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Using Theory of Mind to represent and take part in social interactions: Comparing individuals with high-functioning autism and typically developing controls

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The literature suggests that individuals with autism spectrum disorders (ASD) are deficient in their Theory of Mind (ToM) abilities. They sometimes do not seem to appreciate that behaviour is motivated by underlying mental states. If this is true, then individuals with ASD should also be deficient when they use their ToM to represent and take part in dyadic interactions. In the current study we compared the performance of normally intelligent adolescents and adults with ASD to typically developing controls. In one task they heard a narrative about an interaction and then retold it. In a second task they played a communication game that required them to take into account another person's perspective. We found that when they described people's behaviour the ASD individuals used fewer mental terms in their story narration, suggesting a lower tendency to represent interactions in mentalistic terms. Surprisingly, ASD individuals and control participants showed the same level of performance in the communication game that required them to distinguish between their beliefs and the other's beliefs. Given that ASD individuals show no deficiency in using their ToM in real interaction, it is unlikely that they have a systematically deficient ToM.

Keywords: Autism; Egocentrism; Mental mindedness; Perspective taking; Theory of Mind.

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Autism spectrum disorders (ASD) are defined by behavioural and developmental impairments in social and communicative domains and by repetitive behaviour (American Psychiatric Association, 1994). Among the most striking features ascribed to individuals with ASD are claimed to be their poor "Theory of Mind" abilities (Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Theory of Mind (ToM) refers to the ability to ascribe mental states to others or oneself and to explain and predict behaviour in terms of underlying mental states (Baron-Cohen, Tager-Flusberg, & Cohen, 2000). Even though the latter part of this definition entails verbal and conceptual abilities, the term "Theory of Mind" originates from a study of chimpanzee behaviour (Premack & Woodruff, 1978) and in principle allows for tacit interpretation skills that do not require sophisticated concepts or verbal abilities. However, most studies on ToM have operationalized this construct by evaluating conceptual knowledge of mental constructs in young, typically developing children (Wellman, Cross, & Watson, 2001) or in children with autism spectrum disorders (Baron-Cohen, Leslie, & Frith, 1985; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998).

Yet the main function of a ToM is to master social situations. It is thus surprising that the way people apply their ToM skills to social interactions has been largely ignored in developmental psychology (Frith, Happé, & Siddons, 1994; Keysar, Lin, & Barr, 2003; Klin, Jones, Schultz, & Volkmar, 2003). Social psychology has contributed significantly to this research under slightly different headings—empathy, perspective taking, and attribution of mental states (e.g., Ames, 2004; Epley, Keysar, Van Boven, & Gilovich, 2004; Malle & Hodges, 2005; Malle, Knobe, O'Laughlin, Pearce, & Nelson, 2000). The goal of the current study was to investigate the use of perspective taking and mental-state inference in representing and taking part in dyadic interactions and to compare the performance of adolescents and adults with ASD to the performance of typically developing controls.

Research on the development of ToM has focused on young children and has assumed a quite idealized, and in some respect erroneous, ToM ability in adults. Recent findings in social psychology reveal a more complex picture of adults. One line of research has demonstrated that adults have a sophisticated concept of intentional action. They attend in detail to the mental states involved in it, and they use these concepts widely when they describe and explain behaviour. Yet, even though people attempt to infer the thoughts and feelings of another person, their accuracy is far from perfect (e.g., Ickes, 1993; Klein & Hedges, 2001). In particular, people often have difficulties appreciating that others may be ignorant about some fact or have a false belief about it (Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006). Consequently, at times they behave egocentrically, assuming that the other individual has access to their private knowledge (Keysar et al., 2003; Nickerson, 1999).

