social abilities was confirmed (Capodieci et al., 2019; Hoza et al., 2002; Owens et al., 2007). • Only communication impairments partially mediated the relation between ADHD and the overestimation of social abilities (Owen et al., 2003; Staikova et al., 2013).

Note: ADHD: Attention deficit hyperactivity disorder; ASD: Autism Spectrum Disorders; TD: Typically developmental children; ToM=Theory of mind

6.2 Study limitations and suggestion for future research

Although the present dissertation offers novel evidence and highlights the importance of studying both social functioning and self-perception of abilities in children with ADHD, some limitations need to be mentioned, and a number of other aspects might be addressed in future research. While some of the issues were presented in the discussion sections of the single studies, the focus here is on more general aspects.

A methodological constraint concerns our samples' characteristics. First of all, we were unfortunately unable to run a power analysis because the number of participants with a clinical diagnosis was based on a delicate balance that needed to be struck between the amount of time practitioners and families could be available. The children included in the study also had to meet very restrictive inclusion and exclusion criteria, as previously mentioned in the participants' description of each study. Secondly, the relatively small sample sizes made us unable to study possible differences related to the predominately subtype of ADHD shown. Previous studies underlined similar difficulties independently from the ADHD manifestations (Semrud-Clickeman, 2010), but further studies should try to confirm and extend our findings considering this aspect. Third, each sample showed a large disproportion between males and females. In the literature sex differences in the ADHD rate is well documented, with a male to female ratio of about 3:1 (Willcutt, 2012), moreover previous findings underlined as males likewise show more severe symptoms among diagnosed individuals. However, further research should try to replicate our findings by assessing samples of children with a similar proportion of both male and female participants. Finally, a marked variability in participants' ages within each clinical sample was taken into account. Although our groups were always matched for, evidence suggested that both social abilities and self-perception of abilities develop dung both childhood and adolescence (Semrud-Clickeman et al., 2010), it is likely that the developmental trajectory of these abilities may assume specific features

in each age step. Future studies might reduce this variability by adopting more restrictive criteria in order to analyse narrow age groups in cross-sectional research. Of course, longitudinal studies would be the best methodological choice to analyse more in depth developmental changes in both social abilities and self-perception of abilities.

Another limitation of our studies, particularly of the Study II, III and IV, is that we relied on cross-sectional data rather than investigating each ability during the development. Despite the direction of the relations chose for our studies were based on several well-established theoretical models, it is not possible confirmed the directions of the cause-effect relations highlighted. As previously mentioned, further studies could include longitudinal data to endorse these relations.

Another limitation that seems important to mention, concern the types of task used in the first two studies of the present dissertation. The best recognized method to assess social functioning is the direct observation of social behaviour in real context (as school) or the use of sociometric diagrams among peers (Hoza et al., 2005). Unfortunately, due to the characteristics of our samples recruited in clinical services, these methodologies were not applicable. A behavioural cognitive method was, indeed, used to devise our experiments albeit proposing the use of videos to make children able to better identify themselves with real social interaction contexts. Additional information on their social abilities might be obtained in further studies by means of other methods, using computerized approach. Thanks to the technology would be indeed possible to simulate the presence of other participants in the same online context to directly assess social behaviour of children with ADHD (as prosocial abilities and aggressiveness).

Finally, in the last two studies we focused on the self-perception of abilities, and considered only some children's abilities (as social and behavioural problems), additional studies may include other life's areas to understand if the overestimation of abilities affects other domains. Moreover, we only considered the role of some aspects (i.e., clinical impairments, neuropsychological deficits

or pragmatic language impairments) as potential predictor of the self-perception overestimation, but other studies may test alternative hypotheses to understand if other factors influence this overestimation. A specific aspect that may be considered is the role of contextual factors such as the parenting style (Emeh & Mikami, 2012). Several previous studies underlined, indeed, as parental feedback and educational styles have an important impact on the development of self-esteem and self-perception (Emeh & Mikami, 2012). The interactions between parents and children with ADHD are characterized by higher negative and directive behaviours than parents of TD children (Wells et al., 2006). In addition, parents of children with ADHD are less likely to mention and attend to positive behaviours displayed by their children and interact with their children in more negative ways when compared with the parents of TD children (Danforth, Barkley, & Stokes, 1991; Johnston & Mash, 2001). Taken these considerations into account, it is possible that the PIB is a sort of protective mechanisms shown by children with ADHD. It would be interesting to consider whether naturalistically occurring interaction patterns between parents and their children may relate to children's expression of PIB.

