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Examining correlates of cooperation in autism

Imitation, joint attention, and understanding intentions

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ABSTRACT The goal of the current study was to examine the contribution of three early social skills that may provide a foundation for cooperative performance in autism: (1) imitation, (2) joint attention, and (3) understanding of other people's intentions regarding actions on objects. Fourteen children with autistic disorder (AD) and 15 children with other developmental disabilities (DDs) matched on nonverbal developmental age (AD, mean 27.7, SD 9.8; DD, mean 33.4, SD 11.1) and verbal developmental age (AD, mean 21.5, SD 12.3; DD, mean 28.4, SD 11.0) participated in the study. Children with autism showed poorer performance on imitation and joint attention measures, but not on the intentionality task. Multiple regression analyses showed that imitation skills and joint attention contributed independently to cooperation, above and beyond the understanding of intentions of actions on objects.

KEYWORDS
autism; cooperation; social development

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Cooperative activities are central to human social life. Within a cooperative activity, the cooperating partners are responsive to each other, they have a shared goal, and they mutually support each other in their roles in order to achieve that shared goal (Bratman, 1992). According to the evolutionary

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account proposed by Tomasello et al. (2005), the ability to engage in cooperative activities with shared intentions may be unique to humans. These authors proposed that the ability to cooperate develops out of the intertwining of two complementary processes during the first 2 years of life: development of the capacity to *understand* other persons' intentions, and development of the capacity to *share intentions* and *experiences* with others. Tomasello et al. (2005) hypothesized that impairment in cooperation skills in children with autism was due to their inability to *share* intentions and experiences with others, despite their ability to *understand* intentions. On the other hand, Sally and Hill (2006) proposed that the cooperative deficit in autism is the result of deficits in understanding mental states including intentions. The aim of this article is to examine these two alternative explanations of the cooperation deficit in children with autism.

Imitation plays a fundamental role in the development of coordinated acts. Imitation provides the child with mutual connectedness and shared social experiences (Meltzoff, 2005; Trevarthen et al., 1999). Eckerman (e.g. Eckerman and Whitehead, 1999), on the basis of a series of experiments, described a developmental trajectory in which communication via non-verbal imitation leads to the acquisition of cooperative coordinated actions in toddlers. Eckerman and Peterman (2001) suggest that toddlers form thematically related responses to a partner's action through intentional imitative acts which constitute a shared experience. Interestingly, in a longitudinal study of toddlers seen at 14 and 22 months, Forman and Kochanska (2001) reported both concurrent and predictive consistency between frequency of imitation of the mother and cooperation with her requests.

A second socio-cognitive skill associated with cooperative behavior demonstrated in several studies is the knowledge of the partner's mental states. However, the knowledge about others' mental states is not sufficient to engage in cooperative activities. Cooperation requires that the partners *share* intentions to reach a common goal (Tomasello et al., 2005). Such sharing is first manifested by infants as young as 9 months when they engage in joint attention, a triadic interaction involving the coordinated visual attention between two people on an object or event (Bono et al., 2004). Joint attention allows for two or more individuals to exchange information regarding goals in non-verbal cooperative activities without relying on verbal communication (Brinck and Gärdenfors, 2003). In human infants and children, gaze and point following are instances of shared intentionality (Brooks and Meltzoff, 2005; Tomasello and Carpenter, 2007). Behne et al. (2005) showed that 14-month-old infants, in the context of a hiding–finding game, follow and rely on adults' pointing to retrieve a hidden object, only when the adult is looking at them as opposed to when the adult is looking at his/her own hand. The authors interpret this finding as evidence of intersubjective sharing. In a recent article, Brownell et al. (2006) showed that 2-year-olds' ability to respond to bids for joint attention from an adult was positively associated with their ability to cooperate. To summarize, both imitation and joint attention represent aspects of social coordination related to the ability to cooperate in typical development.

Autism is a neurobiological disorder that is diagnosed by three areas of behavior: (1) impairments in social behavior, (2) deficits in communication and language, and (3) restricted and repetitive behaviors and/or interests (American Psychiatric Association, 1994). While social functioning is severely affected, not all aspects of social development are equally impaired in autism. For instance, attachment does not appear to be impaired in autism (e.g. Capps et al., 1994). Furthermore, despite impairments in reading others' mental states (e.g. Baron-Cohen, 2001), at least two different groups have shown that children with autism appear to understand other people's intentions regarding actions on objects as examined through Meltzoff's Behavioral Re-enactment Procedure (Aldridge et al., 2000; Carpenter et al., 2001). These findings suggest that children with autism are not completely blind to others' minds, but can 'read' the meaning of others' overt behaviors regarding intended acts on objects. Children with autism in group studies also appear to have some knowledge of what others see (Leekam et al., 1997) or, in some cases, of what others know (Baron-Cohen, 1995) regarding objects. Thus, children with autism seem to understand something about other people's knowledge concerning objects in terms of individual intentionality, such as their individual perceptions and intentions.