Limitations of the adult ToM can be identified if an adult-appropriate task is used that leaves room for error. In the widely used standard false-belief task, which is assumed to demonstrate a fully-fledged ToM from six years of age onward (Wellman et al., 2001; Wimmer & Perner, 1983), the subject knows the actual hiding location of an object and also knows that another person falsely believes it is hidden in a different place. When asked to predict where that person will look for the object, young children tend to confound their knowledge with the knowledge of the other person and predict that the other will look where the object really is, not where that person (falsely) believes it is. This failure to attribute false beliefs disappears after age four. Yet, by slightly modifying this task, Birch and Bloom (2007) showed a lingering confounding of self- and other-knowledge even with adults. Instead of asking for a categorical prediction about where the person will look for the object, the researchers asked for a probability estimate. Indeed, adults estimate the probability that the other will look at the true location to be higher when they themselves know the location than when they don't, again confounding somewhat their own knowledge with the knowledge ascribed to the other. In evaluating ToM in individuals with autism, then, it is crucial to measure ToM performance in tasks that are sensitive both to the ability and its limitation. We will describe two such tasks that are new to the literature on autism and ToM and examine the relative performance of individuals with ASD and neurotypical controls.

Do individuals with ASD show limited ToM abilities? The literature does not provide a clear-cut answer to this question (e.g., Gernsbacher & Frymiare, 2005). The results vary with age, IQ, and the nature of the task (Begeer, Koot, Rieffe, Meerum Terwogt, & Stegge, 2008; Rajendran & Mitchell, 2007). One of the most common ways to evaluate ToM skills has been to use conceptual tasks such as the false-belief task. This approach has provided evidence for impaired ToM abilities in school-aged children with ASD (Yirmiya et al., 1998). However, adolescents and adults with ASD, in particular those with normal IQ (high-functioning ASD) often pass conceptual ToM tasks at various levels of complexity (Bowler, 1992; Dahlgren & Trillingsgaard, 1996). Moreover, their performance on such tasks does not predict social behaviour in everyday settings (Fombonne, Siddons, Achard, & Frith, 1994; Frith et al., 1994; Peterson, Slaughter, & Paynter, 2007; Travis, Sigman, & Ruskin, 2001).

Though adolescents with high-functioning ASD often perform adequately on standard conceptual ToM tasks, they seem to perform worse on more advanced measures of ToM. These can include advanced "static" tests such as paper-and-pencil tasks that focus on the conceptual understanding of relatively complex interactions, requiring inferences of second-order mental states and the understanding of irony or emotional display rules. These tests have uncovered robust differences between children with high-functioning ASD and controls (Happé, 1994; Jolliffe & Baron-Cohen, 1999; Kaland et al., 2002). However, adults with high-functioning ASD show no impairments on these tasks, and, just like controls, are able to acknowledge both the existence and the importance of mental states (Roeyers, Buysse, Ponnet, & Pichal, 2001). Such adequate performance of high-functioning ASD adults is often attributed to cognitive compensation, the ability to use general cognitive and language skills to circumvent the conceptual ToM problem and still find a solution to the task (Bowler, 1992; Frith et al., 1994; Tager-Flusberg, 1993).

More dynamic, behavioural tests did indicate ToM limitations in high-functioning adults with ASD, even in those who pass static tests (Dziobek et al., 2006; Golan, Baron-Cohen, Hill, & Golan, 2006; Jolliffe & Baron-Cohen, 1999; Kleinman, Marciano, & Ault, 2001). For example, movie clips of acted or naturally occurring social interactions consistently elicit less-adequate explanations and less empathic accuracy in adults with high-functioning ASD than in controls (Heavey, Phillips, Baron-Cohen, & Rutter, 2000; Ickes, 1993; Roeyers et al., 2001).

Though there is evidence for ToM impairments in ASD individuals, none of the evidence emerged from situations in which these individuals were engaged in actual interaction. Conversely, some evidence suggests that even children with high-functioning ASD might perform unimpaired in some settings of actual interactions. In a study by Begeer, Rieffe, Meerum Terwogt, and Stockmann (2003) children with high-functioning ASD showed clear impairments in correcting another person's false beliefs during natural interactions, but their performance improved when they were motivated to respond adequately. Moreover, a study by Ponnet, Buysse, Roeyers, and de Corte (2005) suggests that adults with high-functioning ASD can spontaneously ascribe thoughts and feelings to a person with whom they just interacted at similar rates as controls. Thus, more research is clearly needed to examine the scope and limits of adequate ToM performance of high-functioning ASD individuals in contexts of social interaction.

