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Brief Reports

Brief Report: Developmental Change in Theory of Mind Abilities in Children with Autism

Shelly Steele,[1] Robert M. Joseph,[1] and Helen Tager-Flusberg[1,2]

This longitudinal study investigated developmental change in theory of mind among 57 children with autism aged between 4 to 14 years at the start of the study. On an initial visit and one year later, each participant was administered a battery of tests designed to measure a broad developmental range of theory of mind abilities from early (e.g., desire) to more advanced (e.g., moral judgment) mental state understanding. Both group and individual data indicated significant developmental improvement in theory of mind ability, which was primarily related to the children's language abilities.

KEY WORDS: Theory of mind; longitudinal study; autism; language.

INTRODUCTION

In recent years, one of the liveliest areas of research in the field of autism has been on theory of mind (Baron-Cohen, Tager-Flusberg, & Cohen, 1993, 2000). Many studies have found that children with autism show specific deficits in theory of mind, and that they perform significantly less well on theory of mind tasks than matched comparison children (see Baron-Cohen, 2000, for a review). The theory of mind hypothesis of autism is compelling for its ability to explain important aspects of the core social, language, and imaginative impairments that characterize the disorder (Baron-Cohen, 1995; Happé, 1994).

The majority of studies on theory of mind in autism have focused on changes that take place at around age 4 in normally developing children. At this age, children typically develop a representational understanding of mind, as measured by standard false belief tasks (Perner, Leekam, & Wimmer, 1987; Wimmer & Perner, 1983). Current research has stressed a more developmental perspective (e.g., Wellman & Lagattuta, 2000), encompassing developments that take place from infancy (e.g., understanding intentional action) through middle childhood (e.g., interpreting non-literal language). Unfortunately, research on autism has generally not taken this broader perspective on theory of mind, and has shown little concern about whether children with autism show developmental changes in this cognitive domain.

Only two studies have conducted longitudinal investigations of theory of mind abilities in children with autism. The first was a follow-up study by Holroyd and Baron-Cohen (1993), with 17 of the children who participated in Baron-Cohen, Leslie, and Frith's (1985) original study on false belief understanding in children with autism. Seven years later Holroyd and Baron-Cohen found no difference in the number of children with autism who passed false belief. Furthermore, 2 of the 4 original children who had passed now failed, and only 1 participant showed improved performance. In a second study, Ozonoff and McEvoy (1994) examined changes over a 3-year period in a group of 17 adolescents with autism using a larger number of tasks to measure standard false belief understanding as well as more advanced theory of mind abilities. Again, few participants improved in their performance: only 1 on a standard false belief task and 3 on a second-order belief task.

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Thus, longitudinal studies on theory of mind development in children with autism have found no significant changes over time. The evidence, however, is limited because the studies included relatively small samples, and they did not include younger children or a developmentally sensitive range of theory of mind tasks. The purpose of the current study was to re-open the question of whether children with autism do show change over time in theory of mind abilities. We included a comprehensive set of theory of mind tasks designed to span the developmental range from 18 months to early adolescence, and tested each child twice on visits spaced one year apart. In addition, we examined the relationship of developments in theory of mind ability to other salient developmental factors, including IQ and language abilities.

METHOD

Participants

The sample included 57 children aged 4 to 14 at the start of the study, who were part of larger project on language functioning in autism. A diagnosis of autism was confirmed on the initial visit on the basis of the Autism Diagnostic Interview-Revised (Lord, Rutter, and LeCouteur, 1994) and the Autism Diagnostic Observation Schedule (Lord *et al.,* 2000). In addition, an expert clinician examined all participants to confirm that they met DSM-IV criteria for autism. Table I provides descriptive information for the participants at Time 1 and Time 2.

Measures

Cognitive Ability

IQ level was assessed in the first year with the Differential Abilities Scales (DAS) (Elliott, 1990). Children were administered either the Preschool or School-Age version of the DAS depending on their age and ability level. The DAS yielded a full scale IQ (FIQ), and verbal (VIQ) and nonverbal (NVIQ) subscores for all the children tested within age level.

Language

Two standardized measures of vocabulary were obtained from all the participants at Time 1 and Time 2: the Peabody Picture Vocabulary Test, Third Edition (PPVT-III) (Dunn & Dunn, 1997), which measures receptive vocabulary, and the Expressive Vocabulary Test (EVT) (Williams, 1997), which measures expressive vocabulary. Because scores on the PPVT-III and EVT are highly correlated, and the tests were developed with the same normative sample, we combined the scores on these tests to yield a single vocabulary score.

