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## Pragmatic inference abilities in individuals with Asperger syndrome or high-functioning autism. A review

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### ABSTRACT

This review summarizes studies involving pragmatic language comprehension and inference abilities in individuals with Asperger syndrome or high-functioning autism. Systematic searches of three electronic databases, selected journals, and reference lists identified 20 studies meeting the inclusion criteria. These studies were evaluated in terms of: (a) purpose of study, (b) participant characteristics and (c) procedures. Across the studies, the ages of participants varied between 6 and 57 years. The pragmatic comprehension and inference abilities measured varied from homograph comprehension to ability to understand non-literal statements. Pragmatic inference weaknesses, but not inabilities, were found throughout the studies. However, researchers did not wholly agree on the reasons and the extent of processing difficulties. The most commonly suggested explanations for pragmatic inference deficits were theory of mind and central coherence.

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Asperger syndrome (AS) and high-functioning autism (HFA) belong to the autism spectrum disorders (ASD) and are characterized by impairments in the development of communication and social skills and the presence of stereotyped behaviour, interests and activities. In ICD-10 (World Health Organisation, 1993) and DSM-IV (American Psychological Association, 1994) criteria, both autism and AS share the same criteria in impairments in reciprocal social interaction and restricted, repetitive and stereotyped patterns of behaviour, interests and activities. AS differs from autism primarily in that it does not involve general delay in language or cognitive development. Thus, in AS there may or may not be problems in communication similar to those associated with autism, but significant language delay would rule out the diagnosis. At the moment it is well known that pragmatic language difficulties are one of the salient disabling features of these disorders (e.g., Landa, 2000; Ozonoff & Miller, 1996; Ramberg, Ehlers, Nydén, Johansson, & Gillberg, 1996).

Definitions of pragmatics vary according to the theoretical background and focus of the study. However, regardless of differences in definition there is a consensus that utilization of context when inferring the meaning of an utterance belongs to the field of pragmatics, and that social and cognitive factors affect the pragmatic aspects of language comprehension and expression. The same expression can have a different meaning in a different communicative situation, and by exploiting context it is possible to understand the speaker's intention. In a comprehension situation, there is a need to understand the linguistic information of an utterance, but without cognitive abilities that are necessary for pragmatic inference, utterance interpretation remains lacking. When utilizing contextual information, there is a need for an ability to pay attention to relevant factors (Buckley, 2003; Wilson & Sperber, 1988). In addition, an ability to operate and store information is essential, and development of memory is therefore one factor supporting the development of utterance comprehension (Cohen, 1989; Gathercole & Baddeley, 1993; Oakhill, 1984). For instance, long-term memory has an important role in recording and storing new knowledge and experiences (Catania, 1992), while working memory works as a tool when integrating information from different sources (Cohen, 1989). Inference can be seen as a cognitive process connecting information from different sources. It is an especially important ability when deriving an implied meaning of an utterance, as shown by studies about text comprehension in children (Cain & Oakhill, 1999; Cain, Oakhill, Barnes, & Bryant, 2001; Oakhill & Yuill, 1986).

In the interpretation of utterances, a person's own world knowledge and beliefs play an important role, and mind-reading (i.e. theory of mind) ability is needed. Theory of mind is considered to be an ability to infer one's own and other people's beliefs, intentions and emotions (Baron-Cohen, 2000). It also includes an ability to understand mental activities, such as understanding of one's own thought processes and those of others (Eisbach, 2004). Basic understanding of the mind normally develops in children between the ages of 3 and 5 years (Bloom & German, 2000; Siegal & Beattie, 1991; Wellman, Cross, & Watson, 2001; Wellman & Lagattuta, 2000), which is the same age when development of pragmatic comprehension progresses actively (Bucciarelli, Colle, & Bara, 2003; Loukusa, Leinonen, & Ryder, 2007; Loukusa, Ryder, & Leinonen, 2008; Ryder & Leinonen, 2003). There is strong evidence suggesting that difficulties in mind-reading ability belong to ASD (e.g., Baron-Cohen, 2000; Tager-Flusberg, 2000; Rutherford, Baron-Cohen, & Wheelwright, 2002), and that this ability is linked to performance in pragmatic tasks (Happé, 1993; Martin & McDonald, 2004; Papp, 2006; Surian, Baron-Cohen, & van der Lely, 1996).

This review summarizes findings of studies which have investigated how individuals with AS or HFA infer meanings where it is necessary to utilize contextual factors, such as social and world knowledge, earlier experiences and verbally given information. In this review we describe the characteristics of these studies (participants, investigated abilities and used methods) and the main

results. First we describe how children and adolescents with HFA or AS infer pragmatic meanings, starting with developmental aspects, and after that we describe adults' performance. The main purpose of this review is to inform and guide clinicians and researchers as to what kind of weaknesses individuals with AS and HFA have in the area of pragmatic inference. This knowledge is important in order to direct rehabilitation to core problems. This review can also stimulate future research efforts aimed at developing new and even more specific and sensitive methods for measuring pragmatic inference in these individuals.