In the current study we compared high-functioning ASD adolescents and adults with typically developing controls on two new tasks. The *narrative task* requires participants to read a story describing an ambiguous social interaction and to later retell the story. The *interaction task* requires participants to engage with another person in a highly structured communication game. Thus, both tasks require the handling of a social interaction, but a represented one in the narrative task and an experienced one in the interaction task. Both require linguistic processes, but of production in the narrative task and of comprehension in the interaction task. Most important, both require mental state inferences, but one in service of meaningful representation and the other in service of successful mastery of an interaction goal.

STUDY 1: NARRATIVE TASK

Typically developing adults routinely use mental-state terms in their narrative representation of social interactions (Barker & Givón, 2005), but there are no data on adults with high-functioning ASD on this ability. There is some indication that they use fewer mental-state formulations than control participants when interpreting ambiguous geometric shapes that enact a social plot in a cartoon animation (Klin, 2000; Klin et al., 2003). In the current study, a simpler method was employed, taking advantage of the ubiquitous situation of hearing or reading about an interaction and having to describe it to another person. All participants read a short story about an ambiguous interaction between two people (Malle & Holland Rogers, 2008). The story described the story characters' behaviours but made no explicit reference to their mental states, such as beliefs, desires, or emotions. After some delay, participants were asked to retell the story. If people spontaneously make sense of ambiguous social interactions by inferring underlying mental states, these inferences should emerge in the retelling as mental state words such as "wanted", "thought", "was confused" and "trusted", even though none of those words were part of the original story. Consistent with Klin et al.'s results, we expected that the ASD group would include fewer references to mental states in their retelling narratives than control participants.

Method

Participants. Participants were 68 adolescents and adults (53 males, 15 females), including 34 participants with an autism spectrum disorder and 34 typically developing control participants, who were matched on chronological age and cognitive abilities. The ASD participants were recruited from two psychiatric institutions in the Netherlands. Their diagnostic classification was based on assessments by a psychiatrist and multiple informants (psychologists and educationalists). All participants fulfilled established diagnostic criteria according to the DSM-IV-TR (American Psychiatric Association, 2000). For part of the ASD sample, additional diagnostic information was obtained from the Children's Social Behaviour Questionnaire (CSBQ; Luteijn, Minderaa, & Jackson, 2002) and from the self-reported and parental-reported Autism Spectrum Quotient (Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). These measures confirmed the clinical diagnoses (see Table 1).

The control group was recruited from schools, colleges and universities around Amsterdam, the Netherlands. IQ scores for all participants were

TABLE 1
Details of the two participant groups

	ASD (n = 34)	*Control (n = 34)*	*Group comparison*
Age (years;months)	16;7 (4;2)	16;8 (3;8)	$p = .94$
Gender (Male/Female)	26/8	27/7	$p = .77$
FSIQ[a]	108.5 (21.1)	105.8 (18.3)	$p = .62$
CSBQ (parent)[a]	41.8 (17.6) ($n = 16$)	6.4 (8.5) ($n = 19$)	$p < .000$
AQ (parent)[a]	35.3 (3.0) ($n = 6$)	21.9 (3.8) ($n = 6$)	$p < .000$
AQ (self-report)[a]	33.0 (3.9) ($n = 9$)	23.5 (2.6) ($n = 9$)	$p < .000$

Notes: ASD = Autism Spectrum Disorder, FSIQ = full-scale IQ; CSBQ = Children's Social Behaviour Questionnaire; AQ = Autism Quotient Questionnaire. [a]Means (SD).

obtained by a short version of the Wechsler Intelligence Scale for Children-III (Wechsler et al., 1991) or the Wechsler Adult Intelligence Scale (Wechsler, 1997). Four subtests (Vocabulary, Arithmetic, Block Design, and Picture Arrangement) were administered to assess intelligence. These subtests are known to correlate highly with Full-scale IQ in the general populations (Donders, 2001).

Material. In this task, participants read a short story about an interaction between a man and a woman in a domestic context (Malle & Holland Rogers, 2008; see appendix). The story included no terms that explicitly referred to mental states such as beliefs, desires, emotions or intentions. However, the text provided clues about the story character's mental states—for example, by referring to their physical state (a trembling hand) or their behaviour (suddenly leaving the room). After an average of 20 minutes (during which the interaction task, described in Study 2, was administered), participants were asked "Could you retell the story?" and "Could you tell me what the story was about?"