Theory of Mind

Ten theory of mind tasks were administered. The tasks were divided into 3 developmentally sequenced batteries: early, basic, and advanced. The early battery included a desire and a pretend task tapping the emergence of simple mental state concepts. The basic battery included 4 tasks: perception/knowledge, location-change false belief, unexpected-contents false belief, and sticker hiding, all tapping a representational understanding of mind. The advanced battery included 4 tasks that assessed more complex social cognitive concepts: second-order false belief, lies and jokes, traits, and moral judgment. The tasks in all the batteries included both control and test questions. Children received a certain number of points for each task, based on the number of key test questions that were correctly answered. Children could earn a total of 56 points on the theory of mind tasks: 8 points for the early battery,

Table I. Descriptive Characteristics of Participants at Time 1 and Time 2

	Time 1				Time 2		
	N	*M*	*SD*	Range	*M*	*SD*	Range
Chronological age (mos)	57	91.7	28.0	51–170	105.3	28.1	61–185
Theory of mind score	57	12.3	14.5	0–50	16.3	16.0	0–53
PPVT-III raw score	57	64.4	32.6	12–155	81.7	34.8	26–177
EVT raw score	57	49.6	19.2	21–118	60.7	22.8	28–137
FIQ	57	77.2	19.7	42–141			
VIQ[1]	54	75.6	18.0	51–118			
NVIQ[1]	54	85.0	21.5	43–153			

[1] Subscale IQ scores were available only for children who tested within age-level on the DAS.

22 points for the basic battery, and 26 points for the advanced battery. Children's performance on each task (except for sticker hiding) was also scored categorically as pass/fail, using standard criteria employed in other studies. See the Appendix for a description of each task, the maximum number of points possible, and the passing criterion for each.

Procedures

Participants were tested at the Eunice Kennedy Shriver Center in Waltham, Massachusetts. Each year's visits were typically conducted on two or three different days, and children were given breaks as needed. In the first year, children always completed the IQ and language testing before the theory of mind tasks were administered. There were 4 versions of the stories and stimuli used for each theory of mind task. Children were randomly assigned to one of the versions at Time 1, and were then given a different version at Time 2. This counterbalancing procedure minimized repeated measures effects.

At Time 1, all participants were administered the tasks from the early battery. Participants who scored at least 2 points on the desire task were also administered the basic battery; participants who were able to pass at least 1 false belief test question were administered the advanced battery. Children were always administered all the tasks in each battery. At the second testing period, children who had passed both tasks in the early battery at Time 1 began with the basic battery, and were given credit (8 points) for the early battery.

RESULTS

Children's scores on the theory of mind and language measures at Time 1 and Time 2 are presented in Table 1. Paired-sample t-tests showed significant increases from Time 1 to Time 2 in theory of mind scores ($t(56) = 5.17$, $p < .001$), in PPVT-III raw scores ($t(56) = 10.16$, $p < .001$), and in EVT raw scores ($t(56) = 8.22$, $p < .001$)[1]. Looking at individual data, shown in Figure 1, we found that the theory of mind score decreased for 21% of the sample, stayed the same

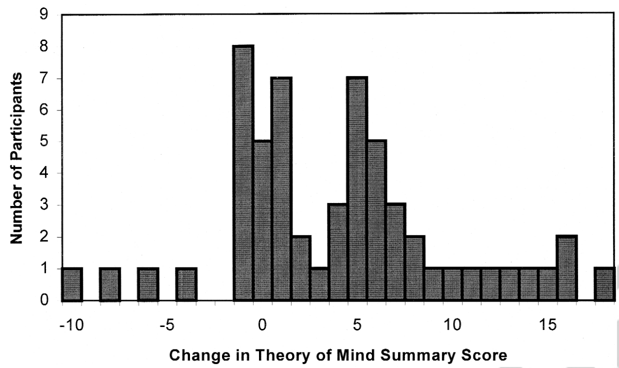

Fig. 1. Difference from Time 1 to Time 2 in the theory of mind summary score.

for 9%, and increased for 70%. Figure 2 illustrates the distribution of changes in theory of mind score for children at each age. At every age children's scores on the battery increased, and there was no discernible age-related difference in the amount of developmental change in theory of mind abilities for this group of children.

We also computed the number of children passing each task at Time 1 and Time 2. These data are presented in Table II. They illustrate that there were more children whose performance improved on the tasks in the early and basic batteries than on the tasks in the advanced battery.