## 1. Criteria of this study

### 1.1. Search procedures

Systematic searches were conducted in three electronic databases: Medline, CSA Linguistics and Language Behavior Abstracts LLBA, and PsycINFO. The year of publication was not restricted, but the search was limited to English-language journal articles. In all databases, the following terms were inserted into the Keyword field: (a) Asperger\* syndrome and pragmatic\*, (b) Asperger\* syndrome and inferenc\*, (c) Asperger\* syndrome and context, (d) Asperger\* syndrome and comprehension, (e) autism and pragmatic\*, (f) autism and inferenc\*, (g) autism and context and (h) autism and comprehension. Search of the databases and reference lists were made until the end of January 2009; studies published after that are thus not included in this review.

### 1.2. Inclusion criteria

In order to be included in this review, the article had to be a research study that examined by individual testing the ability to infer pragmatic meaning or the ability to utilize contextual information in language interpretation in individuals diagnosed with AS or autism.

Inclusion criteria were as follows:

- (a) The study included participants with AS or autism whose intelligence was within normal range. (The study could also have participants whose intelligence was not within normal range if their performance was separated from those with normal intelligence in the results.)
- (b) In addition to the individuals with AS or HFA, the study had to contain typically developing/functioning participants who formed a control group to which the performance of individuals with AS or HFA was compared.
- (c) The ability to infer pragmatic or contextual meaning was investigated and observed by the researcher. Because in this study our aim was to acquire knowledge about abilities and disabilities detected by researchers, studies where the results concerning pragmatic comprehension abilities were achieved by interviewing other persons (e.g., parents or teachers) were excluded.
- (d) The study had to measure the accuracy of an answer or an utterance.

Because our search included all studies where the keywords were mentioned in the abstract, title or keyword list, a considerable number of studies were excluded on the basis of reading the abstracts. The most common exclusion reasons were: (1) The search terms were only mentioned in the abstract, while the study did not focus on the areas we were interested in. (2) The study did not contain a control group consisting of healthy/typically developing participants. (3) The study did not investigate the pragmatic/contextual inference abilities but some other aspects of pragmatic language. (4) The method was based on interviewing parents or using checklists, and the abilities were thus not tested by the researcher for the study. Finally, 20 studies published between the years 1996 and 2009 were considered in this review (Table 1).

## 2. Methods used in measuring the ability to interpret pragmatic meaning

Within the area of ability to infer pragmatic meaning the accepted studies varied from idiom and homograph comprehension to the ability to infer and explain non-literal statements, such as humour

and irony. Because of this, the methods used varied a lot as well. The most widely used individual method in these studies was Happé's Strange Stories Test (Happé, 1994), which measures the ability to provide context-appropriate explanation for story characters' non-literal statements. It has been developed to function as an advanced test of the theory of mind. However, when looking at the test questions and scenarios it is obvious that answering demands pragmatic inference abilities, and these studies were thus included. In addition to Happé's original study it has been used entirely or partially in studies by Jolliffe and Baron-Cohen (1999a), Heavey, Phillips, Baron-Cohen, and Rutter (2000) and Kaland et al. (2005). The study by Young, Diehl, Morris, Hyman, and Bennetto (2005) investigated pragmatic language in children with ASD using the Test of Pragmatic Language (TOPL, Phelps-Terasaki & Phelps-Gunn, 1992) and the Strong Narrative Assessment Procedure (SNAP, Strong, 1998). Other studies contained different types of material (not standardized tests) developed by other researchers or researchers conducting the studies in order to test pragmatic/contextual inference abilities (see Table 1).

Across the studies, the ages of participants varied between 6 and 57 years. The age range of the study group varied a lot in many of the studies (see Table 1).

### **3. Performance of individuals with Asperger syndrome and high-functioning autism when interpreting pragmatic meaning**

#### *3.1. How do children and adolescents with HFA or AS infer pragmatic meanings?*

At the moment it is not possible to say how and when pragmatic inference abilities normally develop in children with AS or HFA because of the small number of studies conducted on children and because of the large age range of children with AS or HFA within the study groups. To our knowledge, there is only one study where there has been an attempt to compare pragmatic inferencing in children with AS or HFA between two different age groups (Loukusa, Leinonen, Kuusikko, et al., 2007), and another study where the pragmatic answering abilities of the same children have been analysed and compared more specifically (Loukusa, Leinonen, Jussila, et al., 2007). The results showed that compared to the control group of typically developing children (7–9 years), the younger AS/HFA group (7–9 years) did less well when answering contextually demanding questions, while the performance of the older AS/HFA group (10–12 years) fell in between the younger AS/HFA group and the control group (Loukusa, Leinonen, Kuusikko, et al., 2007). For example, in nine implicature questions the means of the groups varied as follows (max score 9): the control group  $M = 8.7$ , the younger AS/HFA group  $M = 7.1$  and the older AS/HFA group  $M = 7.8$ . In addition to the incorrect answers, especially for younger children with AS/HFA it was more typical to continue with their answer after first giving a correct answer or explanation, which then led to an irrelevant answer. One or more topic drifts following the correct answer appeared in 81.2% of the children in the younger AS/HFA group, 39.1% of the children in the older AS/HFA group and in 4.3% of the children in the control group (Loukusa, Leinonen, Jussila, et al., 2007). This means that especially younger children with AS/HFA had difficulty with stopping processing at the relevant point. This tendency to continue an initially correct answer in a contextually inappropriate way was also detected by Kaland et al. (2002).