On the other hand, there are striking social impairments that are widely described in the autism literature and that might limit cooperative abilities in autism. One well-demonstrated deficit involves the imitation of others (e.g. Rogers and Pennington, 1991; Williams et al., 2004). Because of the presumed fundamental role of imitation in the development of more mature socio-emotional skills (e.g. Meltzoff, 1990; Rogers and Pennington, 1991), imitative skills are now studied intensively with the aim to understand their role in autism (see Williams et al., 2004). A second well-documented area of impairment is impairment in joint attention (e.g. Bono et al., 2004; Mundy and Vaughan, 2002). Children with autism show reduced frequency of initiating bids for joint attention with others (Charman et al., 1997) and responding to others' bids for joint attention (e.g. Leekam et al., 1997).

Only a few studies have investigated the ability to cooperate in children with autism. Downs (2003) surprisingly found that 5- to 9-year-old high-functioning children with autism cooperated similarly to a group of typically developing children in a Prisoner's Dilemma task. The author argues that the children had received intensive behavioral treatment, which might have improved their cooperative skills. Recently, Sally and Hill (2006) identified only mild impairments in the cooperation skills of 6- to 15-year-old children with autism as measured through several versions of the Prisoner's Dilemma game. The authors related the tendency to cooperate to the ability to understand mental states in both typically developing children and children with autism. Finally, in a recent study (Liebal et al., 2008) we investigated cooperative abilities in 3- to 5-year-old children with autism compared to children with developmental delay of mixed etiology. Children were invited to cooperate with an adult partner in novel tasks that could be performed successfully without verbal communication, e.g. the child and the adult pulled simultaneously at each end of a long tube in order to open it and retrieve a toy inside the tube. Results showed that the children with autism performed less successfully compared to the children with developmental delay in these tasks.

The goal of this study was to examine candidate correlates of cooperative abilities in young children with autism. Based on the literature, three main variables were evaluated: imitation, joint attention, and understanding of others' intentions. We expected children with autism to be impaired in imitation and joint attention, but not in the understanding of others' intentions of actions on objects. Based on Rogers and Pennington's (1991) neurodevelopmental model of autism, on Tomasello et al.'s (2005) evolutionary theory of cooperation, and Eckerman's (e.g. Eckerman and Whitehead, 1999) developmental trajectory of cooperative coordinated actions, we expected imitation and joint attention to be significant correlates of cooperative abilities.

Method

Procedure

This study was conducted with the approval of the Human Subjects Committee of the University of California, Davis. Consent forms were reviewed with each family involved in the study and all questions were answered before consent was obtained and before measures were gathered. This study was not part of a larger study. All measures administered and conforming to variability requirements are reported here.

Participants

Twenty-nine participants were included in this study and comprised two groups: autistic disorder ($n = 14$) and developmental delay of mixed etiology (DD: $n = 15$). All participants were between the chronological ages of 30 and 60 months. All participants were recruited from the subject pool of the MIND Institute Research Participant Recruitment Core. Table 1

Table 1 **Characteristic of autism and developmental delay (DD) groups**

	Autism (n = 14)		*DD (n = 15)*		*p*
	Mean (SD)	*Range*	*Mean (SD)*	*Range*	
CA (months)	42.1 (8.1)	30–57	43.0 (10.0)	28–60	0.8
NVMA (months)	27.7 (9.8)	16–53	33.4 (11.1)	16–54	0.15
VMA (months)	21.5 (12.3)	7.5–36.5	28.4 (11.0)	8.5–43	0.12
Family income ($)	25,000–50,000	25,000–125,000	25,000–50,000	<25,000–125,000+	0.85
Gender	13 male, 1 female		13 male, 2 female		
Ethnicity	11 Caucasian, 2 Hispanic, 1 African-American		10 Caucasian, 3 Hispanic, 2 Asian		
ADOS–G	14 met criteria		0 met criteria		

Groups showed no statistically significant differences on chronological age (CA), non-verbal mental age (NVMA), and verbal mental age (VMA).

presents descriptive and matching information. There were no significant differences between the children with autism and those with mixed DD on chronological age, non-verbal mental age and verbal mental age. Developmental level in both groups was evaluated through the Mullen Scales of Early Learning (MSEL: Mullen, 1995). The MSEL is a standardized developmental test for children aged 3 months to 64 months. The test consists of four subscales used in establishing verbal and non-verbal abilities: fine motor, visual reception, expressive language, and receptive language. The MSEL was administered to all participants according to standard instructions, and all testers were trained and supervised by licensed psychologists trained in assessing young children with autism and other developmental disorders. Given that most of the children in the autism group and the DD group had scores too low to allow for standard score calculations, we used mental age equivalent scores instead. Mental age scores for verbal (receptive and expressive) and for non-verbal (fine motor and visual reception) as well as for overall intellectual functioning were used as matching criteria.

