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Do Children with Autism have a Theory of Mind? A Non-verbal Test of Autism vs. Specific Language Impairment

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Abstract Children with autism have delays in the development of theory of mind. However, the sub-group of children with autism who have little or no language have gone untested since false belief tests (FB) typically involve language. FB understanding has been reported to be intact in children with specific language impairment (SLI). This raises the possibility that a non-verbal FB test would distinguish children with autism vs. children with SLI. The present study tested two predictions: (1) FB understanding is to some extent independent of language ability; and (2) Children with autism with low language levels show specific impairment in theory of mind. Results confirmed both predictions. Results are discussed in terms of the role of language in the development of mindreading.

Keywords Theory of mind · Non-verbal false belief · Autism · Language impairments

The ability to understand that a person has feelings, thoughts and beliefs that may not match reality is an important aspect of social understanding referred to as possessing a theory of mind (ToM). The ability to attribute such mental states to oneself and others is considered essential in making sense of and predicting other people's behaviour. Much research suggests that at about 4 years of age a fundamental change occurs in children's ToM (Wellman, 1990; Wimmer & Perner, 1983). For example, children's mastery of the semantics of mental state terms emerges at the same age as their mastery of false belief (FB) tasks (Moore, Pure, & Furrow, 1990). Evidence for this change has come from young children's well-documented failure at FB tasks. In the commonly used version of this task, the Sally and Anne task, a child participant watch the experimenter place an object in location A. A doll (or child) who observed this act then leaves the room and the experimenter moves the object to location B. The experimenter then asks the participant where the doll (or other child) will look for the object when they return. The participant is said to pass the task if they indicate that the doll/other child will look for the object in Location A, since this suggests the participant understands that others can have a belief that is different from reality (Wimmer & Perner, 1983). Children with autism have shown to have a consistent deficit on different versions of FB tasks (Baron-Cohen, Leslie, & Frith, 1985; Leslie & Frith, 1988).

A limitation of the traditional FB task is that it cannot be used with nonverbal children. This means that we do not know anything about children with little or no verbal ability such as children with low-functioning autism, young infants or children with severe language impairment.

One question then is whether the classic deficit in ToM in autism extends to the sub-group on the spectrum with little or no language. This question is important because the sub-group on the autistic spectrum with low language ability has been effectively excluded from research studies, due to the FB tasks

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being verbally based. About a third of the autistic population are estimated to be essentially non-verbal (Rutter, 1978). With the broadening definition of the autistic spectrum in recent decades (Wing, Kim, & Volkmar, 2001), and the recognition of many more high-functioning children with autism or Asperger Syndrome, the true percentage of children on the autistic spectrum with low language ability may need to be re-assessed (Baird et al., 2001). But whatever the exact rate of low language ability in autism, it remains the case that since standard ToM assessments rely heavily on language, we know very little about ToM understanding in non-verbal children with autism. There is a need to include this sector of the autistic population in ToM research, to test if the results from such research generalize to the whole autistic population.

A second question is whether the development of a ToM is to some extent independent of language.

Our aim is to provide further evidence relevant to the debate on the relationship between language and ToM during development. For this reason we test two developmental conditions that include language abnormalities: children with autism and children with specific language impairment (SLI). There seem to be two variants of the view that ToM depends on language: (1) Some theorists have made a strong claim, that ToM depends on a minimum level of *syntactic* development (de Villiers & de Villiers, 2000; Tager-Flusberg, 1999), and/or (2) that it depends on *conversational* experience (Harris, 1996; Petersen & Siegel, 1999, 2000). According to the syntactic hypothesis, de Villiers and de Villiers proposed that this specific aspect of syntax provides children with a necessary representational format for understanding false beliefs. In particular, they claim that what is crucial is the syntax of *complementation*, in which a sentence takes a full clause as its object complement. Mastery of the syntax of complementation strongly correlates with children's later performance on ToM tasks (de Villiers & de Villiers, 2000). According to the conversation hypothesis, conversational exposure influences performance on ToM tasks since it makes children aware of different speaker–listener perspectives. Some training studies have shown that 3-year olds involved in rich discourse interactions improve in their understanding of FB tasks (Appleton & Reddy, 1996).