Compared to typically developing children, children with AS/HFA have shown specific pragmatic inference deficits affecting their ability to infer the implication of an utterance and to make inferences from social scripts, metaphors and speech acts (Dennis, Lazenby, & Lockyer, 2001). The differences between the groups increased in relation to the amount of inferencing and intentionality of the tasks, as was also seen later in the study by Loukusa, Leinonen, Kuusikko, et al. (2007), where children with AS/HFA showed difficulties in contextually complex processing, such as detecting implicatures, but not in the comprehension of reference assignments. The study of Norbury and Bishop (2002) showed that the group of normally developing children performed better than the clinical groups of children with HFA, specific language impairment, and pragmatic language impairment in tasks involving story comprehension that required inferencing and understanding of literal meaning. The scores between the clinical groups were quite similar. However, a closer analysis revealed that the children with HFA gave the highest number of answers that were irrelevant to the story context. Groups did not differ in

**Table 1**  
Methods used in studies including tasks measuring pragmatic language inference.

Author(s) (year)	Theme of research	Participants	Material for study interpretation of pragmatic language meaning
Happé (1994)	Developing a new test to measure how individuals with autism provide context-appropriate mental state explanations	6–9-Year-old typical children, $n = 26$ 15–24-Year-old typical adults, $n = 10$ 12–38-Year-old controls with mental retardation, $n = 13$ 13–28-Year-old no-ToM autistic group, $n = 6^a$ 8–24-Year-old 1st-order ToM autistic group, $n = 6^a$ 11–25-Year-old 2nd-order ToM autistic group, $n = 6^a$	The participants were presented the Strange Stories Test that consisted of 6 physical control stories and 18 mental stories which targeted the understanding of double bluff, figure of speech, joke, lie, misunderstanding, persuasion, pretending, sarcasm, and white lie
Kerbel and Grunwell (1998)	Idiom comprehension in children with semantic-pragmatic difficulties	6–7-Year-old typical children, $n = 15$ 10–11-Year-old typical children, $n = 15$ 8–11-Year-old children with language disorder, $n = 15$ 6–11-Year-old children with semantic-pragmatic difficulties, $n = 26$ . These children were divided into subgroups as follows: (a) A priori semantic-pragmatic disorder, age range 7–11 years, $n = 17$ . (b) Asperger syndrome or high-functioning autism (ASP), age range 6–10 years, $n = 9$	Children were presented a taped story with 12 common idioms embedded. In the play task they acted out the story on the play set and in the definition task they had to tell what they thought that idioms of the story meant
Ozonoff and Miller (1996)	The contribution of the right hemisphere to the pragmatic impairments of autism	16–57-Year-old adults with HFA, $n = 17$ 16–45-Year-old typical adults, $n = 17$	Three measures of pragmatic ability were used. (1) Joke measure: 10 short story jokes were chosen from a set by Birhle, Brownell, Powelson, and Gardner (1986) (2) Inference measure: 20 items composed of two sentences from a set by Brownell, Potter, Birhle, and Gardner (1986) (3) Indirect request measure: 20 paragraph-length vignettes from a set by Weylman, Brownell, Roman, and Gardner (1989) During the tasks the neural circuitry was measured using fMRI