Procedure. The participant first read the narrative task story on a computer screen and then completed the interaction task. The confederate was then asked to wait in another room while the participant answered the two questions about the story they had read, and finally they completed the IQ test and were debriefed.

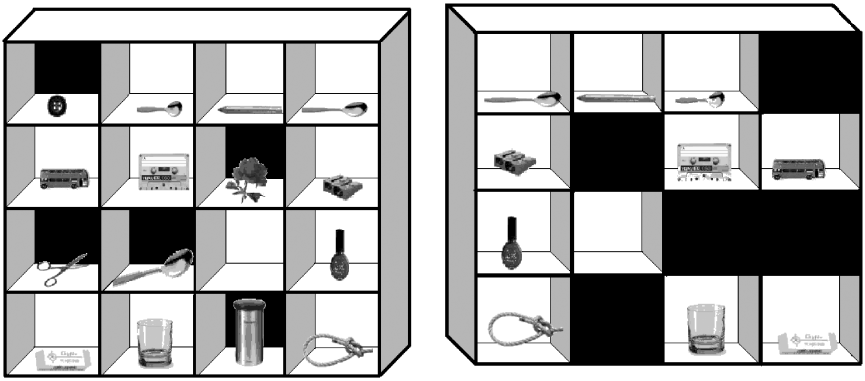
Dependent variables. Participant's retelling of the story was transcribed and scored for the use of mental-state terms. Mental-state terms included all references to beliefs, ideas, or thoughts (e.g., "he thinks", "she knows"), references to desires, hoping, longing or preferences (e.g., “she needed”, “he didn’t want”) as well as references to emotional states (e.g., “he was angry”, “he was feeling sad”). These results held up in separate analyses of specific mental-state categories, beliefs, desires and emotions (*d*s ranging from 0.40 to 0.68). Overall agreement between two independent raters of mental-state references was .78. Disagreements were resolved through discussion.

Results

Differences between the number of mental-state references in the narrative of individuals with ASD or typical development were analysed with an ANCOVA, controlling for participants’ age and full-scale IQ. The ASD group reported fewer mental-state references ($M = 1.06$, $SD = 1.32$) than the control group ($M = 2.38$, $SD = 1.99$); $F(1, 64) = 13.60$, $p < .001$, $d = 0.89$. When the number of mental-state references was divided by the overall number of words used in each recounted story, the ASD participants still reported a lower proportion of mental-state references ($M = 0.02$, $SD = 0.02$) than controls ($M = 0.04$, $SD = 0.04$); $F(1, 64) = 4.36$, $p < .05$, $d = 0.51$.

STUDY 2: INTERACTION TASK

This task was designed to engage participants in an interaction that could be successfully mastered when taking into account the perceptions and beliefs of their interaction partner. Each participant played a communication game in which another person (the “director”) instructed the participant (“the addressee”) to move objects in a grid (Epley, Morewedge, & Keysar, 2004; Keysar et al., 2003; Wu & Keysar, 2007). The two individuals shared knowledge about the location of mutually visible objects, while other objects were visible only to the addressee but not the director. For example, as shown in Figure 1, when the director says to move “the big spoon” the intended target must be the mutually visible spoon. However, if the addressee fails to take the director’s perspective, he or she may consider the occluded spoon as the referent. This confusion may delay the identification of the actual target spoon and possibly even cause the addressee to mistakenly move the occluded spoon that the director could not have referred to, which would be an egocentric error. This task requires the spontaneous and repeated use of ToM to interpret the other person’s behaviour in an unfolding social interaction. If ASD individuals are deficient in their use of ToM, then they should make more egocentric errors and show a longer latency to move the target objects than control participants.



Addressee's view Director's view

Figure 1. Array of objects presented from the addressee's and the director's perspective. One of the critical instructions for the director in this trial was to "move the big spoon to the empty slot". Moving the mutually visible spoon in the top corner slot would suggest adequate perspective taking. In contrast, moving the occluded spoon would suggest an egocentric interpretation. To view this figure in colour, please visit the online version of this Journal.

Method

Participants. The participants were the same as in Study 1.