Evidence that is consistent with both the syntactic and conversational hypotheses shows that high correlations are found between the scores from typically developing 3- to 5-year-olds on standard FB tasks and general language ability (Astington & Jenkins, 1999; de Villiers & de Villiers, 2000); that typically developing children also show improved performance on the FB test when the task is verbally simpler (Chandler, Fritz, & Hala, 1989). Particularly relevant to the syntactic theory, children trained with sentential complement sentences and use of mentalistic terms improve in their FB understanding (Clements, Rustin, & McCallum, 2000; Hale & Tager-Flusberg, 2003). Lohmann and Tomasello (2003) went further and separated different components that seem to promote the performance in FB. Their results showed that language experience (syntax of sentential complements, or perspective-shifting discourse) was sufficient to facilitate children's FB understanding, whereas other training (such as experience of deception) did not lead to the same improvement.

Evidence from studies of deaf children adds to the argument for the dependence of ToM on language. Profoundly deaf children who have not been exposed to sign language early in life fail tests of FB (Gale, de Villiers, de Villiers, & Pyers, 1996; Peterson & Siegel, 1999). The average age of passing a non-verbal FB task in these studies was 7.3 years for oral deaf children compared with 4.4 years for the hearing control group. Deaf children born to signing parents, who share a communicative system and thus have much richer mutual linguistic experiences, develop concepts of FB at the same age as hearing children, suggesting that the importance of conversation can be via sign just as much as through audition.

There are thus two important reasons for using a non-verbal ToM test: to see if this deficit in ToM is universal to people on the autistic spectrum, and to test the relationship between ToM and language in typical development. In the research reported here, we take advantage of the recent availability of a non-verbal FB test (Call & Tomasello, 1999) to test both of the questions above. We use a modified version of this test with two key clinical groups: low-functioning children with autism, vs. children without autism but with SLI. Both of the clinical groups have very low language levels.

We chose to contrast autism vs. SLI because children with the latter diagnosis have a mixed picture in terms of success on ToM tests. Initial studies showed that children with SLI have no impairment in FB reasoning (Leslie & Frith, 1988; Perner, Frith, Leslie, & Leekman, 1989; Ziatas, Durkin, & Pratt, 1998). However, more recent studies have suggested a delay in passing FB tasks in children with SLI that is explicable in terms of the children's syntactic development. Thus, children with SLI perform worse on FB tests compared to same-age peers (Cassidy & Balluramen, 1997; Iarocci, Della Cioppa, Randolph, & Wohl, 1997), and Miller (2001) found that children with SLI performed at a similar level to same-age children with normal language development when the linguistic complexity of the FB task was low. Moreover, we know from the literature that a proportion of children with autism pass FB tasks and that FB tasks are passed by children with autism with higher verbal mental ages (VMA) (Happé, 1995). These studies suggest that ToM may be independent of language when the ToM task is not linguistically demanding, but suggest that language facilitates both acquisition and use of a ToM. The experiment reported below allows for a specific test of the ToM hypothesis of autism, as well as the language-independence view of ToM, by using a non-verbal ToM test with both children with autism, and children with SLI, with very low language ability levels.

The FB task used here is an adaptation of that used by Call and Tomasello (1999) with typically developing children, and with chimpanzees. The FB task was presented as a 'hiding and finding game' and requires little verbal instruction or verbal responses. Call and Tomasello's procedure involved a series of initial trials to master the general task requirements (visible displacement, invisible displacement, ignore the communicator's markers) and then three trials of the non-verbal version of FB (changing location task). We follow the same procedure, adding a new control condition, a true belief (TB) condition and a control condition (CC) which will be described in the procedure section.

We expected this *non-verbal* FB test would distinguish children with autism vs. children with SLI, even if both had very low levels of language. In particular, we predicted that children with autism with low language levels would show a specific impairment in the FB condition but not in the control conditions. We also expect that children with SLI would perform significantly better than children with autism on this task, showing that FB understanding is to some extent independent from language ability.