Jolliffe and Baron-Cohen (1999a)	Ability to interpret non-literal statements in adults with AS or HFA	19-46-Year-old adults with HFA, $n = 17$ 18-49-Year-old adults with AS, $n = 17$ 18-49-Year-old typical adults, $n = 17$	The participants were presented Happé's Strange Stories Test (see above Happé, 1994)
Jolliffe and Baron-Cohen (1999b)	Ability to make contextually meaningful connections between linguistic information (local coherence) in adults with HFA and AS	19-46-Year-old adults with HFA, $n = 17$ 18-49-Year-old adults with AS, $n = 17$ 18-49-Year-old typical adults, $n = 17$	<i>Study 1:</i> Participants were presented sentences that involved homographs with a rare pronunciation and homographs with a common pronunciation <i>Study 2:</i> Participants were presented pairs of sentences and a statement presented as a question along with three answer choices <i>Study 3:</i> Using a tape recorder, the following sentences were presented to participants: lexically ambiguous sentences with a rare interpretation, lexically ambiguous sentences with a common interpretation, syntactically ambiguous sentences with a rare interpretation and syntactically ambiguous sentences with a common interpretation
Heavey et al. (2000)	Usability of the Awkward Moment Test to measure social understanding in autism	22-51-Year-old adults with HFA or AS, $n = 16$ 22-45-Year-old typical adults or adults with mild learning difficulties (groups were matched in terms of intellectual ability and reading competence), $n = 15$	Participants were presented the Awkward Moment Test where they answered questions on characters' mental states and intentions. The test also contained non-social control questions. In addition, participants were presented a shortened version of the Happé's Strange Stories Test including two stories of each of control/physical, irony, double bluff and white lie
Jolliffe and Baron-Cohen (2000)	Integration of information in linguistic processing in adults with AS or HFA	19-46-Year-old adults with HFA, $n = 17$ 18-49-Year-old adults with AS, $n = 17$ 18-49-Year-old typical adults, $n = 17$	<i>Experiment 1:</i> Participants had to arrange sentences coherently in order to make a sensible story <i>Experiment 2:</i> Participants were presented short stories. After that three questions (global inference, desire and comprehension) and a memory task were presented
Dennis et al. (2001)	Inferential language ability in high-functioning children with ASD	Children diagnosed either AS or HFA, mean age 9;9 years ( $SD = 1.6$ ), $n = 8$ Control groups: 3 groups of children age-matched with children with AS/HFA. Every control group did 1-2 parts of tasks so control data came from different children	Children were given non-inferential and inferential tasks. Non-inferential tasks involved vocabulary and ambiguity. Inferential tasks involved mental state verbs (presupposition and implication), scripts, metaphors and speech acts
Kaland et al. (2002)	Ability to make inferences about physical and mental states in contextually complex story context	10-20-Year-old children and adolescents with AS or HFA 10-20-Year-old healthy children and adolescents, $n = 20$	A new advanced test of theory of mind "Stories from Everyday Life" which consisted of questions of lie, white lie, figure of speech, misunderstanding, double bluff, irony, persuasion, contrary emotions, forgetting, jealousy, intentions, empathy and social blunders

Table 1 (Continued)

Author(s) (year)	Theme of research	Participants	Material for study interpretation of pragmatic language meaning
Norbury and Bishop (2002)	Inferential processing and story recall in children with specific language impairment (SLI), pragmatic language impairment (PLI) and HFA	Children with SLI, mean age 9;3 years ( $SD = 0.95$ ), $n = 16$ Children with PLI, mean age 8;8 years ( $SD = 0.99$ ), $n = 24$ Children with HFA, mean age 8;9 years ( $SD = 1.31$ ), $n = 10$ Control group of typically developing children, mean age 8;5 years ( $SD = 0.99$ ), $n = 18$	Story comprehension tasks were presented to children and they were asked questions about the literal content of the story and non-literal questions that required text-connecting and gap-filling inferences. After that the children were asked to recall the final story
Emerich et al. (2003)	Comprehension of humorous materials in adolescents with HFA or AS	11–17-Year-old adolescents with AS or HFA, $n = 8$ Typical adolescents who were age- and gender-matched to subjects, $n = 8$	Participants were presented a cartoon task and a joke task Cartoon task: Ten three-frame set of cartoons with captions from "Garfield". Subjects had to pick the correct funny ending to the cartoon Joke task: ten short story jokes where subjects had to choose the correct funny ending
López and Leekam (2003)	Ability to utilize context in word and object identification, semantic recall ability and ability to utilize context in homograph pronunciation	Children diagnosed with HFA, mean age 14;4 ( $SD = 0.10$ ), $n = 15$ Typically developing children, mean age 13;10 ( $SD = 2.4$ ), $n = 16$	<i>Experiment 1:</i> Palmer's (1975) visual context task was used to investigate the facilitating effect of contextual scenes in object naming <i>Experiment 2:</i> Procedure was similar as in Experiment 1, but all stimuli were presented in words <i>Experiment 3:</i> Children were presented an adaptation of Tager-Flusberg's (1991) visual and verbal semantic memory task <i>Experiment 4:</i> Homograph task of Frith and Snowling's (1983) which investigated whether children utilize context in word pronunciation
Martin and McDonald (2004)	Causes of non-literal language problems in individuals with AS	18–24-Year-old adults with AS, $n = 14$ 18–33-Year-old control adults (first year psychology students), $n = 24$	Cognitive tasks which targeted weak central coherence processes, social inference or theory of mind and the ability to interpret ironic remarks
Kaland et al. (2005)	Social understanding of children and adolescent with AS	10–20-Year-olds with AS, $n = 21$ 9–20-Year-olds typically developing children and adolescents, $n = 20$	The participants were presented Happe's Strange Stories Test (see above Happé, 1994)
Young et al. (2005)	Usability of TOPL and SNAP tests to identify pragmatic language problems in children with ASD	6–14-Year-old children diagnosed with ASD with normal language and cognitive, $n = 17$ Age-, gender-, language- and verbal IQ-matched typically developing children, $n = 17$	Children were investigated by the Test of Pragmatic Language, TOPL (Phelps-Terasaki & Phelps-Gunn, 1992) and by the Strong Narrative Assessment Procedure, SNAP (Strong, 1998)

