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Assessing social-pragmatic inferencing skills in children with autism spectrum disorder

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ABSTRACT

By utilizing the Pragma test this study investigated how sixteen five- to ten-year-old children with autism spectrum disorder (ASD) and sixteen typically developing (TD) children comprehended contextually challenging scenarios demanding 1) contextual inference with theory of mind (ToM), 2) contextual inference without ToM, 3) relevant use of language, 4) recognition of feelings, and 5) understanding false beliefs. The study also compared children's ability to explain their own correct answers. In addition, this study evaluated the sensitivity of three different methods for discriminating the children with ASD from the TD children: 1) the Pragma test, 2) the Social Interaction Deviance Composite (SIDC) of Children's Communication Checklist-2 (CCC-2), and 3) the Theory of Mind subtest of the Developmental Neuropsychological Assessment, Second edition (NEPSY-II). The results showed that children with ASD differed from TD children in questions demanding context utilization. However, the demand of mind-reading in utterance interpretation increased the difference between groups. Compared to TD children, children with ASD had more difficulties in explaining how they had used context to arrive at the correct answer. The discrimination power for detecting children with ASD from TD children was excellent in the Pragma test, good in the SIDC CCC-2 and fair in the Theory of Mind subtest of NEPSY-II. This study showed that by using contextually sensitive materials, such as the Pragma test, it is possible to detect the social-pragmatic inferencing difficulties of high-functioning children with ASD in structured test situations and not only in real-life situations or by using parental reports.

1. Introduction

Autism spectrum disorder (ASD) is characterized by persistent deficits in 1) social communication and interaction, and 2) restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013, DSM-5). As diagnostic criteria shows, social communication difficulties are one of the core features of ASD. During recent years there have been changes in how these persistent deficits in ASD have been viewed since the current diagnostic criterion (DSM-5) of ASD combines social interaction and communication. This is reasonable since social reciprocity is central in both verbal and non-verbal communication and,

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thus, there is no communication without social interaction (Baron-Cohen, 2010; Vaughan & Hogg, 2014). It is obvious that difficulties in social communication increase—for example, the risk of peer discrimination and difficulties with integrating into society (Finke, 2016; Fleisher, 2001; Landa, 2000). Even though social-pragmatic abilities progress with age in individuals with ASD, these difficulties persist into adulthood even in the most capable individuals with normal intelligence with ASD (Jolliffe & Baron-Cohen, 1999a, 2000; Loukusa & Moilanen, 2009; Lönnqvist et al., 2017; Rapin & Dunn, 2003). This increases the importance of studying social-pragmatic inferencing in children with ASD. Due to the complex situational nature of language comprehension in context, it is often thought that social-pragmatic difficulties cannot be effectively captured in structured test situations (Adams, 2002; Volden, Coolican, Garon, White, & Bryson, 2009) and because of that, the clinical assessment of pragmatic skills is mostly done via parental reports. Although currently there are already some tests for assessing pragmatic skills in clinical settings (see e.g., Norbury, 2013), there is still a need to develop valid, research-based test methods for clinical settings that are directed towards evaluating social-pragmatic inference difficulties in children with ASD.

1.1. Social-pragmatic language

Successful communication calls for the ability to go beyond the information given linguistically since many simultaneous contextual and social factors continuously impact upon our interpretations and expressions of language (Gibbs & Colston, 2012; Huang, 2012; Leinonen, Letts, & Smith, 2000). In many situations, utterances have many possible interpretations that are compatible with the linguistic information but these interpretations are not as likely to come into the listener's mind since comprehension is said to be driven by a search for relevance (Huang, 2012; Sperber & Wilson, 1995, 2012). This means that the hearer automatically attempts to utilize only relevant information in utterance interpretation. Pragmatics is described as a study of language use, specifically focusing on how people utilize context in comprehension and expression, and how contextual factors interact with linguistic meaning (Sperber & Wilson, 1995, 2012; Verschueren, 1995). The use of language involves cognitive processes, takes place in the social world, and varies according to cultural constraints (Verschueren, 1995). In real-life situations, understanding what the speaker is communicating and what is his or her intention is a complex process (Gibbs & Colston, 2012; Schmid, 2012; Singer & Lea, 2012). Pragmatic inference is not just interpreting a meaning or intention but it is a continuously changing process of the person adapting to the world (Gibbs & Colston, 2012). Pragmatic abilities affect how a person communicates and behaves in social situations, which in turn affects how others respond to the person, which then subsequently affects his or her actions.

Social perception plays an important role in pragmatic inference, since in order to communicate successfully, a person needs to take other people's emotions, wishes, and intentions into account (Cummings, 2014) and be aware of shared knowledge (Horton, 2012). Language use and social perception (e.g., theory of mind [ToM]) interact with each other from the beginning of children's development (de Viliers, 2005; Miller, 2006; Lohmann, Tomasello, & Meyer, 2005; Nelson, 2005). Since pragmatic language use is always social, with the current knowledge it may even be artificial to try to separate social and pragmatic inference from each other. In this study the term *social-pragmatic inference* is used in studying the understanding of utterances, intentions, feelings, and beliefs based on the *contextual information.*

1.2. Social-pragmatic inferencing skills in children with ASD

Even though there is an increasing number of studies concerning aspects of social-pragmatic language in ASD (e.g., Dennis, Lazenby, & Lockyer, 2001; Lam & Yeung, 2012; Loukusa, Leinonen, Jussila et al., 2007; Whyte & Nelson, 2015) further research is required to ascertain how prevalent these difficulties are in ASD and what their core features are. Many studies have focused on separate functions of social-pragmatic language, such as understanding irony (Wang, Lee, Sigman, & Dapretto, 2006), humor (Emerich, Creaghead, Grether, Murray, & Grasha, 2003), metaphors (Happé, 1995; Rundblad & Annaz, 2010), idioms (Lee, Song, Ham, Song, & Cheon, 2015), and homographs (Hala, Pexman, & Glenwright, 2007; López & Leekam, 2003). In addition, there are many studies focusing on social perception, such as difficulties in recognition of emotion (Kuusikko et al., 2009; Loukusa, Mäkinen, Kuusikko-Gauffin, Ebeling, & Moilanen, 2014) and difficulties in verbal ToM (Durrleman & Franck, 2015; Loukusa et al., 2014). At the moment, one of the most widely used approaches for measuring advanced ToM skills in individuals with ASD is Happè's Strange Stories Test (Happe, 1994; Heavey, Phillips, Baron-Cohen, & Rutter, 2000; Jolliffe & Baron-Cohen, 1999a; Kaland et al., 2005), which measures the ability to provide a context-appropriate explanation for story characters' non-literal statements. It has been developed to function as an advanced test of ToM. However, when looking at the test questions and scenarios of Happè's Strange Stories Test, it is obvious that answering also demands pragmatic inferencing abilities (e.g., understanding ironic utterances demands context utilization in many different ways).