Material. Participants were seated on opposite sides of a grid that consisted of 16 (4×4) open slots. One person was always a female confederate who served the role of director, instructing participants to move objects around in the grid. Five of the slots were occluded from the director's view but were clearly visible to the participant (see Figure 1). One mutually visible slot was empty. All other slots were filled with different objects. The task consisted of five blocks in which the participant moved a total of 64 target objects, four blocks with 12 objects and one block with 16 objects. Out of these 64 objects, 18 were designated "critical": They involved a competitor object that was, from the participant's perspective, a potential referent of the director's instruction (e.g., "Take the big spoon"), but because the object was occluded from the director's view, it could not have been the intended referent. These trials thus contained ambiguous directions, which were contrasted with neutral (non-ambiguous) trials to form a within-subject factor of target type.

The target object and competitor object were always arranged in diagonally opposite quarters of the grid, making the object of attention and reaching easy to discern on video. The instructions in critical trials contained either size ambiguity (e.g., "Move the big spoon") or semantic ambiguity (e.g., the instruction "Move the tape" when a cassette tape was mutually visible but a roll of Sellotape was visible only to the addressee). The position of the critical trials varied in a predetermined random fashion.

Participants were filmed with a digital video camera positioned in the centre of the second row from the top, focused on their face. The camera was approximately 50 cm from their head. A second camera located behind the participants recorded their reaching.

Procedure. The participant and the confederate learned that they would be playing a communication game, which involved one of them telling the other which objects to move around in the grid. To make sure the addressee understood the director's perspective, both participants practiced the roles of director and addressee. The role of the director was then (purportedly randomly) assigned to the confederate, and the role of addressee was assigned to the participant. The director received a drawing that showed the grid from her perspective and specified the order in which the objects should be moved. After each block of moving objects the experimenter returned the objects to their original position in the grid. In the meantime, to make sure that participants believed that the director could not see the objects in the occluded slots, the director was asked to turn around while the grid was being filled with objects.

Dependent variables. Two raters who were unaware of the hypothesis and of participants' diagnosis coded the videotapes for egocentric errors and the latency to move the target object. Egocentric errors were scored when the participant moved the occluded object (e.g., the hidden spoon) and placed it in the empty slot. Inter-rater reliability was 1.00. The latency to move the target object was defined as the temporal window from the director's mention of the object to be moved (e.g., "Move the big *spoon*") to the addressee's putting down the object in another slot.

Results

To examine egocentric errors, we conducted a 2 (Target Type: ambiguous vs. neutral) $\times$ 2 (Group: ASD vs. typically developing controls) ANCOVA, controlling for participants' age and full-scale IQ. In general, participants made more egocentric errors in ambiguous trials ($M = 39\%$) than in neutral trials ($M = 0\%$); $F(1, 64) = 33.16$, $p < .001$, $d = 1.76$. ASD individuals showed a nominally *smaller* error rate ($M = 34\%$) than the control group ($M = 43\%$), but this difference was not significant; $F(1, 64) = 2.52$, *ns*. The same pattern emerged for the percentage of people in each group who were able to avoid all egocentric errors: ASD ($M = 21\%$) vs. control group ($M = 9\%$); $F(1, 64) = 1.65$, *ns*. So the tendency to avoid making egocentric errors clearly showed no advantage for control over ASD individuals.

The number of egocentric errors of the ASD group in the ambiguous condition was substantially correlated with chronological age, $r(34) = -.47$, $p < .01$, and full-scale IQ, $r(34) = -.51$, $p < .01$. The corresponding correlations in the control group were small and non-significant, chronological age: $r(34) = -.12$, *ns*; full-scale IQ: $r(34) = -.20$, *ns*. However, the difference between the correlations in the ASD and control groups did not reach traditional significance levels (for age with egocentric errors: $z = 1.53$, $p = .14$, for IQ and egocentric errors: $z = 1.41$, $p = .17$, respectively).

Participants' latencies of moving objects were longer in ambiguous trials ($M = 3.20$ s, $SD = 0.91$) than in neutral trials ($M = 2.69$ s, $SD = 0.65$), indicating that the presence of a competitor delayed the selection of the target. Importantly, this delay was not significantly larger for the ASD group ($M = 0.60$ s, $SD = 0.58$) than for the control group ($M = 0.42$ s, $SD = 0.51$). Thus, a 2 (Group: ASD vs. control) × 2 (Trial Type: ambiguous vs. neutral) repeated-measures ANCOVA (controlling for participants' age and full-scale IQ) showed a significant main effect of Trial Type; $F(1, 64) = 5.67$, $p < .05$, $d = 0.58$, but no effect of Group ($F < 1$) or interaction; $F(1, 64) = 1.87$, *ns*.