Wang et al. (2006)	Neural basis and the role of prosody and context in irony comprehension	7–16-Year-old children and adolescents with AS 8–15-Year-old typically developing children and adolescents.	Participants listened to scenarios and determined whether the speaker was sincere or ironic. The scenarios included the following conditions: event knowledge + prosodic cue, event knowledge only and prosodic cues only. During the experiment the fMRI data were collected
Hala et al. (2007)	Utilization of meanings of related word primes in pronouncing homographs in children with autism	Children diagnosed with autism, mean age 10;4 ( $SD = 2;6$ ), $n = 14$ Typically developing children, mean age 8;6, ( $SD = 1;8$ ) $n = 14$	Children were presented primes for homographs. There were three types of word targets: semantically related non-homograph targets, semantically related non-homograph targets and semantically unrelated non-homograph targets
Loukusa, Leinonen, Kuusikko, et al. (2007)	Ability to use context when answering questions and when giving explanations for correct answers in children with AS or HFA	7–9-Year-old children with AS or HFA, $n = 16$ 10–12-Year-old children with AS or HFA, $n = 23$ 7–9-Year-old typically developing children, $n = 23$	Children were asked questions with different contextual demands. Material was developed by utilizing relevance theory (Sperber & Wilson, 1995). Test material contained questions of reference assignment, enrichment, implicature, routine and feeling. In addition, children were asked to give explanations for their correct answers to routine, implicature and feeling questions
Loukusa, Leinonen, Jussila, et al. (2007)	Quality of incorrect/irrelevant answers of children with AS or HFA	7–9-Year-old children with AS or HFA, $n = 16$ 10–12-Year-old children with AS or HFA, $n = 23$ 7–9-Year-old typically developing children, $n = 23$	The data builds on a previous paper (Loukusa et al., 2008b). In this study children's incorrect answers to enrichment, implicature, routine and feeling questions were analysed in more detail and classified into categories
Pijnacker et al. (2009)	Ability to derive scalar implicatures in ASD	20–32-Year-old adults with HFA, $n = 11$ 19–40-Year-old adults with AS, $n = 17$ All adults with HFA and AS together, $n = 28$ 19–39-Year-old typical adults, $n = 28$	The material comprised two kinds of scalar terms, <i>some</i> and <i>or</i> . There were four conditions for the scalar term <i>some</i> (true universals, underinformatives, false universals and true existentials) and three conditions for the scalar term <i>or</i> (underinformative disjunctions, true disjunctions, false disjunctions)

<sup>a</sup> In Happé's (1994) study some participants with autism did not have intelligence within normal range. In no-ToM group VIQ varied from 52 to 76, 1st-order ToM group VIQ varied between 65 and 100 and 2nd-order ToM group between 90 and 101. ToM = Theory of mind.



story recall, but there was a connection between story recall and comprehension, suggesting that good comprehension aided story recall.

When interpreting ironic utterances, the hearer must use contextual information and understand the intentions of others (Cummins, 2005; Ivanko & Pexman, 2003). It is therefore not surprising that it has been found that children with ASD have difficulties in some of the irony comprehension tasks (Wang, Lee, Sigman, & Dapretto, 2006). Compared to typically developing children, children with ASD demonstrated weaknesses in tasks where utilizing contextual knowledge of the event was the key element, but unexpectedly, these children performed comparably to typically developing children in tasks where prosodic cues were central. This suggests that children with ASD have difficulties particularly in tasks where interpretation of non-literal language is needed. Results of fMRI showed that when understanding ironic utterances, children with ASD use similar neural mechanisms as typically developing children. However, they had more activity in the right inferior frontal gyrus and in bilateral temporal regions, suggesting that compared to control children, children with ASD had to use more effort when interpreting ironic meanings of utterances. Similarly to understanding irony, understanding of humour demands an ability to derive an intended meaning on the basis of the information available. It is thus not surprising that difficulty to understand humorous material is also a typical feature of autism. Adolescents with autism have difficulties understanding cartoons and jokes, and more specifically, they have difficulties handling the surprise and coherence aspects of humour simultaneously (Emerich, Creaghead, Grether, Murray, & Grasha, 2003). The studies by Kaland et al. (2002, 2005) contained various kinds of questions demanding the ability to infer non-literal meanings and intentions (see Table 1). Compared to physical states, inferring mental states was more problematic to the children and adolescents with AS. Not only did they have more incorrect answers, but they also needed more prompt questions and their reaction times were longer.

By studying the ability to understand idioms (phrases whose meaning cannot be determined by the literal interpretation) or homographs (words that share the same spelling but have different meanings) it is also possible to obtain information about children's ability to utilize contextual information. It has been found that children with AS or HFA show weaknesses in idiom comprehension tasks (Kerbel & Grunwell, 1998) and in some, albeit not all homograph tasks (Hala, Pexman, & Glenwright, 2007; López & Leekam, 2003). It has been shown that if the context requires common interpretation of a homograph, children with autism perform equally with their controls (López & Leekam, 2003). However, when the context requires a less common interpretation of a homograph, children with autism perform significantly less well than their controls, showing that they are impaired in using the sentence context in homograph tasks. The study by López and Leekam also contained tasks where there was no need to process sentences. These tasks investigated whether children with autism utilize pictures (visual) and words (verbal), such as "garden" or "post office", as contextual information when identifying words. Unlike in the case of homograph tasks, children with autism performed comparably to typically developing children in these tasks. On the basis of this the investigators suggested that children with autism do not have general difficulty connecting contextual information, but that they have specific difficulty with complex verbal contexts, such as using sentence context in disambiguating meanings. In an alternative approach Hala et al. (2007) investigated whether children with autism utilize meanings of prime words when disambiguating a target homograph, presenting semantically related and semantically unrelated word pairs to these children and their controls. They found that children with autism are in many cases able to draw connections between primes and targets. However, in the second presentation of the homographs children with autism had a tendency to repeat their first pronunciation regardless of the change in the prime. Based on this, the investigators concluded that children with autism can utilize meanings of related word primes (which is contextual information), but they have difficulties inhibiting prior responses when a homograph is presented later with different primes, indicating executive dysfunction.