Methods

Participants

We tested 16 children with autism, 18 children with SLI, and 15 normally developing children. Four children with autism and three with SLI were excluded as they did not meet inclusion criteria. The clinical participants were selected on the basis of their language production skills, using British version of the MacArthur Communicative Development Inventories (CDIs; Fenson et al., 1993), which was filled out by a parent. To participate in the study children had to have a language production age of less than two years, and a maximum score in verbal comprehension equivalent to two years of age. This made it possible to test children who had very low levels of language development but who were able to comprehend the few verbal interactions that were necessary to take part. The CDIs measure was used as a cut off for selecting the sample of children for each group. Using language production as the fundamental inclusion criterion meant that it was not possible to match all three groups on non-verbal MA as well, since children SLI by definition do not have evidence of other cognitive delays, whilst in autism cognitive impairments may be present. The final analysis includes 12 children with autism, 15 with SLI impairment and 15 normally developing children were included.

The three groups were comparable in terms of socioeconomic status (assessed in terms of parental occupation) and sex (10 males and 2 females in the autism group; 13 males and 2 females in the group with SLI, and 13 males and 3 females in the group of normally developing children). Table 1 shows the characteristics of the groups tested.

Children with Autism

The participants with autism were diagnosed by qualified clinicians linked to the specialist schools, using DSM-IV criteria, and on the basis of the Childhood Autism Rating Scale (CARS) (Schopler, Reichler, & Rochen Renner, 1986) and the ADI and ADOS (Lord, Rutter, DiLavore, & Risi, 1999). The children with autism were recruited from specialist schools specifically for these conditions, in various parts of England.

Mental age (MA) was assessed using the Leiter Nonverbal Scale (Leiter, 1952), the group of children with autism had a mean non-verbal MA of 4.9 years (sd = 1.75) (see Table 1). In order to assess participants' language abilities, the standardised British version of the MacArthur Communicative Development Inventories (Fenson et al., 1993) was used. To participate in the study children had to have a language production age of less than two years, and a maximum score in verbal comprehension equivalent to two years of age. All children fulfilled the indicated criteria.

Children with SLI

The children with SLI were recruited from specialist schools specifically for these conditions, in various parts of England. A diagnosis of SLI was made by

Table 1 Characteristics of the experimental groups in the experiment

Group	Age (years)	Sex (m:f)	Mental age (years)
Autism (n = 12)	8.1 (sd = 1.9)	10:2	4.9 (sd = 1.75)
SLI (n = 15)	8.3 (sd = 1.8)	13:2	7.4 (sd = 1.61)
Normal (n = 15)	4.6 (sd = 0.9)	13:2	4.9 (sd = 0.84)

speech and language therapists linked to the specialist schools on the basis of (1) the presence of receptive and or expressive language (scores greater than 1.5 standard deviations below that expected for their chronological age) as measured by standardised test of language abilities, together with (2) the absence of hearing loss (pure-tone hearing screening: 25 dB at 500, 1,000, 2,000, 4,000, 6,000 Hz), and (3) no other specific neurolodevelopmental diagnosis, together with (4) a non-verbal IQ within the normal range. Only children who met these criteria attended the special school for SLI children.

Further criteria were used in this study to include only children with very low expressive language. To assess participants' language abilities, the standardised British version of the MacArthur Communicative Development Inventories (Fenson et al., 1993) was used. As before, to participate in the study children had to have a language production age of less than two years, and a maximum score in verbal comprehension equivalent to two years of age. All the 15 children selected fulfilled the indicated criteria.

MA was also assessed using the Leiter Nonverbal Scale (Leiter, 1952), and the group of children with SLI had a mean non-verbal MA of 7.4 years (sd = 1.61).

Typically Developing Children

The typically developing children were recruited from a number of schools in Cambridge and surrounding areas. They were selected on the basis of chronological and MA. MA was also measured with Leiter scale (Leiter, 1952). The group of typically developing children had a mean non-verbal MA of 4.9 years (sd = 0.84). We selected children with no language deficit, using the CDIs (Fenson et al., 1993) filled out by parents or school teachers. None of the children were excluded from the sample.