In this study we use a methodology that connects pragmatic and social perception factors in utterance interpretation in order to reflect real-life communication situations where these (and other cognitive, linguistic, and sensory) factors interact with each other giving rise to relevant communication in different situations (see also Perkins, 2007). Because of this, when studying the social-pragmatic functioning of children with ASD, in addition to studying skills separately, we should have studies in which factors are studied using utterances that reflect real-life processing demands as much as possible. In real-life situations, different kinds of factors interact with each other in complex way and the relevant social-pragmatic functioning is a result of these interactions (Gibbs & Colston, 2012; Perkins, 2007). For example, there can be situations where a child with ASD can recognize others' mind content in false-belief questions or recognize separate contextual factors, but he or she cannot utilize these skills in situations where different factors interplay with each other.

Social-pragmatic inferencing is a complex process and regardless of the increase in studies focusing in this, we need a better

understanding of social-pragmatic functioning of children with ASD. Although it is known that children with ASD have challenges with social-pragmatic inferencing—for example, in deriving implicatures (Loukusa, Leinonen, Jussila et al., 2007; Loukusa, Leinonen, Kuusikko et al., 2007)—we do not have good insight into the processing of contextually different kinds of social-pragmatic utterances by children with ASD. Compared to typically developing (TD) children, children with ASD have shown specific pragmatic inferencing deficits that affect their ability to infer the implication of an utterance and to make inferences from social scripts, metaphors, and speech acts (Dennis et al., 2001). The differences between children with and without ASD seem to increase in relation to the amount of inferencing and intentionality a task requires. Loukusa, Leinonen, Jussila et al. (2007) and Loukusa, Leinonen, Kuusikko et al. (2007) showed that children with ASD had difficulties in processing contextually complex utterances, such as detecting implicatures, but none in the comprehension of reference assignments, which are contextually less demanding. In addition, Kaland et al. (2002, 2005) have shown that inferring mental states is more problematic to children and adolescents with ASD, compared to physical states. These findings about the effects of inferencing load and intentionality of tasks are interesting and this should be studied more since it is only possible to direct rehabilitation to the key factors by understanding the features of social-pragmatic language processing.

Social-pragmatic inference difficulties in ASD have been explained in a light of variety cognitive theories—such as ToM (Beaumont & Newcombe 2006; Happé, 1993; Martin & McDonald, 2004), weak central coherence theory (Jolliffe & Baron-Cohen 1999b, 2000; Norbury & Bishop, 2002; Noens & van Berckelaer-Onnes, 2005), and executive dysfunction theory (Hill, 2004)—and cognitively oriented pragmatic theories, such as relevance theory (Happé, 1993; Loukusa, Leinonen, Jussila et al., 2007; Loukusa, Leinonen, Kuusikko et al., 2007) and Gricean maxims (Surian et al., 1996). In addition to the above-mentioned theories, empathizing–systemizing (E–S) theory (Baron-Cohen, 2009, 2010) offers a fruitful background for interpreting social-pragmatic inferencing difficulties in ASD, even if it is not yet commonly utilized in pragmatic language studies. According to the E–S theory, individuals with ASD perform poorly in tasks requiring affective and cognitive empathy, but their ability to use systemizing skills is either average or even above average (Baron-Cohen, 2009, 2010; Goldenfeld, Baron-Cohen, & Wheelwright, 2005; Wakabayashi et al., 2007). This discrepancy between weak empathizing skills (e.g., difficulties in understanding others' emotions and literal interpretation without utilizing the wider social and societal context) and intact or superior systemizing skills causes a specific processing style that includes many kinds of strengths (e.g., good technical skills) but also weaknesses, making young adults with ASD vulnerable to many kinds of exploitation and manipulation (Al-Attar, 2016). In order to support individuals with ASD in the best possible way, we have to learn more about their processing styles and how to assess and support their social communication skills properly.

At the moment, there is still a need to develop pragmatic assessment methods that are sensitive enough to detect the variability of difficulties in understanding social-pragmatic language (see Volden, 2017; Volden et al., 2009). Many individuals with ASD can understand simple pragmatic questions in structured test situations, which can sometimes mislead clinicians, leading them to think that there are no problems with the individual's pragmatic language. There is also a challenge for trying to construct recommendations for intervention simply on the basis of parental reports. The structured assessment of social-pragmatic inference skills makes it possible to compare children's skills with those of other children of the same age, which gives important information about difficulties and helps clinicians to direct rehabilitation and assess its effectivity. Already at the moment, some standardized tests, such as the Test of Pragmatic language, Second edition (TOPL-2, Phelps-Terasaki & Phelps-Gunn, 2007) and subtests, such as The Pragmatic Judgement subtest of the Comprehensive Assessment of Spoken Language (CASL, Carrow-Woolfolk, 1999) have been developed and used with children with ASD (Volden et al., 2009; Whyte & Nelson, 2015). The Pragmatic Judgment subtest of the CASL measures awareness of appropriate language in a situational context and the ability to modify this language as necessary. The study of Whyte and Nelson (2015) showed that these skills develop slower in children with ASD compared to their controls. The TOPL-2 measures child's ability to generate socially suitable response or resolute a conflict in given social situation. Using the earlier version of the test (TOPL) Volden et al. (2009) showed that children with ASD have challenges to answer contextually challenging questions in socially suitably way. However, later study (Koning & Volden, 2012) showed that although children with ASD performed weaker than their controls in TOPL-2, parent-report instrument, Children's Communication Checklist-2 (CCC-2) (Bishop, 2003), was more sensitive in identifying pragmatic language impairment in cognitively and linguistically able children with ASD showing how difficult it is to develop sensitive structured pragmatic assessment method.