The study by Young et al. (2005) investigated how well pragmatic impairments of children with ASD can be detected by TOPL (Phelps-Terasaki & Phelps-Gunn, 1992) and SNAP (Strong, 1998) tests. TOPL provides information within the following six subcomponents of pragmatic language: physical setting, audience, topic, purpose, visual-gestural cues and abstraction, and its score differentiated children with ASD from matched controls. However, the investigators point out that variance within

the ASD group was large, with the result that some of the children with ASD performed comparably to controls. In the SNAP, children with ASD performed more weakly than controls in inferential questions, but similarly in other language tasks, which were syntax, cohesion, story grammar and completeness of episodes, with the result that SNAP did not clearly differentiate language abilities of children with ASD from those of typically developing children.

### 3.2. How do adults with AS or HFA perform in tasks demanding pragmatic inference abilities?

In AS and HFA, pragmatic inference difficulties persist into adulthood. It has been shown that adults with AS and HFA have difficulties selecting the most coherent inference from given alternatives (Jolliffe & Baron-Cohen, 1999b), making context-relevance inferences in the global inference questions (Jolliffe & Baron-Cohen, 2000) and making inferences when misleading information is presented (Ozonoff & Miller, 1996). They also exhibit difficulties in context utilization when interpreting lexically and syntactically ambiguous sentences with rare interpretation (Jolliffe & Baron-Cohen, 1999b) and in comprehension of indirect requests and irony (Ozonoff & Miller, 1996). In the study by Jolliffe and Baron-Cohen (2000) the participants were presented global inference, desire (character's goal) and comprehension questions. In addition, they were requested to recall a story. The results showed that control, AS and HFA groups did not differ on the memory (recall), comprehension and desire tasks, whereas differences were found on the global inference questions where they had to formulate an inference which was contextually appropriate for the story character's action. In addition, in relation to their own performance in other tasks, the AS and HFA groups performed significantly worse on the global inference tasks, whereas in the normal group the performance pattern did not differ between the tasks. On the basis of their findings, the investigators suggest that differences in performance between desire and global inference questions could be explained by weak central coherence, and it seems that these individuals can perform low-level sociocognitive tasks, such as reasoning about desires.

The studies using Happé's Strange Stories Test (Happé, 1994; Jolliffe & Baron-Cohen, 1999a) or part of the test (Heavey et al., 2000) found that adults with HFA or AS did not differ in the performance of physical control stories, but a difference was found in mental state stories when they had to justify story characters' non-literal speech (see Table 1, Happé, 1994, for names of the mental state stories). This shows that these individuals have problems providing contextually relevant mental state explanations. Jolliffe and Baron-Cohen (1999a) suggest two possibilities for the difficulties in the Strange Stories Test: (1) individuals with AS or HFA have difficulties inferring speaker's intended meaning from the context where it has been embedded or (2) they may have difficulties understanding some of the mental states. Thus, difficulties can be caused by problems in central coherence, theory of mind or both (see also Happé, 1994). In addition to the tasks of the Strange Stories Test, Heavey et al. (2000) presented to the subjects the Awkward Moment Test developed by them to measure subtle difficulties in mental understanding. In this test the subjects had to answer questions about mental states that demanded understanding of the film character's beliefs about a social situation and the social significance of the character's actions. There were also control questions that were not related to the social content of the film. Also in this test it was evident that individuals with autism had difficulties answering mental-state questions, and especially explaining the intentions and motives of film characters.

Scalar implicatures refer to terms where the listener has to recognize what the speaker might have said but did not, e.g. when hearing the term *some*, the listener needs to infer that the speaker means *not all*. The study by Pijnacker, Hagoort, Buitelaar, Teunisse, and Geurts (2009) investigated how individuals with AS and HFA derived meanings for the scalar terms *some* and *or*. They found that compared to the control group, adults with AS did not show any problems deriving meanings based on scalar terms. However, adults with HFA performed more poorly and they were slower in responding. In the HFA group the performance was associated with verbal intelligence, but a correlation of this kind was not found in the AS or the control group. In homograph tasks (Jolliffe & Baron-Cohen, 1999b) the results of adults with AS and HFA have been similar to those of the homograph study in children (López & Leekam, 2003), suggesting that individuals with AS and HFA have a tendency to pronounce homographs as they are most commonly pronounced, regardless of the context. Jolliffe and Baron-