Table III shows the correlations between theory of mind scores at Time 1 and Time 2 and the child's age, IQ and language scores at Time 1. In order to investigate which variables at Time 1 predicted the child's theory of mind score at Time 2, a hierarchical regression analysis was conducted with Time 2 theory of mind score as the dependent variable. On the first step, Time 1 theory of mind was entered as the control variable, which accounted for 84% of the variance, $F(1, 52) = 276.74$, $p < .0001$. On the second step, age, VIQ, NVIQ, and vocabulary score were entered stepwise into the model. Vocabulary explained an additional 3% variance, $F(1, 51) = 10.81$, $p < .002$. None of the other variables were significant.

DISCUSSION

The main finding from this longitudinal study was that children with autism do show significant developmental change in theory of mind abilities over the course of one year. Over half the children gained several points, suggesting that they had acquired some mental state concepts during this period. These results

[1] The sticker hiding task was somewhat different from the other tasks in that there were no changes from one year to the next in the stimuli used, and it had the possibility of improvement over trials because of the feedback obtained. We therefore repeated the analyses examining changes in theory of mind from Time 1 to Time 2 omitting this task. The paired-sample t-test was still highly significant: $t(56) = 5.72$, $p < .0001$.

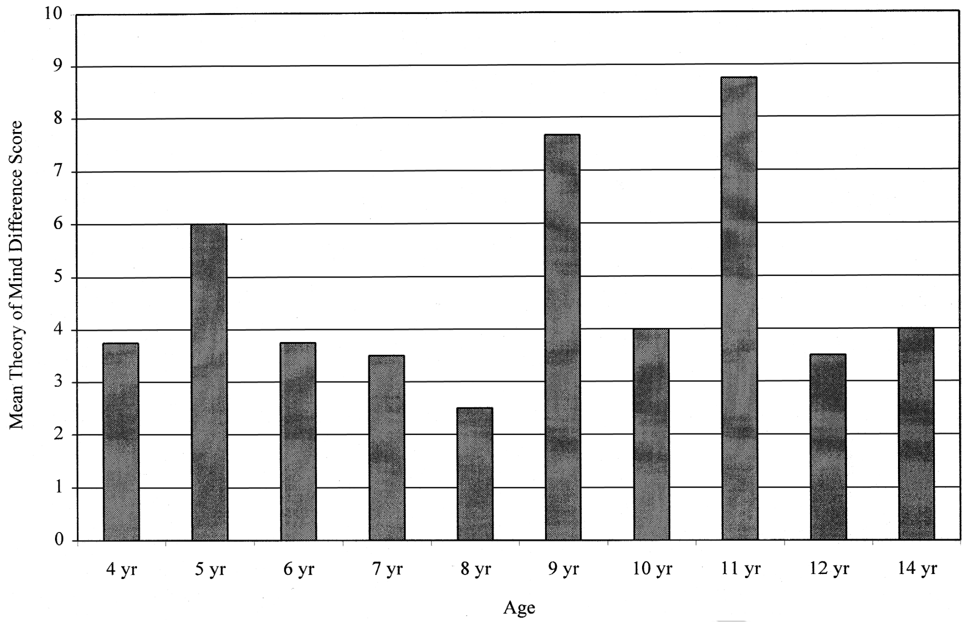

Fig. 2. Change of Theory of Mind summary score by age group.

Table II. Number of Children Passing Each Theory of Mind Task at Time 1 and Time 2

	Pass Year 1		Pass Year 2	
	N	%	*N*	%
Early battery				
Pretend	28	49	36	63
Desire	22	39	24	42
Basic battery				
Perception/knowledge	15	26	19	33
Unexpected-contents false belief	11	19	18	32
Location-change false belief	14	25	15	26
Advanced battery				
Second-order false belief	7	12	8	14
Lies and jokes	3	5	2	4
Moral judgment	2	4	3	5
Traits	4	7	9	16

Table III. Pearson Correlations for Theory of Mind Scores and Measures at Time 1 ($N = 57$)

	ToM Yr2	Age	FIQ	VIQ	NVIQ	Vocab
ToM Yr1	.926*	.534*	.584*	.634*	.385*	.854*
ToM Yr2		.493*	.639*	.683*	.434*	.868*
Age			−.045	.029	−.080	.557*
FIQ				.792*	.924*	.616*
VIQ					.531*	.685*
NVIQ						.429*

*$p < .01$, 2-tailed.

present a different picture from the one portrayed in earlier studies. Neither Holroyd and Baron-Cohen (1993), nor Ozonoff and McEvoy (1994), who both investigated changes in theory of mind abilities over the course of several years, reported significant improvement in their participants with autism.