The SLI group's non-verbal MA was significantly higher than that of the autism group (t = 1,932, df = 12, P < 0.026). With regard to the typically developing group and the autism group, MA matching was possible. Both of these groups had a mean MA of 4.9 years. To control for the lack of matching on non-verbal MA in the SLI group, we covaried for this in the statistical analysis late**.**

Materials and Procedure

Each child took part in the experiment in a quiet room with two experimenters present. The experiment consisted of three different parts: (1) pre-test; (2) screening; and (3) belief tests, as described below. The full session for these tasks last nearly 30 min, and in some cases it was necessary to split the test into two sessions.

The experimental material consisted of two identical non-transparent boxes (4 cm × 4 cm) and a cardboard screen (30 cm × 40 cm) to prevent participants from seeing the boxes during the first part of the experiment. A sweet was hidden in one of the two boxes. One experimenter (the 'hider') sat behind the cardboard screen, facing the child being tested. This experimenter showed the participant the two empty boxes. The child was told they had to find the sweet in one of the two boxes, and that they would be helped by the other experimenter (the 'communicator'). The child was warned by the hider at the start of the test that the communicator was not always right.

The communicator sat between the child and the hider in such a way that they could see where the sweet was being hidden and communicate with the child. The communicator then indicated to the child which container he saw the sweet being hidden in. Where the sweet was placed in each try was quasi-random, care being taken not to put it in the same place for more than two trials in succession. The experiment was divided into three parts: pre-test, screening tests and belief tests.

Pre-test

The first part of the experiment was to demonstrate that the communicator was intending to help the child; and to show what method he would use (pointing). The hider put the sweet in one of the two boxes without the screen being present, so that the entire procedure could be seen by both the communicator and the child. The hider then asked the communicator 'Where is the sweet?', and the communicator indicated the *correct* box, whilst ensuring that the child was watching what was going on. The hider then turned to the child and asked ''Where is the sweet?'. The pre-test stage ended when the child pointed correctly on three successive trials to the baited box. None of the subjects had to be excluded at this stage from the experiment.

Screening Tests

The purpose of these tests were to ensure the child grasped a number of basic prerequisites: (1) The ability to follow the sweet as it was moved from one box to the other, i.e., its *visible displacement*; (2) the ability to follow the sweet when the box containing it was moved from one position to another, i.e., its *invisible displacement*, and (3) the ability to ignore the sign made by the communicator when this was clearly false, i.e. if the child could *ignore the communicator.* To test each of these three conditions, the following methods were used:

(1) *Visible displacement*: Whilst the communicator was absent, the hider opened the box with the sweet and moved this to the other box, within full view of the participant. When the communicator came back, the participant was asked ''Where is the sweet now?'' The child had to indicate the box into which the sweet had been moved. Although the communicator leaving the room was irrelevant in this test, this condition was kept in order to make it comparable to the other tests. (2) *Invisible displacement:* This second test was identical to the one described above, except that while the communicator was absent, not only was the sweet moved but so also was the box containing it. The child had to indicate the box into which the sweet was moved. This test is comparable to Piaget's (1963) object permanence test. (3) *Ignore communicator:* The hider hid the sweet in the view of the communicator, who then left the room before indicating which box contained the sweet. Whilst the communicator was absent, the hider showed the boxes to the child, opened them and moved the sweet from box A to box B. When the communicator came back, the hider asked the communicator where the sweet was. Since he did not know that it had been moved, the communicator in this case pointed to the wrong box. Immediately after this the hider asked the child to find the sweet. The child was deemed to show the ability to ignore the communicator's indication if he/she pointed the other box, to which he or she saw the sweet had been moved.

Each participant was given three attempts at each type of screening test, giving a total of nine trials. Two different types of randomisation were used to decide the order in which the trials were carried out. Participants moved to the next stage only if they were successful in all three trials of each type of test. Four children with autism and three with SLI were excluded because their performance did not meet this criterion. It is interesting to note that the most difficult test for the majority of the participants turned out to be the third condition: ignore communicator. Four children from the autism group and two from the SLI group failed in at least one of the three trials. This procedure resembles that used by Russell and colleague in the Windows Task (Russell, Mauthner, Sharpe, & Tidswell, 1991). One child with SLI failed one trial of the invisible displacement condition. We excluded from the analysis four children with autism and three children with SLI in total.