Cohen (1999b) suggest that difficulties in pronouncing homographs context-appropriately shows weaknesses in central coherence since individuals with AS and HFA do not process self-read material fully for meaning. This is in contrast to the opinion of López and Leekam (2003), who thought that in ASD there is a specific difficulty with complex verbal context, not general difficulties as predicted by weak central coherence. One study which did not find a link between weak central coherence and pragmatic comprehension measured by ironic questions was the study by Martin and McDonald (2004). In their study weak central coherence, which was tested using the Local Global Processing Task (Delis, Kiefner, & Friedland, 1988) was not connected with the ability to interpret irony or the ability to perform in theory of mind tasks. In contrast, second order theory of mind reasoning was connected with the ability to interpret irony.

#### 4. Discussion

It is obvious that language skills alone are not sufficient to understand the pragmatic meaning of an utterance (Sperber & Wilson, 1995; Wilson, 2000) and that pragmatic comprehension difficulties can be evident in children and adults with AS and HFA even if their intelligence is within normal range, as shown by the studies of this review. Difficulties in pragmatic inferencing affect an individual's life widely, making it difficult to communicate with peers and function in community (Fleisher, 2001; Landa, 2000). The studies by Loukusa, Leinonen, Jussila, et al. (2007) and Loukusa, Leinonen, Kuusikko, et al. (2007) provided some evidence that difficulty utilizing contextual information in comprehension decreases with progressing development. However, as the contextual comprehension abilities of children with AS/HFA develop later compared to normally developing children, important developmental stages may be missed. As a result, the mastery of the complexities involved in pragmatic comprehension may not be complete, which is reflected in difficulties in complex communication situations in adulthood. When the inference load increases, it is obvious that also children's difficulties increase (Dennis et al., 2001; Loukusa, Leinonen, Kuusikko, et al., 2007). This study has shown that individuals with AS and HFA have difficulties in many kind of tasks demanding pragmatic inferencing and understanding of intentionality, suggesting higher-level comprehension problems. The studies showed difficulties in many types of tasks, for example, tasks that require inferring about social scripts, metaphors, speech acts (Dennis et al., 2001) and humour (Emerich et al., 2003) and explaining non-literal utterances, such as jokes, sarcasm and persuasion, in a context-appropriate manner (Happé, 1994; Jolliffe & Baron-Cohen, 1999a, 1999b; Kaland et al., 2005).

Despite the fact that children and adults with AS/HFA have difficulties processing contextual information and inferring meaning, it is emphasized that in all studies individuals with AS and HFA were able to answer different kinds of pragmatic questions, even if this ability was less developed than in normally developing children and healthy adults. Therefore, the performance of individuals with AS and HFA indicates deficiencies in pragmatic comprehension and inference abilities, but not an inability (see e.g., Hala et al., 2007; Jolliffe & Baron-Cohen, 2000; Kaland et al., 2002). This poses a challenge in terms of the methods used in measuring the pragmatic inference abilities of these individuals. The methods have to be sensitive enough in order to detect difficulties since many of the individuals with AS and HFA can perform simple tasks demanding pragmatic inference, and this can sometimes mislead clinicians and others to think that there are no problems in pragmatic inference abilities.

Even if most studies found that difficulties in making contextually relevant inferences and using contextually relevant utterances belong to AS and HFA, researchers do not entirely agree on the causes of these difficulties. One of the most commonly suggested explanations for the comprehension difficulties of individuals with AS and HFA is weak central coherence, which means that these individuals have a tendency to interpret utterances in isolation and have problems integrating information from many sources (Jolliffe & Baron-Cohen, 1999a, 1999b, 2000; Noens & van Berckelaer-Onnes, 2005; Norbury & Bishop, 2002). In contrast, according to Martin and McDonald (2004), weak central coherence cannot explain the pragmatic comprehension problems. Their study indicated no association between a local-information processing bias and the comprehension of ironic meanings in young adults with AS. Martin and McDonald present that contextual processing and local-global

processing may be quite independent abilities, and that it is a weakness of the central coherence theory to look at them as the same phenomenon. In their study Martin and McDonald found a connection between theory of mind ability and ironic understanding, suggesting that the ability to understand others' belief states is essential to pragmatic comprehension. Therefore, they argue that lacking theory of mind ability causes pragmatic comprehension difficulties. In addition, many studies that mention central coherence as a possibility causing pragmatic comprehension or inference difficulties, also mention that difficulties can be caused by the theory of mind, too, or that both of them may play a part (Happé, 1994; Jolliffe & Baron-Cohen, 1999a). Thus, when suggesting reasons for pragmatic inference difficulties, many researchers present various possibilities (see also Loukusa, Leinonen, Jussila, et al., 2007). At the moment it is also known that many individuals with AS and HFA pass 1st- and even 2nd-order theory of mind tasks. When theory of mind weaknesses have been found in these individuals, the tasks have required understanding of subtle contextual clues; the processing load has thus been big and deriving the intentions of speakers has been a challenge (Happé, 1994; Heavey et al., 2000).