The knowledge of social and pragmatic language has increased remarkably during the last ten years (see Volden, 2017), which gives us the possibility to develop new research-based methods for assessing different aspects of social-pragmatic language, such as social-pragmatic inference skills. One promising new structured measure for assessing social-pragmatic inference is the Pragma test (Loukusa, Mäkinen, Gabbatore, Laukkanen-Nevala & Leinonen, 2017). It measures social-pragmatic skills that belong to the one of the core diagnostic area of ASD (i.e., social communication and interaction as described in DSM-5). The Pragma test assesses children's ability to utilize contextual information and understand intentions, thoughts, beliefs, and feelings. The Pragma test is developmentally sensitive to measuring children's social-pragmatic inference abilities (Loukusa et al., 2017) and it has also been shown to detect social-pragmatic inference difficulties in a small group of children with ADHD (Loukusa, 2017). However, it has not yet been used in evaluating children with ASD, which is the group it is especially directed towards.

1.3. The aim of this study

The purpose of this study is to investigate how children with ASD comprehend socially and pragmatically challenging scenarios, compared to TD children. Specifically, this study evaluates children's performance in relation to five different kinds of questions: 1) contextual inference with ToM demand, 2) contextual inference without ToM demand, 3) relevant use of language, 4) recognition of feelings, and 5) understanding false beliefs. Understanding different types of scenarios requires different levels of cognitive effort and

Table 1
The ratio of boys to girls, age, and the scores of tests as medians and means (standard deviations are in parentheses), group comparisons (Mann-Whitney *U* test, 2 tailed) and effect sizes for comparisons in children with autism spectrum disorder (ASD) and children with typical development (TD).

	ASD	TD	*p* value	effect size *r*
Boys/girls	15/1	15/1	–	
Age (years)	7;7 (1;7)	7;6 (1;5)	0.838	0.04
Verbal IQ				
Median	88.5	–		
Mean (SD)	92.7 (19.9)	–		
Performance IQ				
Median	90.5	–		
Mean (SD)	97.3 (13.9)	–		
Grammatical closure (ITPA)[1]			0.031	0.38
Median	33.5	37.5		
Mean (SD)	31.8 (7.4)	37.4 (5.7)		
Word-finding (TWF-2)[2]			0.026	0.39
Median	84.5	98.5		
Mean (SD)	88.5 (16.5)	101.0 (14.5)		
Memory (NEPSY-II)[3]			0.004	0.50
Median	8.0	11.0		
Mean (SD)	7.8 (2.3)	7.8 (2.3)		
Theory of Mind (NEPSY-II)[3]			0.005	0.49
Median	7.5	11.0		
Mean (SD)	7.9 (2.4)	10.6 (2.4)		
Comprehension (TTFC-2)[4]			0.002	0.54
Median	31.5	38.0		
Mean (SD)	30.6 (7.5)	38.1		
GCC (CCC-2)[5]			< 0.001	0.81
Median	51.0	94.3		
Mean (SD)	49.7 (9.1)	94.3 (11.8)		
SIDC[6]			< 0.001	0.63
Median	−14.0	−3.5		
Mean (SD)	−13.1 (7.2)	−1.3 (6.7)		

Notes: [1]Subtest of the ITPA (the Illinois Test of Psychological Abilities) standard scores: mean 36, normal range 30–42 (1 standard deviation is 6). [2]TWF–2 = Test of Word Finding, Second Edition, standard scores: 90–110 average; 80–89 slightly below average; 70–79 below average. [3]Subtest of NEPSY-II (the Developmental Neuropsychological Assessment, Second Edition) standard scores: 9–12 at expected level, 7–8 slightly below expected level, 4–6 below expected level. In NEPSY-II the Sentence repetition subtest is performed with children aged six and under, and the Word list interference subtest is performed with children aged seven and above. [4]Scores of the TTFC-2 (The Token Test for Children-2) are presented as raw scores, max score is 46. [5]GCC below 55 means that a child has communication difficulties. [6]SIDC reflects the mismatch between the social communication and language scales. Mismatch is interpreted as an atypical in situation when GCC score is below 55 and SIDC is negative or when GCC score is at or above 55 and SIDC score is −15 or less. Effect sizes r for comparisons were calculated from Mann-Whitney *U* test results using equation r = Z/sqr(N). Effect was considered small if r < 0.3, moderate if r ≥ 0.3 and < 0.5, and large if r ≥ 0.5.

it will have an effect on the performance of children with ASD. This study also evaluates children's ability to explain their own correct answers ("How do you know that?"), in order to understand how ASD impacts on awareness of comprehension processes (i.e., metacognitive awareness).

We also wanted to study how the recently developed Pragma test discriminates between children with and without ASD. In order to investigate the functionality of the Pragma test more deeply we compared its discrimination ability with two measures commonly used with children with ASD in Finland: 1) the Social Interaction Deviance Composite (SIDC) of Finnish version of CCC-2 (Bishop, 2015) and 2) the Theory of Mind subtest of the Developmental Neuropsychological Assessment, Second edition (NEPSY-II) (Korkman, Kirk, & Kemp, 2008).

2. Methods

2.1. Participants

A total of 32 children took part in this study. Sixteen of these children had ASD and sixteen were TD (Table 1). Children were gathered from a Finnish clinical study which explored different aspects of emotional, social and communication of children with ASD (see also Loukusa et al., 2014; Mäkinen et al., 2014). All children were of Finnish extraction and native Finnish speakers living within 100 kilometers from the city of Oulu, Finland, and they all had normal hearing. Participation was voluntary and confirmed by written consent forms, completed by parents. This study was approved by the Ethical Committee of the Northern Ostrobothnia Hospital District.

The children with ASD (aged 5;1–10;7 years old) were recruited to this study from the area of Northern Ostrobothnia Hospital District in Finland via clinics of Child Psychiatry and Child Neurology at Oulu University Hospital. In these clinics permission for this study was asked from the parents of children with ASD. If the permission was given, a speech and language therapist, child psychiatrist or child neurologist phoned to a researcher who then contacted the child's parents and described the research design in detail and gave information and consent sheets. According to a preliminary questionnaire eleven of the mothers and ten of the fathers of the children with ASD were employees with administrative, professional or clerical occupations, and four of the mothers and three of the fathers were manual workers. One mother and one father were studying and one father was self-employed. The information about occupation was not available for one father.