Belief Tests

As well as the three *false* belief tests, as in the Call and Tomasello's original experiment, we gave the participants three *true* belief tests and three control tests. In all these three conditions the hider hid the sweet in front of the communicator but out of the view of the participant. Therefore, in all these three conditions the child has to rely on the communicator's indication in order to make his/her choice. Two different types of randomisation were used to decide the order of the three groups of tasks.

False Belief. When the communicator left the room, the hider switched the position of the two identical boxes, with the child able to see this. Thus, when the communicator returned to the room and was asked where the sweet was, he would give a wrong indication as if he knew nothing of the switch that had occurred. After this (erroneous) indication from the communicator, the participant was asked to point to the box containing the sweet. The correct answer was to indicate the box not indicated by the communicator.

True Belief. In this condition the switching of the boxes occurred in front of both the participant and the communicator. After the switch, the communicator was first asked to point to the box with the sweet in it, and then the participant was asked as well. In this case the communicator pointed to the correct box. The true condition was a measure to assure that during the FB condition the children did not assume that when a switch happens, the communicator is always wrong. The child had to indicate the correct box.

Control Condition. Here, there was no switch (either while the communicator was away, or when he returned). In this condition the communicator pointed to the correct box. The CC verified that during the FB condition the children did not assume that when the communicator goes away, his indication is always wrong.

Table 2 The number of correct answers out of the total number of answers

Groups	TB	CC	FB
Autism	28/36	31/36	5/36
SLI	28/42	33/42	32/42
Controls	39/48	44/48	27/48*

*All results are significant at the $P < 0.01$ level, except this one where $P = .156$

Results

Results are shown in Table 2. This shows the proportion of the correct answers from the total number of answer given by each group. The participants were asked to choose between two alternatives. In order to test that answer were not given at random, binomial analysis revealed that all three groups were significantly above chance in all conditions, except the normal controls on the CC. A multivariate analysis of covariance (MANCOVA) was used with group as independent variable and non-verbal MA as covariate variable. Since there is a significant difference in non-verbal IQ between the SLI and the autism group, we control for non-verbal IQ using it as a covariate. MANCOVA revealed a significant effect of the group variable (F (6;72) = 4.14, $P = .001$, partial $\eta^2 = .26$). MA was not significant (F (3; 36) = .33, $P = .81$, partial $\eta^2 = .027$), showing that MA was not related to FB performance. The non-significance of MA as a covariate suggests it should be excluded from the model.

We ran then a MANOVA with group as an independent variable. Again the analysis showed a significant effect of the group variable (F (6; 78) = 5.98, $P < .000$, partial $\eta^2 = .31$). Furthermore, univariate analysis showed a significant effect only in the FB performance of the three groups (F (2; 39) = 16.67, $P < .000$, partial $\eta^2 = .44$). No significant effect was shown in the TB (F (2; 39) = 1.67, $P = .2$, partial $\eta^2 = .076$) or in the CC (F (2; 39) = 2.25, $P = .12$, partial $\eta^2 = .09$). The performance of the groups in the three conditions is shown graphically in Fig. 1. Post-hoc analysis (Games-Howell, adjusted for unequal variances) shows that the significant difference between groups in the FB is due to the low performance of the group with autism. The significance levels are shown in the Table 3.

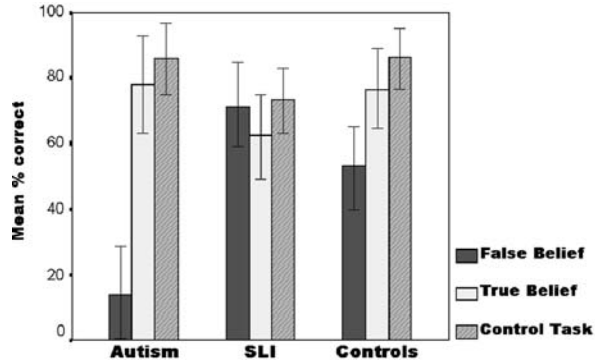

Fig. 1 Proportion of correct answers. Bars represent 95% confidence intervals for the estimated mean

Discussion

This is a preliminary study of the role of language in ToM tasks in low functioning children with autism and typically developing children. It set out to test if children with autism show a deficit on a FB test when the verbal component is reduced to a minimum. It means that the earlier result from mid-functioning children with autism who had a VMA of at least a 4-year-old level can be generalised to children with autism who have an even lower language level. Our results confirm that a ToM impairment is still evident even in low functioning children with autism who are rarely studied.