There are two possible explanations for why our findings differed from these earlier studies. First, we included a younger sample of children; the majority of our participants were below the age of 9 at the start of the study. In contrast, the participants in the earlier studies were older, and all were adolescents at the time of the second testing period. It could be that only younger, pre-adolescent children with autism show developmental changes in theory of mind. The data presented in Figure 2 do not suggest that there is a significant effect of age on the rate of developmental change in theory of mind abilities. The children over age 10 showed similar increases in theory of mind scores over the course of a year as did the children under age 10, and there is no evidence for a plateau in development in early adolescence. The alternative explanation for our findings is the use of a larger number of theory of mind tasks, selected to tap a broader developmental range in theory of mind abilities. Our theory of mind battery allowed us to score children's performance not only as pass/fail, but also with a cumulative point score that had a wide range, with a lower floor and higher ceiling than is typical in research in this area. Thus, we used a more sensitive measure of theory of mind that was able to detect developmental change in our sample. The analysis of performance on each of the tasks, as shown in Table II, indicates that there was more developmental change in the early and basic batteries, with few children able to pass any of the advanced tasks.

In our exploration of factors predicting increases in theory of mind scores, we found that vocabulary level predicted gains in theory of mind. This finding supports earlier cross-sectional studies on the relationship between language ability and theory of mind in children with autism. Several studies have found that measures of vocabulary or grammar are closely related to theory of mind performance in children with autism (e.g., Dahlgren & Trillingsgaard, 1996; Happé, 1995; Sparrevohn & Howie, 1995; Tager-Flusberg, 2000; Tager-Flusberg & Sullivan, 1994). Similar findings have also been reported for normally developing children, especially in recent longitudinal studies (Astington & Jenkins, 1999; de Villiers, 2000), suggesting that language plays a causal role in the development of theory of mind abilities in both normally developing children and children with autism.

This study highlights the importance of taking a developmental perspective on theory of mind in autism (Tager-Flusberg, 2001). Our findings present a challenge to the current pessimistic view portrayed in the literature, that children with autism show no significant improvements over time in theory of mind. Instead, we have found that the majority of children make gains in this domain, which has important implications for considering related social and communicative skills in these children. The findings also provide support for the role of training studies with autistic children that target not only theory of mind abilities but also language. Finally, this study underscores the value of providing social-communicative interventions for children with autism in the expectation that they may show developmental progress that has consequences for their ability to function more effectively in their everyday environments.

APPENDIX

Theory of Mind Tasks

Early Battery

Pretend: Based on Kavanaugh, Eizenman, & Harris (1997), this task tested the ability to use a doll as an independent agent in a pretend scenario. The task included 4 vignettes involving a mother and baby. Participants were asked to complete each vignette by using the mother doll to act out the next logical event (e.g., feeding the hungry baby) in a scenario initiated by the experimenter. Score = 0–4; Passing criterion = at least 3.

Desire: Based on Wellman and Wooley (1990), this task tested the ability to predict action based on an agent's stated desire. Two stories were narrated using props. In each story the main character is looking for an object, which could be in one of two named locations. The character fails to find the desired object in the first location. The test questions ask whether the character will continue to search, and why. Score = 0–4; Passing criterion = at least 3.

Basic Battery

Perception/Knowledge: Based on Pillow (1989) and Pratt and Bryant (1990), this task tested the ability to infer knowledge from perceptual access. On each trial, participants observed one doll who looked in a box and another doll who simply touched the box, and were then asked a knowledge question (*Does X know what's in the box?*). Score = 0–2; Passing criterion = 2.

Location-Change False Belief: Based on Wimmer and Perner (1983) and Baron-Cohen *et al.* (1985), this task included 2 stories in which an object is moved while the main character is absent. The stories were told using props, and participants were asked a knowledge (*Does X know where Y is?*), prediction (*Where will X look first for Y?*), and justification question (*Why?*). Score = 0–6; Passing criterion = at least 4.

Unexpected-Contents False Belief: Based on Perner *et al.* (1987), participants were shown a 4 different familiar containers that had unexpected objects inside. Test questions included representational change (*When you first saw this container, what did you say/think was inside?*) and false belief (*What will X say/think is inside?*). Score = 0–8; Passing criterion = at least 6.

Sticker Hiding: Based on the penny-hiding game (Devries, 1970), this task required the participant to hide a sticker in one hand. The experimenter guessed the location of the sticker; wrong answers resulted in the participant keeping the sticker. After training on the task, 10 test trials ensued. The ability to hide the sticker from the experimenter on the last 5 trials and to engage in deceptive strategies were scored. Score = 0–6.