All children with ASD were diagnosed by experienced child psychiatrists or by child neurologists using ICD-10 (World Health Organization, 1993) criteria based on the Autism Diagnostic Interview-Revised (ADI-R) (Lord, Rutter, & LeCouteur, 1995), the Autism Diagnostic Observation Schedule (ADOS) (Lord, Rutter, Dilavore, & Risi, 2000) and other investigations by a multiprofessional team at the Clinic of Child Psychiatry or Child Neurology at Oulu University Hospital. In this study we followed the current view that ASDs should no longer be categorized into different disorders and we use only diagnosis of ASD (see DSM-5). The IQs of the children with ASD (see Table 1) were assessed by psychologists of Oulu University Hospital or children's health centers using the Wechsler Scale of Intelligence (WPPSI-R, WPPSI-III, WISC-III or WISC-IV). We did not manage to get the exact Verbal IQ (VIQ) and Performance IQ (PIQ) values from two children but it was evident from the psychologist's statement that these children's IQs were within the normal limits.

The TD children (aged 5;2–10;0 years old) were recruited from local nurseries and mainstream schools at the city of Oulu, Finland. Children's teachers gave written information and consent sheets to the children who gave them to their parents, after which the children returned the written consent to their own teachers. The typical development was verified by a parent-reported developmental history questionnaire from the children whose parents gave permission to participate in this study. Twelve of the mothers and thirteen of the fathers of the TD children were employees with administrative, professional or clerical occupations. Two of the mothers were manual workers and two were studying. One father was self-employed and the information about occupation was not available for two fathers.

In order to get some background information about the children's current abilities, all the children's language skills were investigated by the Test of Word Finding, second edition (TWF-2) (German, 2000), where the accuracy of word-finding ability is measured using tasks requiring the naming of nouns, verbs, and categories from pictures, and the completion of sentences (Table 1). In TWF-2 seven children with ASD and one TD child performed below average. The children's grammatical knowledge was evaluated with the grammatical closure subtest of the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy, & Kirk, 1968) where three children with ASD and one TD child performed below average. In addition, depending on the child's age, verbal working memory was tested with NEPSY-II subtests of Sentence Repetition (for those aged 6 or below) or Word List Interference (for those aged 7 and above), and their mind-reading abilities were tested with the Theory of Mind subtest of NEPSY-II. In Sentence Repetition or Word List Interference subtest four children with ASD performed below expected level whereas in Theory of Mind subtest five children with ASD and one TD child performed below expected level (see also Loukusa et al., 2014 where these results of the most of the children participating in this study are analyzed in detail). Children's sentence comprehension skills were also investigated using The Token Test for Children, Second edition (TTFC-2). The TTFC-2 is carefully translated (forward and back-translation) into Finnish for research purposes. However, since the TTFC-2 is not standardized into Finnish, in this study, scores are presented only as raw scores. In addition, the Finnish version of CCC-2 was used to investigate the children's communication in everyday life of which results showed that 13 children with ASD had atypical relationship between the General Communication Composite (GCC) and the Social Interaction Deviance Composite (SIDC). In general, the background information showed that the children with ASD performed weaker in tests than TD children, which reflects reality when doing studies with clinical samples.

2.2. Material

The Pragma test was developed to measure utilization of context, social language use, and understanding of intentions, thoughts, beliefs, and feelings in utterance interpretation. The material contains 39 questions that require the ability to understand the implied meaning of each utterance. The questions aim to study how children manage to derive conclusions by retrieving and integrating contextual information—such as world and social knowledge, physical context, and prior verbal information. In the Pragma test the given context consists of short verbal scenarios that are presented together with pictures, small characters, plastic animals, or a story (which is presented in short sections to minimize memory requirements). Usually one question (and follow-up question) was asked after every scenario but in four cases, there were two questions after scenarios. This meant that when doing Pragma, children were presented 35 different kinds of scenarios.

Children's answers were scored 0 = incorrect and 1 = correct. We report answer scores both for a total scale of all 39 items and separately for each question type (*Contextual inference with ToM demand, Contextual inference without ToM demand, Relevant use of language, Recognition of feelings* and *Understanding false beliefs*). In the Pragma test, there are not the same number of different kinds of questions since we wanted to focus on pragmatic and social factors that most probably cause challenges to children with ASD based on earlier studies (see Loukusa & Moilanen, 2009). In our earlier studies (Loukusa, Leinonen, Jussila et al., 2007; Loukusa, Leinonen, Kuusikko et al., 2007) we used material that was constructed within framework of relevance theory. Even if the material of the Pragma contains a couple of the same questions used in our earlier studies (see detailed description of the Pragma in Loukusa et al., 2017), most of the questions are new and not used in earlier studies with children with ASD.

Examples of the different question types and of correct and incorrect answers to the Pragma test are presented in the following.

Contextual inference with ToM demand (18 items)

Scenario (presented with paper dolls): There has been a race at school. Vera was the slowest runner in the whole class. Vera goes to Tina's house after school. Maddie is also there. Tina and Maddie suggest playing tag. Vera says, "I have to go home," and leaves right away.
Question: Why did Vera say "I have to go home"?
Given context:

Visual: Vera, Tina, and Maddie paper dolls.
Verbal: Vera was the slowest runner in the race at school. When Tina and Maddie suggest playing tag, Vera wants to go home.

World knowledge: If you are the slowest runner, you will easily be caught. In addition, you will have difficulties in catching other children who are faster than you.
Conclusion: She wants to go home because she does not want to play tag.
Example of a correct answer (from a six-year-old boy with TD): "She doesn't want to play tag."
Example of an incorrect answer (from a six-year-old boy with ASD): "Because she is in a hurry to get home"

Contextual inference without ToM demand (ten items)

Scenario (presented with a picture): The children have visited Santa's Village in Lapland. The next day they tell their teacher that "There were plenty of other children there."
Question: Where was there lots of other children?
Given context:

Visual: A picture showing children talking with their teacher.
Verbal: The children had visited Santa's Village in Lapland.

World knowledge: Santa's Village in Lapland is a very popular place, especially for children.
Conclusion: "There" refers to the Santa's Village, which the children have visited.
Example of a correct answer (from a six-year-old boy with ASD): "In Rovaniemi" (Santa's Village is located in the city named Rovaniemi).
Example of an incorrect answer (from a five-year-old boy with ASD): "Here" (pointing to the children in the picture).

Recognizing feelings (five items)

Scenario (presented with paper dolls): Billy has made a drawing of the family home. When his mother sees the drawing, she says "This looks like something we should hang on the living room wall."
Question: How does Billy feel?
Given context:

Visual: Mother and Billy paper dolls.
Verbal: Billy has made a drawing and when his mother sees it, she wants to hang it on the wall.