The latencies in the ambiguous condition of both the ASD and control groups were significantly correlated with chronological age, $r(34) = -.55$, $p < .01$ and $r(34) = -.59$, $p < .01$, respectively, and full-scale IQ, $r(34) = -.35$, $p < .05$ and $r(34) = -.20$, $p < .05$, respectively, suggesting that all participants were able to respond more quickly with increasing chronological and mental age.

In sum, all participants, whether ASD or control group members, produced some errors of perspective taking, but ASD individuals produced no more than did control participants. Response latencies, too, showed no group differences (see Table 2).

Correspondence between narrative and interaction tasks. Separate analyses of the HFASD and control groups indicated no correlations between mental-state references in the narrative task and either egocentric errors

TABLE 2
Mean (*SD*) proportion of reaching errors and reaction times following neutral or ambiguous instructions on the perspective taking task

	Reaching errors		*Reaction time (s)*	
	Ambiguous	*Neutral*	*Ambiguous*	*Neutral*
ASD ($n = 34$)	0.34 (0.23)	0	3.29 (0.99)	2.68 (0.70)
Control ($n = 34$)	0.43 (0.21)	0	3.12 (0.82)	2.70 (0.60)

(HFASD: $r = .05$; control: $r = .22$) or delays (HFASD: $r = .12$; control: $r = .10$) in the interaction task.

GENERAL DISCUSSION

This study compared adolescents and adults with ASD and typically developing control participants on two tasks. One task required participants to represent and narrate a social interaction scene, the other required them to take the perspective of the other in a structured social interaction. The narration task showed the documented difference in the use of mental-state terms, such that ASD individuals used fewer terms of belief, desire, and emotion when retelling a short story than did control participants. By contrast, ASD individuals and controls were identical in their ability to take another person's knowledge into account when interpreting what she/he said. This demonstrates that ASD individuals can be just as effective as controls in using their ToM when it really matters: When they try to understand others' behaviour. These results, therefore, argue against the suggestion that ASD individuals have a deficient ToM.

The most sceptical interpretation of our findings would point out that they are null results that contrast with the vast literature that suggests ToM impairments in autism (e.g., Baron-Cohen, 1995; Yirmiya et al., 1998). But Rajendran and Mitchell (2007) argued against a dismissal of tests that don't show differences between ASD and neurotypical individuals. Such a dismissal stems from "the assumption that individuals with autism do have an impaired ToM, implying that tests which do not reveal impairments must be insensitive or unsuitable" (p. 229). However, performance on the interaction task is sensitive to a variety of factors. It varies with mood as people perform more egocentrically when they are happy than when they are sad (Converse, Lin, Keysar, & Epley, 2008); it varies with culture as Westerners show more egocentrism than East Asians (Wu & Keysar, 2007) and it varies with levels of friendship, as friends show more egocentrism than strangers (Savitsky, Keysar, Epley, Carter, & Swanson, 2009). So the task captures something psychologically real and systematic, and it demands the very perspective taking processes that are assumed to be lacking in autistic individuals.

Most importantly, one of the most trusted methods used to argue that ASD individuals lack ToM is the false-belief task (Baron-Cohen, Leslie, & Frith, 1985). The present interaction task and the false-belief task employ the same underlying logic. They both dissociate the knowledge of self and that of the other and assess the ability of the self to take the perspective of the other. Therefore, if the false-belief task is supposed to reflect ToM ability, then the interaction task must reflect it as well. Furthermore, our task requires participants to use their ToM to interpret actions in real time, thus requiring spontaneous, non-reflective use of this ability. The interaction task is thus directly related to one of the main functions of ToM to begin with—to interpret the behaviour of others. Therefore, the fact that the task does not display differences between ASD and control individuals must be explained rather than dismissed.