The children with autism were free from any other medical condition, had no visual or hearing impairment, had non-verbal developmental level of 16 months or higher, spoke English as their first language, had been diagnosed with autism by an outside agency, received current clinical diagnoses of autism by expert researchers in the lab, and met criteria for autism on two diagnostic systems: DSM-IV and the Autism Diagnostic Observation Scale–Generic (ADOS–G, module 1: Lord et al., 1999). The examiners who administered the ADOS–G were trained to reliability of 85 percent or better item agreement over three consecutive administrations with a psychologist who had been previously trained to reliability at the University of Michigan's training workshops. Reliability was maintained at 85 percent by double-scoring 20 percent of protocols across the period of data collection. The children with autism as a group were receiving 5–40 hours per week of behavioral therapy, 1–2 hours per week of speech therapy, and 1–2 hours per week of occupational therapy.

The DD group comprised four participants with speech and language delay, one participant with Down syndrome, one participant with other genetic abnormalities, and nine participants with developmental delays of unknown etiology. The children with DD all had normal vision and hearing, were mobile, had non-verbal developmental level of 16 months or higher, and spoke English as their first language. None were considered by clinicians in the past to have autism, and none currently met DSM-IV or ADOS–G criteria for autism. The children with DD were receiving 1–2 hours of speech therapy and 1–3 hours of occupational therapy or physical therapy, as well as special education services.

Four additional participants (two from the autism group, two from the DD group) had to be excluded from the study due to distress and lack of attention to the tasks (two participants), unavailability for further developmental assessment (one participant), and videotaping problems (one participant).

Experimental measures

Imitation Battery This Imitation Battery was developed by one of the authors (SJR) and comprised two different sets of tasks: (1) four *manual acts* (none involving objects; e.g. pat chest with one hand) and (2) four *actions on objects*. This battery was administered by following procedures described in Rogers et al. (2003). Scoring criteria were based on a pass or fail system for each item administered, with 0 reflecting no action at all or an action that appeared unrelated to the target action, and 1 reflecting an action related to the target action modeled by the examiner. Therefore, scores ranging from 0 to 4 were obtained for each portion of the battery (i.e. (1) manual acts and (2) actions on objects). Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 25 percent of the tapes. Intra-class correlation was 0.84, indicating an excellent level of agreement.

Spontaneous imitation In addition to the previous imitation tasks, we also examined spontaneous imitation in the following way. The experimenter began a tape recorder while sitting opposite the child. As the music started, the experimenter alternated three 20 second episodes in which she sat still and three 20 second episodes in which she swayed from one side to the other to the music, clapping her hands and smiling in time to the music. Children were never told to imitate the adult, or praised or encouraged to imitate the adult. For two of the three 'move' episodes and two of the three 'still' episodes, the experimenter and the child had access to a maraca. During the 'move' episodes the experimenter swayed her body and a maraca from one side to the other, gently shaking the maraca on each side, while during the 'still' episodes she put the maraca on the table. Four types of imitative movements in response to the experimenter included: (1) bodily movements from side to side, (2) movements with the maraca, (3) stopping the movements in coordination with the examiner, and (4) starting the movements in coordination with the examiner. The task was coded on a 5-point Likert scale, with 0 reflecting no imitative movements at all and higher scores reflecting increased number of movement types (0 = no movements at all; 1 = one type of imitative movement previously described; 2 = two types of imitative movements; 3 = three types of imitative movements; 4 = four types of imitative movements). Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 25 percent of the tapes. Intra-class correlation was 0.94, indicating an excellent level of agreement.

Response to joint attention Response to joint attention was measured through a task from the Early Social Communication Scales (ESCS: Mundy et al., 1996). The ESCS is a semi-structured play interaction that provides opportunities for skills such as joint attention, turn-taking, and requesting. For the purpose of this study, we only administered the 'response to joint attention' task of the scale. In order to elicit a response to joint attention, the experimenter, after getting the child's attention, called out the child's name and looked and pointed to posters on the wall located to the left, right, and behind the subject, a total of six times (two times for each direction). Response to joint attention was coded as the number of times in which the child followed the experimenter's point by turning his/her head and eyes in the specified direction, with possible scores from 0 to 6. Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 25 percent of the tapes. Intra-class correlation was 0.97, indicating an excellent level of agreement.