World knowledge: Only nice drawings are hung on the wall. Usually only the best pictures are hung on the living room wall.
Conclusion: Billy feels good that his mother likes the drawing so much that she want to hang it on the wall.
Example of a correct answer (from an eight-year-old boy with ASD): "Good."
Example of an incorrect answer (from a seven-year-old boy with ASD): "Bad."

Relevant use of language (four items)

Scenario (presented with paper dolls): Vera comes up to Maddie and is angry. Maddie has told someone the name of the person Vera has a crush on, even though she had promised not to tell anyone. "I can't trust you anymore," Vera says and adds, "I told you not to tell anyone." Maddie had passed on Vera's secret and feels really bad about it.
Question: What could Maddie say to fix the situation?
Given context:

Visual: Vera and Maddie paper dolls.
Verbal: Maddie has passed on Vera's secret, even though she said she would not tell anyone.

World knowledge: If someone tells you a secret, you should not tell it to anybody else.
The relevant way to function in this situation: Apologize for telling someone the secret.

Example of a correct answer (from a 5-year-old girl with TD): Sorry!
Example of an incorrect answer (from a 7-year-old boy with ASD): "Umh, you are an idiot."

False beliefs (two items)

Scenario (presented with paper dolls, plastic cows, and pens): Vera and Tommy are visiting a farm animal park with their father. Vera and Tommy are going to look at the sheep. Father says, "I'll go and buy a bottle of water. I'll catch up with you afterwards." But when Vera and Tommy go to the sheep pen, it's empty, so they decide to go and see the cows instead.
Question: Where will Vera and Tommy's father look for them?
Given context:

Visual: Vera, Tommy, and father paper dolls; two plastic cows; and two pens.
Verbal: The children changed their plans when their father was absent and decided to go and see the cows instead of the sheep.

Social knowledge: When someone is absent, she or he cannot know if other people have changed their mind unless informed.
Conclusion: Vera and Tommy's father will look for them at the sheep pen.
Example of a correct answer (from a five-year-old boy with TD): "Where the sheep are."
Example of an incorrect answer (from a nine-year-old boy with ASD): "There." (pointing at Vera and Tuukka who are at the cow enclosure at that point).

In addition to these questions, the children were asked to provide explanations for the correct answers to 13 questions ("How do you know that?") to see if they were aware of, and able to articulate, how they had derived the answers based on the context. Usually the child explained the answer by telling one (or more) of the premises that he or she had utilized when making the conclusion. For example, the above presented question from the category of Recognizing feeling contained a follow-up question requiring explanation. In that question the accepted explanation for correct answer "Good" was, for example "The picture was so nice that it was hung on the wall" where incorrect explanation was, for example, "He started to laugh." Every explanation was scored in relation to the child's original answer. Sometimes children explained their answer before explanation question was asked and also in these cases the child's explanation was scored as a correct one.

2.3. Procedure and scoring

Each child was tested individually in a quiet room in his or her day nursery or school from three to four times depending mostly on the child's attention skills. The duration of the sessions varied from 30 min to one hour, lasting an average of 45 min. Investigations were performed by a speech and language therapist (SL or LM). Each assessment session was recorded by video camera and children's answers to the questions of the Pragma were later orthographically transcribed from the records. The scoring was done from these transcriptions by a speech and language therapist (SL). Other tests were scored (SL or LM) as instructed by the manual of each test.

In order to check the reliability of scoring intraclass correlation was calculated from the total scores between two raters (SL and LM) from a sample of eight children (four children with ASD and four with TD). Interrater reliability value (intraclass correlation coefficient, see Bland, 2015) was 0.986 for answer scores and 0.944 for explanation scores indicating that scoring was reliable.

2.4. Statistics

Despite of the small number of participants, the answer scores of the Pragma test fulfilled the criteria of the normal distribution (Shapiro-Wilk = 0.92, $p = 0.023$) and thus, group differences were investigated by using the *t*-test and Cohen's *d*. As the Pragma test contained five different types of questions multiple comparisons were done and thus, critical *p*-value (Bonferroni adjustment) was calculated. The relation between age and pragmatic answer score was modelled by linear regression analysis, where age was used to predict the scores for correct answers.

Because the follow-up question requiring the explanation of a correct answer was only asked if the correct answer was given, in order to explore a child's ability to provide explanations, the number of correct answers (*f*) had to be taken into account and thus relative frequency numbers were calculated for these comparisons (relative frequency = [number of correct explanations/*f*] · 100%). After that, *t*-test and Cohen's *d* was used when comparing group differences in relative frequency scores.

To further examine the extent to which the performance in the Pragma tasks helped to distinguish ASD children from TD children, Receiver operating characteristic (ROC) curve analysis (Bland, 2015; Metz, 1978) was conducted. A ROC curve represents the resulting values of the sensitivity (i.e., the proportion of positives who are correctly identified as having ASD) and specificity (i.e., the proportion of negatives who are correctly identified as not having ASD). The ROC curve has a reference line in the diagonal presenting a random predictor i.e. where there is no difference between the two distributions (the area will be equal to 0.5). The random predictor is commonly used as a baseline to see whether the model is useful. The closer the curve is to the left-hand border and the top border of the ROC space, the more accurate the test is. Likewise, the closer the curve is to the 45° diagonal line of the ROC space, the less accurate the test is.

Area under the curve (AUC) is a measure of the discriminatory power of the correct identification. AUC results can be interpreted as an excellent for AUC values between 0.9–1, good for values between 0.8–0.9, fair for values between 0.7–0.8, poor for values

Table 2
Correct answers for different question types and comparisons between groups.