One explanation of the lack of differences in the interaction task is that when individuals with ASD need to process the other person's beliefs and knowledge in a real social interaction, they can do so just as well as typically developing individuals. Therefore, they appear to have an intact ToM when it counts—when they have to interpret the behaviour of real others in a real setting. This may be too strong a conclusion, however, because the interaction task represents only one particular kind of interaction—a structured referential communication—and does not always generalize to other social interactions. Even so, our results are consistent with other findings that have shown that structured social interactions elicit adequate use of ToM skills, as evidenced by similar responses to others' mental or emotional states and similar empathic accuracy in children and adults with ASD and matched controls (Begeer, Rieffe, Meerum Terwogt, Stegge, & Koot, 2007; Begeer et al., 2003; Begeer, Rieffe, Meerum Terwogt, & Stockmann, 2006; Ponnet et al., 2005).

What is it about structured interactions that allows successful social behaviour in ASD individuals? Structured interactions remove two challenges that normally hamper ASD individuals' social behaviour in unstructured, freely unfolding social interactions. First, ASD individuals are easily over aroused, which often results in attempts to regulate their arousal with stereotypic and withdrawal behaviour (Belmonte & Yurgelun-Todd, 2003; Liss, Saulnier, Kinsbourne, & Kinsbourne, 2006; Raymaekers, van der Meere, & Roeyers, 2004). Such behaviours make interactions awkward and difficult to conduct. Second, children with ASD often process information in a piecemeal rather than holistic way, thus failing to integrate information on a global, abstract level. Information that emerges during unstructured social interactions often requires such global processing to understand the meaning of the interaction (Frith, 2003; Happé, 1993). Both over arousal and piecemeal processing may be neutralized in structured social interaction. Such interactions are rule driven and therefore predefine the meaning of most steps in the interaction, so global processing is no longer essential for appropriate responses (see also Gallagher, 2004).

The availability of a well-defined structure also opens the possibility that ASD individuals may not have solved the critical trials in the interaction task by using a ToM. Rather, they might have adopted the general rule never to pay attention to the "objects with a black background" because the director could not refer to them. Whether such a rule requires a prior mental state ascription that the director doesn't *see* them or doesn't *know* about them, is an interesting further question. One finding in our study is consistent with the idea that ASD individuals might have solved the task by way of such a "smart rule". In the ASD group, we found a correlation between reaching errors, age, and IQ. The older and more intelligent the ASD participants were, the more effective they were in the interaction task. Thus, they might have relied more on their experience and general cognitive abilities than on actual inferences about mental states. Similar correlations, in particular between IQ and social competence, have been shown in earlier studies on ASD (Bolte & Poustka, 2003; Buitelaar, van der, Swaab-Barneveld, & van der Gaag, 1999; Kamio, Wolf, & Fein, 2006; Klin et al., 2007; Steele, Joseph, & Tager-Flusberg, 2003; Yirmiya, Sigman, Kasari, & Mundy, 1992). The absence of such correlations among typically developing individuals are often explained by assuming that these individuals rely on a more intuitive, automatic perspective-taking ability that requires less conscious cognitive reflection (Klin et al., 2003). However, the interaction task does not by itself reveal what cognitive processes individuals used to solve the task. Furthermore, using a smart rule is still likely triggered by considering what the other person knows. Moreover, it may often be adaptive to use rules in social interactions and we should be careful not to argue that typically developing individuals wholly refrain from using rules in their ToM behaviour. These issues are important considerations in future research.

In contrast to the structured interaction task, the situation described in the narrative task was unstructured and ambiguous. To the extent that the meaning of this interaction was difficult to comprehend for individuals with ASD, they may have tried to restate verbatim what was said in the story, resulting in fewer mental-state references. However, gist recall beyond the given text does not necessarily include mental-state references, so a difference in memory functions can not fully explain the current findings. Still, it could be that in response to unstructured social interactions, individuals with autism do not recruit mental-state inferences but that in response to structured interactions they do recruit mental-state inferences.