Intentionality tasks (Meltzoff, 1995) Eight objects similar to those used in Meltzoff's (1995) original study were used. For each of the eight objects, children first participated in a 20 second *baseline control condition*, in which they played with the object. If children produced or attempted to produce the target action during the baseline period, an alternative action was used for the following demonstration and response period. After the baseline period, the experimenter demonstrated an action on a given object in one of two different ways: *imitation* and *failed intention*. In both imitation and failed intention conditions, the experimenter demonstrated an action three times. In the imitation condition, the experimenter modeled the entire target action three times. In the failed intention condition, the experimenter tried to do the target action three times, but was unsuccessful each time. This task was administered by following Meltzoff's (1995) procedure. Scoring involved production of target actions in the three conditions: baseline, imitation, and failed intention. Credit for the production of a target action was given if the child produced the target action modeled by the experimenter for the imitation condition, and if the child produced the target that the experimenter tried to complete but failed for the failed intention condition. Because a novel act was always modeled, the baseline was always zero. Scores in the two other conditions could range from 0 to 4 (one point was assigned for each of the four trials performed correctly in each condition). Inter-rater reliability was established prior to scoring and was maintained throughout the study by having two coders independently rate 25 percent of the tapes. Intra-class correlation was 0.94, indicating an excellent level of agreement.

Cooperation tasks Four types of non-verbal cooperative tasks were administrated (from Warneken et al., 2006). Two of these tasks were played with the child in two different roles. Therefore, a total of six tasks were administered. The general procedure for all tasks was as follows. After a short familiarization, the demonstration phase began during which two female experimenters (E1 and E2) demonstrated the task once, for example, by showing how they could make the cube bounce on the trampoline together. Afterwards, E2 withdrew, and E1 initiated the task by starting to perform her role on the apparatus and encouraging the child to join by saying 'your turn'. Successful task performance required both partners to perform their roles synchronously. No language was used to instruct or direct. These tasks were performed with the following toys.

- *Elevator task*. The goal of this task was to retrieve an object that is inside a vertically movable cylinder. Before one person could access the object through the opening of the cylinder from one side of the apparatus (role A), the other person had to position herself on the other side and push the cylinder up from underneath and hold it in place (role B). It was impossible for a single person to perform both actions simultaneously, as a transparent screen prevented reaching to the opening while pushing the cylinder up.
- *Tube-with-handles task*. The goal of this task was to retrieve a toy that is enclosed in a tube. The tube, which was 110 cm long and 10 cm in diameter with one handle on either side, could only be opened by two

persons simultaneously pulling at both ends. The length of the tube made it impossible for children to grasp both handles at the same time.

- *Double-tube task*. Two tubes 75 cm long were mounted on a box in parallel, and on a 20° incline. The game was played by one person sending a wooden block (or another toy) down one of the tubes from the upper side (role A) and the other person catching it at the other end with a tin can (role B).
- *Trampoline task*. Two C-shaped hoses 3 cm thick were connected with flexible joints to form a ring of 67 cm diameter, which was covered with cloth. Two persons could make a wooden block jump on the trampoline by holding the rim on opposite sides. Owing to the joints that were integrated in the ring, the trampoline collapsed when being held on only one side.

The tasks were videotaped and coded from tape by two coders blind to diagnosis. Following Warneken et al.'s (2006) procedure, each trial received one score of a rating scale designed to assess the child's skills to coordinate her actions with the partner during the cooperation tasks. Scores for the double-tube and the elevator tasks ranged from 0 to 2, and scores for the tube-with-handles and trampoline tasks ranged from 0 to 3. Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 25 percent of the tapes. Cohen's kappa was computed to measure inter-rater reliability. Values for Cohen's kappa ranged from 0.72 to 1 (tube-with-handles task, $\kappa = 0.77$; elevator task (roles A and B), $\kappa = 0.72$; trampoline task, $\kappa = 1$; double-tube task, $\kappa = 0.92$). Cohen's kappa was 0.87, indicating an excellent level of agreement.

Results

Preliminary analyses

The data were first reviewed for skew, kurtosis, and outliers. One cooperation task (elevator task A and B) was excluded from the analysis because of ceiling effects (means and SDs are reported in Table 2). There were no problems with floor effects. Given the small size of the sample and lack of perfectly normal distributions, group differences were analyzed through both parametric and non-parametric tests, obtaining similar results. Descriptive analyses showed that the inclusion of females in the sample did not change the direction of the associations among variables. Therefore, male and female participants were analyzed together.