Advanced Battery

Second-Order False Belief: Based on Sullivan, Zaitchik and Tager-Flusberg (1994), two picture stories were told. In each story, a child character is to receive a surprise gift from a parent. Unbeknownst to the parent, the child inadvertently finds the object. Second-order ignorance, belief and justification questions tapped participants' ability to conceptualize what the parent character thinks/knows about what the child character thinks/knows. Score = 0–6; Passing criterion = at least 4.

Lies and Jokes: Based on Sullivan, Winner, and Hopfield (1995), this task tested participants' ability to distinguish between lies and ironic jokes (or sarcasm). In each of 4 picture stories, a child utters a literal falsehood (e.g., *"I did a good job eating my peas"*) that an adult character knows to be false. To distinguish a joke from a lie, participants had to take into account whether the child character knows that the adult character knows the truth. Test questions included judging the false statement as a joke or lie and justifying the answer. Score = 0–6; Passing criterion = at least 4.

Traits: This task, based on Yuill (1992) tested participants' ability to judge intent on the basis of personality traits. Participants were told 8 picture stories in which one of two characters is described in terms of a personality trait (e.g., *kind, mean, shy*). Each story ends with a negative outcome (e.g., an art project is knocked to the floor) of ambiguous intent. Test questions tapped participants' ability to use the trait information to judge whether the outcome was intended or by accident. Score = 0–8; Passing criterion = at least 6.

Moral judgment: Based on Mant and Perner (1988), participants were told 4 picture stories in which two classmates make plans to meet, for example, to go to the movies. In each story, the main character fails to come to the planned meeting as a result of canceling the plans without telling the other character or, alternately, as a result of an uncontrollable event (e.g., the bus breaks down). At the end of each story, participants were asked to make a moral judgment, and justify their answer (*Was it good, bad, or in between?*) about the main character's behavior. Score = 0–6; Passing criterion = at least 6.

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Page 1

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Experimental Results

We found very insignificant variations in in the proportions of segmented neutrophils, lymphocytes, and monocytes. We were unable to find any definite relationships in view of the small variations. In some cases an increase in the proportion of mono cytes was found after a course of intra-arterial procaine infusions. for instance, whereas before treatment a Monocyte count of between 1 and 65 percent was observed in 62 patients after treatment this range of monocyte counts was observed in 40 patients similarly, monocyte counts of between 7 and 12(6) were found before treatment in 87 patients and afterreatment in 100 patients.

As an additional measure, in order to obain a deeper understanding of the nature of the processes taking place in the patient after intra-arterial infusion of procaine, G. N. UDINTSEV and V. B. Blank [1957] undertook an investigation with the object of studying possible changes in the morphological composition of the blood in patients with peptic ulceration.

This investigation was in direct relationship to our own, and helps in the solution of problems6 concerning the reflex regulation of the blood system in general, and during intra-arterial $C_{13}H21ON_3$ infusion in particular. ¶Changes in the leucocyte count of the peripheral blood and in the monocyte formula were studied. A study of the morphological changes in the immediately after infusion and for some time threofater was also thought to be of interest.

The patients investigated were divided into two groups The patients of the first group were investigated as follows 1) before infusion, 5) on the 3rd day after the second infusion, and 6) 5 days after the last intraarterial procaine infusion.

In order to study the course of these changes to repeated intra-arterial procaine infusions and the reaction of the body for a longer period of time, the *second* group of patients was investigated (1) before infusion, (2) 10 minutes after infusion, 3 1 hour after infusion, and (4) the day after infusion. The same investigations were also repeated on the 3rd and 5th day and terminated in a final investigation 5 days after the last infusion, i.e., on the 12th to 13th day after the patients first infusions. Seventy peptic ulcer patients—forty males and thirty females were examined.

MARK USED IN MARGIN	EXPLANATION
bold	Set boldface
℘	Delete
℘̂	Delete and close up
⁀#⁀	Close up to normal space
⁀	Close up
cap	Capitalize
lc	Set lower case
^,^	Insert comma
^;^	Insert semicolon
sp	Spell out
#	Insert space
tr	Transpose letters [or words]
f	Substitute letter written in margin for letter[s] struck out in text
lc	Set lower case after initial capital
]	Move right
[	Move left
no ¶	Run into same paragraph
⋎6	Make superscript
⋏21	Make subscript
¶	Start new paragraph
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blood	Insert word[s] written in margin [only for brief additions]
thereafter	Correct word as shown [rewrite badly mangled words]
⊙	Insert period
⊙	Insert colon
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=/	Retain hyphen
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