Question Type (max score)		Mean	SD	Group difference *t*-test	*P*-value	Cohen's *d*
Contextual inference with ToM demand (18)	ASD	6.6	3.8	t(24.2) = −4.44	< 0.001	1.57
	TD	12.2	3.3			
Contextual inference without ToM demand (10)	ASD	7.0	2.8	t(17.6) = −3.39	0.003	1.20
	TD	9.4	0.8			
Recognizing feelings (5)	ASD	3.0	1.3	t(27.9) = −2.84	0.008	1.00
	TD	4.1	1.0			
Relevant use of language (4)	ASD	1.4	1.3	t(27.3) = −3.53	0.001	1.24
	TD	2.8	0.9			
False belief (2)	ASD	1.1	1.1	t(17.0) = −3.28	0.004	1.16
	TD	1.9	0.3			
Total score (39)	ASD	19.2	8.2	t(24.2) = −4.74	< 0.001	1.68
	TD	30.5	4.8			

Note. TD = Typically developing children. ASD = Children with autism spectrum disorder.
Equal variances not assumed. Significant difference for question types: $p < 0.01$ (Bonferroni adjustment).

between 0.6–0.7 and failed for AUC values between 0.5–0.6 (see El Khouli et al., 2009; Lüdemann, Grieger, Wurm, Wust, & Zimmer, 2005). In order to compare the functionality of the Pragma with other measurements, ROC curves were also produced with the SIDC CCC-2 and the ToM subtest of NEPSY-II. Since Pragma is a new test we also analyzed which items are the best in detecting children with ASD from typically developing children in terms of their true positive rate (sensitivity) and true negative rate (specificity).

3. Results

3.1. Group comparisons in the answer scores from Pragma

Compared to the control group, the answer scores of the ASD group were significantly lower than in the TD group (Table 2). The biggest difference between the ASD and TD groups was in relation to questions demanding contextual processing with ToM demand (a significant difference with a very large effect size). However, the difference between the ASD and TD groups was significant, with there being large effects for other types of social-pragmatic questions (see Table 2). Linear regression analysis demonstrated significant association between age (in months) and the scores for both the children with ASD (Adjusted $R^2 = 0.625$, $p < 0.001$) and TD children (Adjusted $R^2 = 0.456$, $p < 0.002$).

3.2. Group comparisons of explanation scores

The analysis of the relative frequency showed that children with ASD were able to successfully explain 43% of their correct answers, whereas TD children could successfully explain 74% of their correct answers, indicating that compared to children with TD, children with ASD had more difficulties in explaining how they had used context to arrive at the correct answer ($t = -3.399$, $p = 0.002$, $d = 1.24$).

3.3. Identifying children with ASD

In distinguishing children with ASD from TD children the discriminatory power to the Pragma test was excellent (AUC = 0.926, SE = 0.048, $p < 0.0001$, 95% CI = 0.83–1.00) and good to the SIDC CCC-2 (AUC = 0.890, SE = 0.061, $p < 0.0001$, 95% CI = 0.77–1.00). Whereas the Theory of Mind subtest of NEPSY-II reached fair discriminatory power (AUC = 0.783, SE = 0.080, $p = 0.006$, 95% CI = 0.63–94) (Fig. 1).

3.4. Item analysis of Pragma

Single item analysis of answers revealed eleven questions (from the total of 39) that had the highest sensitivity and specificity in distinguishing children with ASD from TD children (Table 3). When looking at the question types of the most sensitive questions, there is a need to keep in mind that Pragma contained a different number of each different question type, and thus it is better to look at the content of sensitive questions separately and not just at question types. However, it was notable that answering to all except one of these questions (question number 29, Table 3) demanded contextual inference and mind-reading abilities or social knowledge.

4. Discussion

The current study examined the social-pragmatic inferencing skills of high-functioning children with ASD, compared to TD children. As suggested on the basis of the earlier studies (e.g., Lam & Yeung, 2012; Loukusa & Moilanen, 2009; Whyte & Nelson, 2015) and the diagnostic criteria of ASD (as detailed in *DSM-5*), children with ASD had difficulties when answering questions

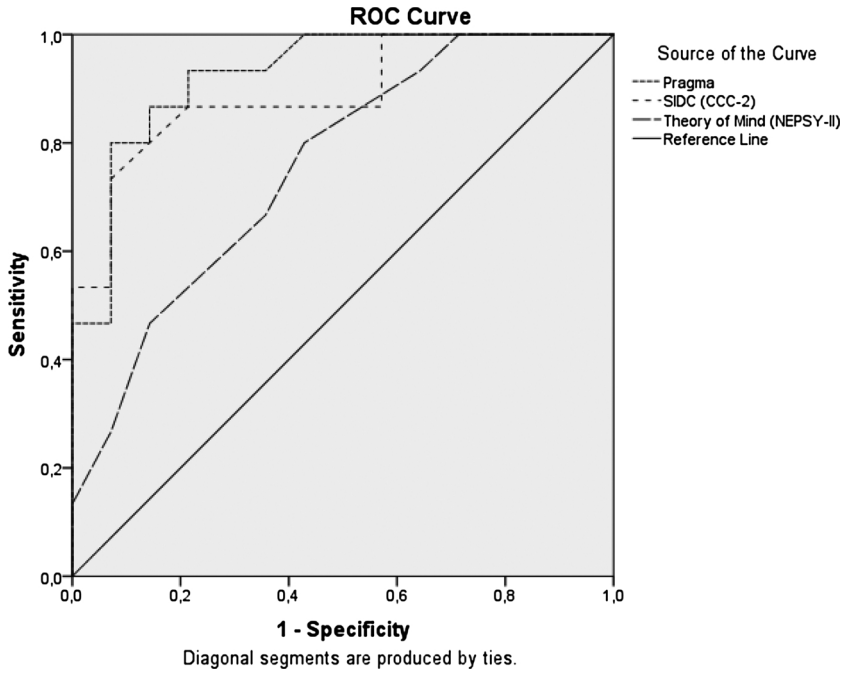

Fig. 1. The discriminatory power of the Pragma test, the SIDC CCC-2, and the Theory of Mind subtest of NEPSY-II in detecting children with ASD. Area under the curve (AUC) is a measure of the probability of correct identification. The closer the ROC curve is to the upper left corner, the higher the overall accuracy of the test. Reference line describes the situation where there is no difference between the two distributions.

demanding social-pragmatic inferencing abilities. The current study adds to the earlier literature with the finding that these difficulties are wide-ranging, showing challenges in many types of questions demanding the utilization of contextual factors in social-pragmatically diverse situations, even if these difficulties are not as pronounced across all the tasks. In addition, the current study showed that by using contextually sensitive materials, it is possible to also detect the social-pragmatic inferencing difficulties of high-functioning children with ASD in structured test situations and not only in real-life communicative situations.