Table 2 **Means and standard deviation for each measure as a function of group**

Main measures	*Groups*		*p*
	Autism	*DD*	
Intentionality (Meltzoff's task)			
Failed intention	2.83 (0.72)	3.10 (0.83)	<0.01
Imitation	2.30 (0.86)	3.40 (0.73)	0.33
Response to joint attention	3.30 (2.52)	5.50 (1.13)	<0.01
Imitation			
Actions on objects imitation	1.90 (1.38)	3.40 (1.02)	<0.05
Manual acts imitation	2.60 (1.08)	3.60 (0.94)	<0.05
Spontaneous imitation	1.40 (1.56)	3.00 (1.28)	<0.01
Cooperation			
Tube with handles	1.21 (1.41)	2.60 (0.83)	<0.01
Trampoline	1.50 (1.24)	2.36 (0.71)	<0.05
Double tube A	0.49 (0.30)	0.83 (0.21)	<0.01
Double tube B	0.34 (0.45)	0.85 (0.31)	<0.01
Elevator A	1.92 (0.26)	1.92 (0.26)	n.a.
Elevator B	1.81 (0.48)	1.93 (0.26)	n.a.

Group comparisons

Cooperation tasks, level of coordination Results showed that the level of coordination was significantly lower for the children with autism relative to the children with DD in the tube-with-handles task ($t(27) = 3.25$, $p < 0.01$), the trampoline task ($t(27) = 2.32$, $p < 0.05$), and the double-tube task in both roles (role A, $t(27) = 3.36$, $p < 0.01$; role B, $t(27) = 3.2$, $p < 0.01$).

Imitation When compared to children with DD, children with autism showed a significantly lower performance in the actions on objects imitation task ($t(26) = 2.5$, $p < 0.05$), manual acts imitation task ($t(24) = 2.5$, $p < 0.05$), and spontaneous imitation task ($t(24) = 2.82$, $p < 0.01$).

Response to joint attention (RJA) In comparison to children with DD, children with autism showed a significantly lower number of responses to joint attention ($t(27) = 3.13$, $p < 0.01$).

Intentionality task (Meltzoff, 1995) Analysis of the intentionality task involved a mixed 2 (group: autism versus DD) by 2 (condition: imitation versus intention) within group factorial design. No main effects of group or condition were found. A significant interaction of group and condition was found, $F(1, 27) = 5.62$, $p < 0.05$. Participants with autism in comparison to participants with DD performed significantly worse in the imitation condition ($t(27) = 3.35$, $p < 0.01$) but not in the intention condition ($p = 0.33$). No further analyses were included in the imitation portion of the Meltzoff task. The intention score was strongly correlated with both the imitation composite and the response to joint attention (RJA) measure in the autism group, but not in the DD group (see Tables 3 and 4). This might suggest a different meaning of the intention tasks for the two groups; so we empirically tested differences in these relationships across groups. For this purpose, we built a regression model in which we predicted failed intention performance from imitation, group, and a product vector obtained by multiplying imitation by group. The predictors were entered at the same time. Results show that the product vector did not contribute independently to failed intentions. Therefore, the relationship between imitation and failed intention was not significantly different across groups. A similar approach was used to test differences across groups in the relationship between joint attention and intention. We built a regression model in which we predicted intention from joint attention, group, and a product vector obtained by multiplying joint attention by group. Similarly, interaction effects of group by joint attention were not significant, showing that the relationship between joint attention and intention did not significantly change across groups. These results do not support the possibility that the failed intention condition measured different constructs in the two groups.

Composite scores

Cooperation composite Internal consistency among four cooperation scores (double-tube A and B, tube-with-handles, and trampoline tasks) was examined using Cronbach's alpha (Cronbach, 1988). The trampoline, tube-with-handles, and double-tube A and B scores were standardized and combined into a total cooperation composite by averaging the four scores. Internal consistency yielded an alpha of 0.82, which was considered very good.

Imitation composite Three measures of imitation were administered: manual acts, actions on objects and spontaneous imitation. Similarly to the cooperation composite, internal consistency was examined using Cronbach's alpha (Cronbach, 1988). Internal consistency yielded an alpha of 0.9, which was considered very good. Thus, an imitation composite was created by averaging these three scores and substituting missing values with the mean (we had three missing values for manual acts, one missing value for actions on objects, and three missing values for spontaneous imitation).