It could be argued that the task was more difficult for children with autism by requiring an increased reliance on joint attention and non-verbal social cues. However, the two screening conditions that tested the ability to follow the communicator's pointing and ignore the communicator's indications control for these variables. Thus our sample was composed of children with autism who could follow the movements of the sweet and the actions of the experimenters.

We have also confirmed that this non-verbal FB test does not present any difficulty for normally developing children of age four, and for older children with SLI. These results are in line with previous research concerning these two populations. In normally developing children Call and Tomasello (1999) reported a strong correlation between performance on a standard FB test and a non-verbal version. As with Call and Tomasello's study, our findings with normal children question the extent that linguistic demands play on the performance obtained by 4-year-old children.

Table 3 Significance level on the post-hoc tests for each group on each condition

	Autism–Control	Autism–SLI	SLI–Control
False belief	$P = .002$	$P = .001$	$P = .143$
True belief	$P = .989$	$P = .309$	$P = .275$
Control task	$P = 1$	$P = .236$	$P = .184$

Our results from the group of children with SLI are consistent with the majority of studies that show normal abilities in ToM in these children when the linguistic demands of the task are minimised (Cassidy & Balluramen, 1997; Miller, 2001). Children with SLI did not show any difficulty on the non-verbal FB test reported above. However, we cannot exclude the possibility of a delay in their development of ToM. In different studies children with SLI were successful on FB tasks, but the children were aged on average 7–8 years (Leslie & Frith, 1988; Ziatas et al., 1998). Our sample also had a non-verbal MA of 7 years. However, the dissociation between their language competence (very low level) and performance on ToM tasks still allow us to conclude that language and ToM development must be relatively independent.

What about the idea that syntactical aspects of language most influence the development of ToM? In particular, it is claimed that the syntactic ability to build subordinate clauses allows the child to reason about mental states that are discrepant with the state of the world, as, for example, in a FB task. To pass a FB task, a representation has to be embedded in another, or, rather, made subordinate to it (e.g. ''Jane *thinks* the cookies are in the cabinet'' (de Villiers & de Villiers, 1995). This hypothesis is supported by findings which show that sentential complements syntax training improves children's performance in FB tasks (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003). We agree that these findings suggest that syntactic development may *facilitate* ToM understanding. However, this does not imply that syntax competence is *necessary* for ToM competence. To substain a causal relationship between language and ToM there should not be cases of dissociation between these two abilities. However, research from adult patients with aphasia reveals that reasoning about mental states can proceed in the absence of explicit syntactic knowledge. Thus, in one case study, a man with severe agrammatic aphasia retained the ability to solve ToM tasks despite his inability to understand or produce language propositions (Varley, Siegal, & Want, 2001). The children with SLI in the current study also provide evidence for a dissociation between syntax competence and ToM. We acknowledge that language and ToM generally emerge in parallel, supporting each other in their reciprocal development, but the present findings also suggest they can be selectively impaired. This data seems to provide support for the existence of a separate 'module' for ToM, one that is selectively impaired in children with autism, and which functions normally in children with SLI.

To rule out the hypothesis that conversational experience leads to success in ToM task, we can look at the SLI performance. Children with SLI performed the best and their language skills were far below the average. Therefore we can conclude that conversational experience is not essential for ToM development. No conclusion can be draw concerning the role of other aspects of social interaction, since these were not measured in this study.

Future studies should use larger samples in order to test how robust the present results are. In addition, a control group of children with autism but with no language impairment could be included, to verify if the non-verbal ToM test produces similar results across the autism spectrum. Secondly, a sample of younger children with SLI could give us more information about the possibility of a delay of ToM competence. Finally, the task was preceded by several screening tests that made the task quite repetitive. It would be useful in the future to refine the task to make it shorter and more ecologically valid. We also acknowledge that our task, whilst substantially less verbal than the classic FB task in involving no narrative, still involved verbal questions (''Where is the sweet?'') and the challenge for future work in this area would be to produce a completely non-verbal FB task.

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