Second, the ability to take another's perspective during actual interactions may be triggered in a different way than the ability to attribute mental states to story characters that one is not engaging with (Slaughter, Peterson, & Mackintosh, 2007; Taumoepeau & Ruffman, 2008). The absence of a direct engagement may hamper the motivation to ascribe mental states to story characters in ASD individuals, who strongly depend on explicit cues (Begeer et al., 2007). The frequency of mental-state referencing in children with ASD was recently even found to be independent from the actual tendency to engage in conversations about mental states in real-life interactions (Muller & Schuler, 2006). Furthermore, a perspective-taking error in social interaction could elicit direct feedback from interaction partners. This may provide a beneficial context for individuals with ASD who have shown improved performances under explicit and goal-directed conditions (Begeer et al., 2006, 2007; Rajendran & Mitchell, 2007).

Two further limitations of our study must be acknowledged. First, the limited availability of information from standardized diagnostic measures could reduce the validity of participants' diagnoses. However, when the analyses were run for only those participants for whom this information was available all the effects of interest remained, even though the number of participants was reduced to 22 ASD and 22 control individuals. Second, age and IQ were correlated in both ASD and control individuals in our sample. While this has no impact on our main question, it did not allow us to disentangle the separate contributions of IQ and experience on ToM performance.

The vast majority of the substantial body of ToM publications (750 papers in the period 1985–2000 alone) used variants of false-belief tasks (Hughes et al., 2000). It is high time that research turned to an analysis of the multiple components and dimensions that constitute ToM skills (Malle, 2008). Our studies take a small step in this direction by examining dimensions such as represented versus experienced social interaction; structured versus ambiguous social tasks; and linguistic production versus comprehension. We found that comprehension in experienced structured interactions may not pose a problem for ASD individuals' ToM performance. Systematic variation of these and other components in future research may reveal the specific kind of ToM deficits that ASD individuals display. A careful examination of age groups between childhood and adulthood is another imperative for future research. To that end, more information is needed on neurotypical adult ToM skills along multiple dimensions and across multiple tasks to provide the baseline for studying these dimensions in adults with ASD. Knowledge at this level of specific components may then suggest specific training approaches to alleviate particular difficulties that ASD individuals encounter.

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APPENDIX

The mental state story

Justine came into the dining room, cupping her hand beneath a spoon that dripped yellow sauce. "Aren't those flowers great? Four dollars for the bouquet, how about that? Did you wind the clock?"

Howard did not look up from the newspaper. "Later," he said.

"Please?"

He looked up. "Watch the spoon. You're going to stain the carpet."

"It chimed seven. This clock is really slow."

"You just dribbled."

She looked down. "I caught it." She showed him her cupped hand. "See? Dinner is going to be great. Now would you wind the clock?"

He took in a deep breath, then exhaled loudly. "All right." He closed the paper. The headline read, "DEATH TOLL RISES".

After she had gone back into the kitchen, he read the lead story again. Then he stood and went to the mantle where the clock sat among ballerina figurines. He opened the clock's crystal. As he fitted the key into the clock, his hand trembled. He hesitated. He took another deep breath, let it out slowly, and dropped the key into his pocket without winding the clock.

Howard looked toward the kitchen, bit his lip, then took the clock down from the mantle. Inside the door was taped a business card from the jeweller who had replaced a broken spring. Howard pulled the card free, then jammed it against the flywheel. The clock stopped ticking. Then he wound it.

He returned to the table just as Justine carried in their salad bowls. "Did you wind it?" she asked.

"Didn't I say I would?"

She put the bowls down and turned back toward the kitchen. "I'm fussing, I know. The house just isn't right without that clock chiming the quarter hours."

Howard folded his newspaper, and after she had again left the room he said, "I agree."

She came back in with their dinner plates. "How was your day? Mine was marvellous. Business was slow all over the store, but I had three big ring-ups. Bianca said it's all about attitude."

He cut his meat.

"So how was your day?"

"My day." He shook his head.

"Not so good? Tomorrow will be better."

"I'm not counting on it."

"Well your job has always given you a great deal of..."

"It's not my job," he said. He nodded at the paper.

She followed his gaze towards the headline. "You can't let that get you down."

"Can't I?"

She twisted her napkin in her hands. "It doesn't have to touch us."

"It's better if it does touch us. It's touching everyone."

If the clock had been running, it would have struck the quarter-hour by now.

He said, "There are times when it is obscene to be cheery. Obscene!"

Justine's face was white. She threw her wadded napkin onto the plate. She knocked her chair over in her hurry to stand and leave.

Howard's hands trembled again as he speared a bite.