Correlates of cooperative behavior

Plan of analyses The aim of this analysis was to understand the relative contributions of imitation, joint attention, and understanding of other people's intentions to the ability to cooperate. Through a hierarchical regression model, the first set of analyses aimed to confirm the hypothesis that the main impairment contributing to the cooperation deficit in autism is the inability to share experiences and intentions rather than to understand others' intentions. Then, in a second set of regression analyses, we changed the order of entry of the predictors to ensure that the results were not dependent on the order in which the predictors were entered.

Hierarchical regression model Given the high correlation among the three measures of imitation (see summary scores for imitation battery) for this analysis, we used the imitation composite. Correlations among our predictors (imitation composite, response to joint attention (RJA), understanding of other people's intentions, and verbal developmental age) are presented in Tables 3 and 4. In order to accomplish the aim of this phase, a hierarchical multiple regression analysis was conducted (Table 5). The dependent variable in the regression was the score in the cooperation composite. The predictors were entered in four steps: (a) child diagnosis, (b) imitation composite, (c) RJA, (d) understanding intentions and verbal mental age. Then we controlled for four interaction effects: diagnosis × imitation, diagnosis × RJA, diagnosis × understanding intentions, and diagnosis × verbal mental age. The rationale for building our model was the following: we removed the variance of diagnosis by entering child diagnosis in the first step; then we entered our hypothesized predictors, namely imitation in the second step and RJA in the third step; and in the

Table 3 **Correlations among predictors of cooperative behavior in children with autism**

Measures	*Imitation composite*	*Response to joint attention*	*Failed intention*	*Verbal mental age*
Imitation composite	1.00			
Response to joint attention	0.58*	1.00		
Failed intention	0.66*	0.59*	1.00	
Verbal mental age	0.55	0.55	0.66	1.00

* $p < 0.05$.

Table 4 **Correlations among predictors of cooperative behavior in children with DD**

Measures	*Imitation composite*	*Response to joint attention*	*Failed intention*	*Verbal mental age*
Imitation composite	1.00			
Response to joint attention	0.51	1.00		
Failed intention	0.18	0.38	1.00	
Verbal mental age	0.13	0.17	0.23	1.00

*$p < 0.05$.

fourth step we tested whether the contributions of verbal mental age and failed intentions would add significant variance. Our cooperation tasks were developed to be independent of language; however, given that the experimenters invited the children to play by saying 'your turn', we wanted to empirically test a possible contribution of verbal mental age in cooperation abilities.

The final significant equation, with diagnosis, imitation, and response to joint attention entered, explained 67 percent of the variance in cooperative behavior. In the first step of the regression, child diagnosis was a significant

Table 5 **Summary of hierarchical regression analysis for variables predicting cooperative abilities in children with autism and children with other developmental disabilities**

Step and predictor	*Step 1*		*Step 2*		*Step 3*		*Step 4*	
	t	*b*	*t*	*b*	*t*	*b*	*t*	*b*
1 Child diagnosis	−3.75***	−0.61	−1.45	−0.24	−0.21	−0.35	−1.27	−1.90
	(R^2 = 0.37, *F* change = 14.03***)							
2 Imitation			3.53***	0.56	1.79*	0.34	0.77	0.15
			(R^2 = 0.60, *F* change = 12.487***)					
3 Joint attention					2.34**	0.40	2.33**	0.40
					(R^2 = 0.67, *F* change = 5.51**)			
4 Intentions							0.91	0.13
Verbal mental age							0.48	0.07
							(R^2 = 0.68, *F* change = 0.83)	

* $p < 0.08$; ** $p < 0.05$; *** $p < 0.01$.

predictor: children with autism responded less to bids for cooperative behavior ($b = -0.72$; $p < 0.01$). Child diagnosis explained 37 percent of the variance in cooperative behavior. In the second step, imitation significantly predicted cooperative behavior ($b = 0.56$, $p < 0.01$) and added 23 percent of explained variance. In the third step, RJA significantly predicted cooperative behavior and added 7 percent of explained variance to the model (similar results were obtained when we changed the order of entrance of imitation and join attention). The fourth step, involving understanding of intentions task and verbal mental age, failed to add significant variance to the model (F change = 0.83, $p = 0.37$). Finally we tested the interaction effects of diagnosis and (1) imitation, (2) RJA, (3) understanding intentions, and (4) verbal mental age. None of these interaction effects was significant; therefore the relationship between predictors and cooperation did not vary as a function of diagnosis.

These results confirmed our hypothesis that imitation and joint attention both explain unique variance in cooperation. However, outcomes of a regression analysis may be biased by the order of entry of the variables into the model. For this reason, we performed a second set of multiple regression analyses in which we changed the order of entry of the predictors and the dependent variable was the score in the cooperation composite as before. By changing the order of the predictors we obtained results similar to the first regression analysis. Results showed that both imitation and RJA accounted for unique variance even when entered at the last step (imitation, F change = 5.15, $p < 0.05$; RJA, F change = 3.98, $p < 0.05$), while understanding intentions and verbal mental age failed to add significant variance when entered before imitation, RJA, or group. Therefore, understanding intentions and verbal mental age did not account for unique variance in cooperation.