4.1. Social-pragmatic inference skills in children with ASD

This study found that in the Pragma test children with ASD differed from TD children in all the different types of questions (*Contextual inference with ToM, Contextual inference without ToM, Relevant use of language, Recognition of feelings*, and *Understanding false beliefs*) that demanded socially or pragmatically challenging context utilization. The biggest difference between groups was in the questions that demanded contextual inference with mind-reading, which was expected on the basis of earlier research (Heavey et al., 2000; Jolliffe & Baron-Cohen, 1999a; Loukusa & Moilanen, 2009). If we interpret our findings of wide-ranging social-pragmatic inference difficulties within the framework of the E−S theory (Baron-Cohen, 2009, 2010), social-pragmatic inference can be interpreted as a form of an individual's implicit problem solving. Social-pragmatic inference is not consistent or predictable and it demands both cognitive and affective empathy, and also ability to connect information from non-predictable sources. Therefore, when interpreting socially or pragmatically difficult situations it is not possible to use rule-guided systemizing and this makes it particularly difficult for many individuals with ASD.

This study confirmed the earlier findings (Loukusa, Leinonen, Kuusikko et al., 2007) that showed that when compared to TD children, children with ASD have difficulties in explaining how they use context to arrive at correct answers. This shows that these children have difficulties in metacognitive awareness, which impact on communication. This is an area that would benefit from further research in the future. Given our findings it is clear that children's metacognitive abilities should be taken into consideration when working on intervention strategies for these children.

4.2. Assessing social-pragmatic skills in children with ASD

At the moment, in clinical work, social-pragmatic skills are mostly measured using parental reports and questionnaires. This is mostly due to the fact that it is difficult to measure children's social-pragmatic communication skills in clinical settings because they vary between situations (Adams, 2002; Volden et al., 2009). However, being aware of the complex nature of pragmatic functioning, there is a need to also develop structured measurement tools. In order to justify the intervention to authorities, there is often a need to show test results that clearly show that, compared to TD peers, a child has social-pragmatic communication difficulties that require attention. Additionally, in the busy clinical world, observing the child in natural communication settings is often too time-consuming,

Table 3
The eleven questions of Pragma that were the highest in their sensitivity and specificity in detecting children with ASD.

Question	Number of incorrect answers from children with ASD	Number of incorrect answers from controls	True positive rate (sensitivity)	True negative rate (specificity)
32. (ConTom) Scenario: The children were told a story where a dog named Timmy downed Millie and ran away and started to chase the cat. Millie is angry at home. In the evening Millie sits on the sofa reading a newspaper. Timmy comes and sits next to her and gives Millie his paw. Millie looks at Timmy and says "Well, all right" and smiles. Question: *What does Millie mean when she says "Well, all right" to Timmy?*	14	5	0.875	0.688
24. (Feelings) Scenario (told with characters and animals): Vera and Tommy are visiting a farm animal park with their grandpa. The children want to pet the goats. The animal attendant says that only one of the children can pet the goats. Grandpa says, "In that case, Tommy gets to pet them because he's older." Tommy exclaimed with excitement, "Oh yes! That's great!" Vera is really annoyed. When they leave the pen, Vera hangs her head. Question: *How does Tommy feel now?*	14	7	0.875	0.563
37. (ConTom) Scenario: Using characters, the children were told a story where Maddie has told Tina that she cannot look at horses since she wants to be there only with Sara. Later, Billy, a friend of the girls, walks up to them holding a basket full of apples. "Would you like some?" he asks. Tina says, "Yes, please," and she is soon followed by Sara. Maddie stays behind and looks on, wondering if she should join them. Question: *Why does Maddie wonder if she can join them?*	13	6	0.813	0.625
34. (ConTom) Scenario: This is an earlier question, based on the same story that featured in question 37 (see above). Using characters, the children were told that Maddie and Sara are looking at some horses. Sara has also asked Tina to come and look at the horses with them. When Tina comes, Maddie says, "So much for that quiet moment." Question: *Why does Maddie say that?*	13	8	0.813	0.500
9. (ConTom) Scenario: Using a picture, the children were told that Mary was throwing a ball around indoors, even though she knows that she's only allowed to do so outside. Mary tried to throw the ball onto the sofa, but it hit a painting on the wall instead. The painting fell down and broke. Her father comes home and asks "What on earth has happened to the painting?" Mary says, "The cat jumped on it and it fell down. It wasn't my fault." Question: *Why does Mary say that?*	12	3	0.750	0.813
31. (ConTom) Scenario: This question is based on the same story as used in question number 32 (see above). The children were told a story about how Timmy the dog runs away and Millie's bad mood. After this, the children are told that Millie's father, Peter, says, "It's time to eat." Millie says, "Timmy won't be eating anything today." Question: *Why did Millie say that Timmy won't be eating today?*	11	2	0.688	0.875

(*continued on next page*)

Table 3 (*continued*)

Question	Number of incorrect answers from children with ASD	Number of incorrect answers from controls	True positive rate (sensitivity)	True negative rate (specificity)
13. (RelevUse) Scenario: Using characters, the children were told that Billy is telling his aunt about his trip to his grandma's, where he also went skiing. Suddenly he starts to tell her about his new water bottle and then about their neighbor Nick's winter boots—then he asks his aunt if she knows anything about how to use a microwave. That's when his aunt interrupts him and says, "Hold on, Billy!" Billy knows that something is wrong with what he has said. Question: *What was wrong?*	11	3	0.688	0.813
14. (RelevUse) Scenario: Using characters, the children were told that Vera comes up to Maddie and is angry. Maddie has told someone who Vera has a crush on, even though she had promised not to tell anyone. "I can't trust you anymore," Vera says and adds, "I told you not to tell anyone." Maddie has passed on Vera's secret and feels really bad about it. Question: *What could Maddie say to fix the situation?*	10	1	0.625	0.938
30. (ConTom) Scenario: This question is based on the same story that featured in questions 31 and 32 (see above). The children were told a story about Timmy the dog running away. After that, the children were told that two boys help Millie catch the dog. Millie and Timmy walk home. Timmy wags his tail, but Millie doesn't say anything. When Millie and Timmy get home, her father Peter has come home. Peter says "Hello" to Millie in a cheerful manner, but she only glances angrily at him and says nothing. Question: *Why is Millie in a bad mood?*	10	2	0.625	0.875
35. (Feelings) Scenario: This is a question based on the same story as featured in questions 34 and 37 (see above). Using characters, the children were told that Maddie and Sara were looking at some horses. Sara had also asked Tina to come and look at the horses. Tina comes and Maddie tells her "You can't come here because Sara and I are here alone, it's just the two of us." Question: *How does Sara feel?*	9	1	0.563	0.938
29. (ConNoTom) Scenario: This is a question based on the same story as featured in questions 30, 31, and 32 (see above). The children were told a story about Timmy the dog running away. After that, the children were told that Millie runs after Timmy and tells Timmy to come to her, but Timmy won't obey her. Two boys, who are standing near Timmy, are looking at them. Millie calls out to the boys, "Help!" and calls to Timmy, "Come here!" Question: *What does Millie mean when she says "Come here!" to Timmy?*	9	1	0.563	0.938