6.3 Clinical implications

Clinical implications may be drawn from our findings, shedding more light on assessment, interventions and differential diagnosis with ASD based on social functioning and self-perception abilities of children and adolescents with ADHD.

Despite social functioning impairment is not required for a diagnosis of ADHD, our studies emphasize the importance of considering these aspects during the assessment phase. Our results showed, indeed, the importance to empirically assess social functioning in clinical evaluation and suggested that the use of parents' report give only a partial view of the real abilities of the child. Our findings may also encourage clinicians to investigate different aspects of social functioning (e.g., social perception, social functioning and social knowledge). Specifically, our results underlined as

the performance of children and adolescents with ADHD was significantly lower only in tasks very close to real every-day life interactions. This result highlights the importance to propose tasks as similar as possible to real-life interactions during the clinical assessment to capture the social functioning profile associated with ADHD (Magill-Evans et al., 1995). In addition, our studies revealed the importance to keep attention in the interpretation of self-reports during the assessment of abilities in children and adolescents with ADHD. In some areas of functioning ADHD population could show an unrealistic self-concept which may predict worse long-term outcomes (Owens & Hoza, 2003). This aspect is a key characteristics considered that children and adolescents with ADHD who overestimate their own competences may not respond well to treatment, resulting in negative consequences in adolescence and adulthood (Owens et al., 2007), probably because an accurate self-perception is essential to enable change in behaviours (McQuade et al., 2017).

About interventions, our studies helped the identification of specific strengths and weaknesses in the cognitive profiles of individuals with ADHD, underlined as specific abilities could have a major role in the refinement of intervention programs. A thorough investigation of the social functioning domain could orient the design of social skills intervention programs to improve these abilities, given their importance in daily life, at school, and in leisure activities. Specifically, social performance emerged as the main impairments of children with ADHD. Treatments may include assertive trainings and behavioural procedure to promote these behaviours. Additionally, as emerged from the Study II, children with ADHD experienced social functioning problems mainly because of inattention and theory of mind difficulties. These findings underlined as interventions should focus not only on the core symptoms of ADHD (as attention problems), but also include specific trainings to improve theory of mind and perspective taking. Moreover, judging from the results of the Study IV, pragmatic language abilities should be also included among the social skills trainings, and could be helpful in improving social perspective taking and realistic self-concept in

children and adolescents with ADHD. This could prompt new suggestions for improving clinical approaches, as existing interventions for ADHD seem to have little effect in improving pragmatic language, social skills and social perspective taking (Hoza et al., 2004; Staikova et al., 2013).

Finally, a better understanding of the social functioning might also help in the differential diagnosis, shedding light on the differences between the social profiles of ADHD and ASD. As reported the comorbidity rate between these two disorders is incredibly high (Biederman & Faraone, 2005) and have posed a diagnostic challenge because of similarities in some symptoms (Fine et al., 2008). Our studies may help in the differentiation of specific difficulties on both social functioning and self-perception abilities in the two clinical populations. In detail, our findings underlined clearly as social functioning impairment affect both populations considered, but with some differences. Children with ASD showed significantly higher deficits in several areas of social functioning (e.g., social perception and knowledge), whereas children with ADHD had significant difficulties mainly in social performance. Moreover, a greater overestimation of social abilities seems to be a distinctive feature only of ADHD population.

To conclude, investigating social functioning and self-perception of abilities in individuals with ADHD is a highly complex issue. There is still space for further research on the domains of social functioning, and on the general self-perception of abilities of children with ADHD, specifically comparing their abilities to other neurodevelopmental disorders. The present dissertation was an effort to raise and clarify some points, but other questions remain open and will require further studies.

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