Discussion

The aim of this study was to explore the contribution of several early social skills to the ability to cooperate with others in young children with autism. In a previous study (Liebal et al., 2008), we identified both cooperative capacities and cooperative deficits in this group. In the current study, we examined associations between cooperation and candidate-related social-cognitive skills – including imitation, joint attention, and understanding of intentions on objects, skills that emerge earlier in development – in an attempt to identify primary deficits in the development of social cognition in autism. We analyzed candidate correlates of cooperation based on several theoretical accounts, in literature focusing on both typical and atypical development. Our main finding was that both imitation and joint attention are significant correlates of cooperative behavior, a finding in line with previous research in both autism and typical development. Our findings challenge theories (Sally and Hill, 2006) relating the unfolding of cooperation primarily to the understanding of mental states such as intentions.

The deficit in imitative abilities in autism is well established (Williams et al., 2004). Moreover, the link between imitative abilities and cooperative behavior described in typical development (Forman and Kochanska, 2001) makes imitation an especially meaningful candidate variable for explaining the cooperative deficit. Our results support some aspects of Rogers and Pennington's (1991) neurodevelopmental model, in which imitation has a crucial role in the social deficit of autism. To our knowledge, no previous studies have analyzed the relationship between imitation and cooperative behavior in autism. Therefore, our contribution seems particularly relevant for the autism research arena.

The second main area explored in our study was the understanding of intentionality. Tomasello and colleagues (2005) recently provided an evolutionary theory suggesting a failure of cooperation in autism due to the inability to share intentions. The authors hypothesized that children with autism would be deficient in the capacity for *sharing* required for participating collaboratively in activities. This account is partially supported by our findings: despite unimpaired performance in the failed intentions tasks, a result that confirms previous research (Aldridge et al., 2000; Carpenter et al., 2001), children with autism responded less to bids for cooperative behavior than did children with other developmental disabilities. Our data do not fully support Tomasello's model, given that the understanding of intentions is not related to the ability to cooperate with others in children with autism. On the other hand, our findings show that in autism the ability to understand intentions does not translate into the ability to *share* experiences, as seen in the imitation deficit, and intentions, as seen in the joint attention's deficit. The model is further supported by the fact that the impaired performance in joint attention and imitation significantly predicted cooperative behavior. Tomasello and colleagues' evolutionary theory and Rogers and Pennington's model of imitation can be conceptualized as complementary rather than competitive explanatory accounts of the social impairment in autism. Both imitation and joint attention may be the missing pieces for creating the sharedness required for participating collaboratively in an activity described by Tomasello and colleagues.

In this study, we confirmed previous findings indicating that the understanding of intentions on objects may be a preserved mental state in young children with autism. This result does not easily mesh with the line of reasoning that attributes many characteristics of autism to deficits in the understanding of others' mental states (e.g. Frith, 1989; Happé, 1994;

Tager-Flusberg, 1992). However, findings from several studies and different methodologies suggest that children with autism may understand others' intentions on objects (Aldridge et al., 2000; Carpenter et al., 2001; Castelli, 2006; Russell and Hill, 2001). The dissociation between the imitation and the intention portions of the Meltzoff task in the autism group may seem surprising. However, this finding has been replicated in at least two other studies (Aldridge et al., 2000; Hepburn and Rogers, unpublished) and is in line with research showing differentiated patterns of performance in tasks requiring imitating actions on objects in children with autism. For instance, the imitation of more meaningful actions on objects is less impaired than the imitation of less meaningful actions (Rogers and Williams, 2006). Certainly, the use of only one measure of intentional understanding represents a limitation of the study. Future research investigating the correlates of cooperation should use a variety of measures of intentional understanding.