Regardless of some differences in opinions concerning weak central coherence and ToM, at the moment it looks as if they are both the most widely used explanations for pragmatic language difficulties in AS and HFA. However, difficulties directing toward contextually relevant information (Loukusa, Leinonen, Jussila, et al., 2007; Loukusa, Leinonen, Kuusikko, et al., 2007; Papp, 2006) and difficulties in executive dysfunction (Hill, 2004) might also be worth considering when discussing pragmatic inference abilities. Generally, it has been suggested that executive function deficits may underlie the symptoms of ASD (Bíró & Russell, 2001; Ozonoff & Griffith, 2000), affecting planning and mental flexibility. Thus, executive functions may also affect pragmatic expression and comprehension that require a sophisticated ability to use and interpret language in a flexible way according to the situation (Hill, 2004) and to direct one's attention to relevant factors (Papp, 2006). It was surprising that most of the studies investigated here did not mention the effect of executive dysfunction or attention to the ability to derive meaning from the context. However, there was a study by Hala et al. (2007) where executive dysfunction was suggested to be the reason for inhibiting prior responses affecting contextually appropriate homograph pronunciation. On the basis of the suggested reasons for pragmatic inference difficulties in the studies reviewed here, we conclude that it may be that the reasons for difficulties vary between individuals, which is why explanations for difficulties do not necessarily need to exclude one another. Some individuals may have difficulties in all complex processing, whereas in others there may be a specific reason causing difficulties. It might also be that in childhood, difficulties are shown more widely in all complex areas of language processing, whereas in adulthood, difficulties are more specific in their nature. However, on the basis of current knowledge, we cannot say this for sure.

Theoretical frameworks and methods of the studies vary widely, which makes it difficult to compare different studies and their results. However, this is not only a negative thing, because different kinds of frameworks give more knowledge about inference abilities. Investigators' different backgrounds provide a wider perspective to interpret results when, for example, experts in speech and language therapy, psycholinguistics, psychology and psychiatry join their knowledge, helping us to learn more about the complex nature of these difficulties.

On the basis of this study it can be suggested that in rehabilitation of individuals with AS or HFA it would be useful to see pragmatic inference as one of the important areas. It is crucial that children with AS or HFA get repeated experience from the same kind of situations demanding pragmatic inference. This makes it possible for children to develop internalized routines or schemas that they can utilize in utterance interpretation in the future. It is also useful to teach strategies of how to connect various types of contextual information via deduction. Even though it may be that connection of information does not happen automatically in individuals with AS or HFA all of the time, it is obvious based on the studies summarized here that in many instances individuals with AS or HFA are able to connect different kinds of information appropriately in order to derive meaning. When practising these areas, tasks should be planned so that the processing load increases gradually, since difficulties increase with an increasing processing load (Dennis et al., 2001; Loukusa, Leinonen, Kuusikko, et al., 2007). Individuals with AS and HFA are able to engage in some complex contextual processing and they have building blocks that enable them to learn to process increasingly complex contextual data;

thus it can be supposed that rehabilitation could be successful because it is directed to partial or emergent ability.

Literal interpretation of language and difficulties in context utilization are well-known features of AS and HFA. It is therefore surprising that so few studies addressing these issues were found for this review. On the basis of this, it is obvious that there is still a need for studies investigating different aspects of pragmatic inferencing. In particular, there is a need for studies exploring developmental traits in these children. It would be beneficial to study pragmatic comprehension abilities of children with AS/HFA as early as possible. In addition, there is a need for longitudinal studies to follow up the developmental changes in the pragmatic language comprehension of individual children. Only by studying developmental phases of abnormal development it is possible to understand how different developmental pathways might cause different phenotypical outcomes (see also Karmiloff-Smith, 1998). It would also be beneficial to study the effect of visual support in pragmatic inference by comparing the results of similar kinds of pragmatic inference demands with and without visual support. Many therapy programmes for children with ASD are based on the use of strong visual support, so it would be important to study how great the effect of visual support is in the comprehension of these children and to what extent increased visual support can compensate for comprehension difficulties. However, it is good to bear in mind that strong visual contextual support is not always available in everyday communication situations, and it is therefore also important to study children's performance in situations with minimal visual contextual support. The connection between mind-reading ability and pragmatic inference abilities is well known (e.g., Happé, 1993; Martin & McDonald, 2004; Surian et al., 1996). It would also be beneficial to study in more detail the connection between pragmatic comprehension abilities and other cognitive, social and language functions in children with AS/HFA. It would be especially interesting to study individual children's pragmatic, emotional, social, language and cognitive abilities in order to find out what developmental areas are most problematic and how the different developmental areas interact. On the basis of this review it is also obvious that more research is needed to develop assessment tools targeting the unique language disabilities of individuals with ASD that involve higher level comprehension tasks (see Young et al., 2005). At the moment, there are some methods available for clinicians and researchers to detect pragmatic inference difficulties, but a future challenge is to develop tests and materials which are even more sensitive and aimed specifically at detecting difficulties of individuals with ASD.

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