Note: ConToM = Contextual inference with theory of mind; Feelings = Recognition of feelings; RelevUse = Relevant use of language; ConNoTom = Contextual inference without ToM. True positive rate = $\frac{\sum \text{True positive}}{\sum \text{Condition positive}}$; True negative rate = $\frac{\sum \text{True negative}}{\sum \text{Condition negative}}$.

so structured tests offer a time-saving way to measure the child's abilities. Even if there are already some pragmatic language tests, such as the Test of Pragmatic Language-Second Edition (TOPL-2) (Phelps-Terasaki & Phelps-Gunn, 2007), there is a need to develop research-based methodologies for assessing social-pragmatic functioning. Earlier studies have shown that compared to children with TD, children with ASD performed weaker in the TOPL-2 (Koning & Volden, 2012) and in its earlier version, the TOPL, (Volden et al., 2009) which are based on the Situational-Discourse-Semantic Model. However, although the TOPL-2 showed weaknesses in children with ASD it was not as good for identifying pragmatic impairment in cognitively able children with ASD as CCC-2 was (Koning & Volden, 2012).

Unlike the TOPL-2, the Pragma test does not directly follow any of the pragmatic frameworks although ideas of pragmatic theories, such as relevance theory, and cognitive frameworks of autism, such as theory of mind deficit, have been utilized when planning test questions. The Pragma test is designed so that most questions measure the areas that the review by Loukusa and Moilanen (2009) showed to be difficult for children with ASD. This study showed the diagnostic validity of the Pragma test as it enabled the identification of children with ASD and TD children and thus measured the areas that are particularly difficult for children with ASD as it was planned. Thus, this study showed that by using the research-based test, it is possible to also show social-pragmatic inferencing difficulties in structured test situations.

Since the Pragma test is a new tool and has not been used before with children with ASD, we wanted to compare its discriminatory power with that of the SIDC CCC-2 (parental report) and the Theory of Mind subtest of NEPSY-II (clinical test). We found that the Pragma test and the SIDC CCC-2 identified children with ASD from the TD children better than the Theory of Mind subtest of NEPSY-II, even though the subtest also reached borderline significance. On the basis of our findings, we suggest that in clinical settings when assessing social-pragmatic communication skills in children with ASD, the best way would be to connect information from the parental report and clinical assessment. By using contextually sensitive materials, it is possible to also detect the social-pragmatic inferencing difficulties of high-functioning children with ASD in clinical settings. Well-founded clinical assessment also helps speech and language therapists and neuropsychologists to direct intervention to core difficulties by also utilizing the strength areas.

4.3. Critical appraisal of the study

Even though this study gave support to the investigation of the pragmatic inference skills of children with ASD in clinical test settings, the context of the questions was not as complicated as it would be in spontaneous communicative situations. Therefore, although the material showed to be able to detect differences, it is possible that it did not enable the detection of the small differences between groups. For example, in test situations processing time was not limited, whereas everyday communication is time pressured. Additionally, the test material contained different numbers of questions for each different question type, which diminishes the generalizability of comparisons of different question types. On the basis of earlier research findings (see Loukusa & Moilanen, 2009) the Pragma test is planned to focus on areas that have been observed to be challenging for children with ASD. Therefore, the number of questions varies between different question types, the most questions falling on ones that measure contextual inference with mind-reading demand.

In this study, the same speech and language therapist (SL) participated in investigation, transcribing and scoring of the data. Thus, she was not blind for children's group status. In future studies it would be better if scoring would be done by a different person. Our sample size was small due to the strict inclusion criteria and small clinical population in the area of the Oulu University Hospital, Finland. A bigger sample size would have added statistical power and added to the generalizability of the results. In addition, as the background information shows, in this study children with ASD also had some language weaknesses. This reflects the reality of children with high-functioning ASD since these children were recruited from the clinics where they have been diagnosed. Since social-pragmatic skills result from many interacting abilities (Perkins, 2007), the children's language skills may have had some effect on children's social-pragmatic inferencing performance, even though they cannot explain the results. In the future studies, language level should be controlled more precisely since there are also findings showing that in addition to ToM basic language skills aid the development of pragmatic language in children with ASD (Volden et al., 2009).

4.4. Clinical implications

On the basis our results we suggest that in the clinical assessment of social-pragmatic language abilities, a combination of structured tests (such as Pragma) and parental report (such as CCC-2) should be used together in order to get the best possible view of a child's abilities within a reasonable clinical timeframe. If there are the resources, the assessment should be complemented with observation of language use in the widest possible contexts as much as is possible. Since social communication weaknesses are defining features of ASD, proper assessment of social-pragmatic skills should be done for all of the children who present features of ASD. Such assessments also build a base for planning intervention. At the moment, there are some promising intervention programs, such as Social Communication Intervention Project (Adams, Lockton, Gaile, Earl, & Freed, 2012; Adams, Lockton, Gaile, Freed et al., 2012) directed at social-pragmatic functioning. Our findings could also be utilized when planning interventions for children with ASD. For example, this study showed that it would be good to support metacognitive awareness ("How do you know that?" questions) as a part of strengthening social-pragmatic inferencing abilities. Since this study showed that when children's age increased, both children with ASD and TD children become more and more able to utilize contextual information in their inference, it is also probable that interventions for social-pragmatic inference skills are effective between the ages of five to ten since they are directed towards the developmentally sensitive area.

4.5. Conclusions

The findings show that in ASD, social-pragmatic inferencing difficulties are varied and that they increase with greater demands for mind-reading. In addition, children with ASD do not gain the same awareness as their TD peers from the contextual cues utilized in the comprehension process. In the framework of E–S theory, this could suggest that children with ASD struggle in social-pragmatic inference situations because inference is not rule-guided and does not follow predictable rules. Awareness of the processing style of individuals with ASD is important both for individuals with ASD and for their community, since difficulties in social-pragmatic inference affect an individual's quality of life in various ways, impairing interaction with peers and more broadly in other everyday situations.

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