One may argue that imitation is not only a measure of sharing experiences, but also a measure of understanding intentions on objects. However, while certain kinds of imitation such as the imitation of functional actions on objects certainly involve intentional understanding, we do not think that our three measures of imitation did. The actions on objects to be imitated were not conventional. For example, the item involving a toy car involved turning the car over and patting the bottom of the toy. Moreover, the imitation of a non-meaningful manual act (not involving objects) and the spontaneous imitation of bodily movements clearly do not involve the understanding of intentions on objects. It may also be argued that response to joint attention is not a measure of sharing intentions and perhaps initiation of joint attention would have been a better measure. While future research investigating the correlates of cooperation should include measures of initiating joint attention, in the literature several accounts consider response to joint attention an example of shared intentionality (e.g. Behne et al., 2005; Brooks and Meltzoff, 2005; Tomasello and Carpenter, 2007). For these reasons we interpret our results as showing that the inability to form shared experiences and intentions is related to the cooperative deficit in autism. On the other hand, according to a leaner interpretation our results would simply show that diminished imitation skills and diminished response to joint attention are related to poor cooperative abilities in children with autism. Our findings are certainly preliminary, and therefore future research should help to shed light on these two interpretations of the cooperative deficit in autism.

Based on the results of the multiple regression analysis, we suggest that an impairment in imitation and joint attention alters developmental trajectories involving cooperative development and prevents children with autism from fully participating in cooperative tasks. While cross-sectional designs cannot answer questions about developmental trajectories, the rich research literature describing the age of emergence of imitation, joint attention, and cooperation seems to support the inference that deficits in imitation and joint attention would alter the development of cooperation. Imitation appears to be present in some capacity from birth (Meltzoff and Moore, 1977). Joint attention typically emerges during the 9–12 month period (e.g. Bono et al., 2004). Cooperative behavior has been described not earlier than 18 months (Warneken et al., 2006). Of course, longitudinal studies are certainly necessarily to confirm the developmental trajectory suggested.

Finally, the relationships we found among cooperation, imitation, and joint attention emphasize the importance of targeting imitation and joint attention skills in intervention programs for children with autism. Rogers (1999) emphasized the relevance of developmental models for guiding and achieving more effective treatments. By working with very young children with autism, and carefully prising apart what they understand about other people, what they do not understand, and what skills appear to lead to greater understanding, we are in a position of being able to treat more precisely the nature of the social impairment in autism.

One alternative explanation of our results might be that our participants did not engage in cooperative activities with joint goals, but rather copied the adult's object-directed actions such as throwing a cube down a tube or pulling the handles of a tube. The argument would be that the children simply reproduced an action on the toys that the experimenter was performing during the demonstration. However, our scoring system only credited cooperation when the child waited for the adult to join the play and, once the game started, the child synchronized his/her actions with the adult. Imitation of the action as a solitary activity did not warrant coordination with the actions of the partner. Thus, we think that our tasks really measured the ability to cooperate with a partner. On the other hand, children had to rely on modeling to understand the tasks. Modeling presents a unique challenge to young children with autism, a challenge that may well be inextricably connected to difficulties with sharing goals, the focus of this study.

Another plausible interpretation is that children did not cooperate because they did not attend to the experimenters' models due to a social orienting impairment (Dawson et al., 2004). However, in our methodology child visual attention was gained before the tasks were administered; this was also checked by videos. Performance was only scored if the videos documented that the child was watching the examiner. Thus, child visual attention as a variable was managed in the methodology. However, we did not use more sophisticated measures of child visual attention such as eye tracking. This may constitute a limitation of our study and a question that may be asked in future research.

There are several limitations in this study. The small size of the sample does not allow generalization of the findings to the larger population of people with autism. Furthermore, children with autism in California receive intensive intervention following diagnosis and, thus, this group of children may not be representative of all preschoolers with autism recruited from similar communities who fit our descriptions. However, our sample performed similarly to previous samples from many other studies on tasks of joint attention and imitation, and thus give no indication of different developmental trajectories than seen in other studies of preschoolers with autism. Given the exploratory nature of the study, these limitations were felt to be acceptable. Future research should investigate cooperation with larger samples and with a longitudinal design. Moreover, future research should also investigate the relationships among joint attention, imitation, and cooperation in a more detailed manner. We examined only one aspect of joint attention: response to joint attention. Given the promising relationship found between joint attention and cooperation in the current study, future studies should examine the nature of this association by including measures of initiating joint attention**.** Finally, the use of a mixed DD group, rather than a more homogeneous group, is a further limitation of this study, though using children with heterogeneous developmental delays as control group is a common practice in autism research (e.g. Dawson et al., 2004; Leekam and Ramsden, 2006).

As in many other social behaviors in autism, these findings demonstrate a capacity for partial social accomplishments. In this study these were related, not to general developmental maturity, as demonstrated by the non-significant relationship between cooperation abilities and verbal mental age, but to specific social abilities that can be improved through treatment, imitation (Ingersoll and Schreibman, 2006), and joint attention (Whalen and Schreibman, 2003). To what extent any treatment that changes imitation and joint attention can improve the social deficits in empathy, cooperation, theory of mind, and other more mature social abilities in autism are questions for future treatment studies.

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